



North Yorkshire  
County Council

# Flood Investigation Report

## Tadcaster



Business and Environmental Services


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### Revision Schedule

Revision	Date	Details	Author	Checker
V1	10/11/16	1 <sup>st</sup> draft for comment	H Grayson	V1
V2	21/11/2016	Version 2	M Young	V2
V3	24/11/2016	Version 3 – refs & figs	H Grayson	V3
V4	16/12/2016	Final Review	J Batt	V4

### Reviewer Record

Revision	Date	Reviewer	Organisation	Sign off
V3	15/12/2016	M Young	NYCC	
V4	14/05/2017	P Tweed	NYCC	

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Records of the public sewer system included are a facsimile of the statutory record provided by Yorkshire Water Services Ltd (YWSL). For the purposes of this report minor sewers and other non-relevant data have been omitted from the plans for clarity.

## **Purpose**

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 RMAs had relevant flood risk management functions during the flooding incident of December 26<sup>th</sup> – 27<sup>th</sup> 2015 , 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 records of internal property flooding and road closure information from a variety of sources. While every effort has been made to verify the locations of the Section 19s identified, the nature of the data and the methods used to collate this information mean that it does not include every occurrence of flooding. This data only identifies where flooding has been reported and is indicative only.

## **Acknowledgements**

Mouchel would like to thank the following for their cooperation and assistance in this investigation:

North Yorkshire County Council Flood Risk Management Team

North Yorkshire County Council Highways Department

North Yorkshire County Council Emergency Planning Unit

Selby District Council

The Environment Agency

Yorkshire Water Services Ltd

Tadcaster Flood Action Group

## **Date of site inspection:**

7 September 2016

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## 1 Executive Summary

On the 26<sup>th</sup> of December 2015, flooding associated with heavy rainfall following Storm Eva inundated a significant number of properties, both residential and commercial, and caused severe damage to highway infrastructure in the town of Tadcaster.

Widespread and substantial rainfall had fallen over West and North Yorkshire throughout November and December 2015. Many rivers rising in the Pennines, including the Wharfe, recorded their highest ever flows by a significant margin during December 2015. On the 26<sup>th</sup> December rainfall in the middle reaches of the catchment was proportionately more significant than that over the Pennines. This pattern of rainfall had particular consequences for communities in the Lower Wharfe, both in terms of the scale of the flooding and the lead times available for issuing warnings.

It had already been very wet for an extended period of time - data shows that in the Wharfe catchment, November 2015 was the second wettest since 1909 and total runoff from the catchment was at its highest level ever recorded. The Wharfe catchment received more than twice the long term average rainfall for December, with the result that the catchment was fully saturated and unable to absorb any more rainfall before rain started to fall again on Christmas Day and Boxing Day.

The River Wharfe flowing through Tadcaster exceeded the capacity of the flood defences, and spilled over into the streets. In total 79 properties in the area of Wharfe Bank Terrace, Bridge Street, Commercial Street, Mill Lane, Wharfe Bank, Beech Close, High Street and Church Yard reported internal flooding. The flooding affected residential dwellings, St Mary's Church, commercial properties and also the town's health and medical centres.

The flooding and subsequent collapse of Tadcaster Bridge resulted in the closure of A659 at the bridge, separating the two sides of the town either side of the River Wharfe.

As part of the multi-agency response to the incident, to which the community has made a significant contribution, a temporary footbridge was installed by the County Council's Highways team within weeks of the collapse, to provide a pedestrian route during repairs to the bridge structure. The A659 road bridge has now been repaired.

Residential and commercial properties have been provided with assistance from the Government's "Resilience and Resistance Grant" scheme. North Yorkshire County Council has conducted investigations into surface water and drainage assets around Bridge St and is coordinating with Yorkshire Water to progress issues highlighted. The Environment Agency is seeking funding from central government for an improved flood defence scheme for Tadcaster and the Lower Wharfe villages.

This report has identified the actions and responses of the Risk Management Authorities which have responsibilities during a flood event in Tadcaster. It is understood that all Risk Management Authorities have undertaken appropriate actions.

## 1.1 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.

## 1.2 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.

### 1.3 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 Section 19 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.

### 1.4 Location of this Investigation

Tadcaster is a market town in the Selby District of North Yorkshire which is home to approximately 6000 residents<sup>1</sup>. Tadcaster (Grid Reference: SE 48772 43504) is the last town on the river Wharfe before the confluence with the Ouse, 16 km downstream at Cawood. Tadcaster is located to the north of the A64 and east of the A1 approximately 16 km to the southwest of York, as shown in Figure 1.0. The town has low lying land both upstream and downstream which forms the river’s natural floodplain. The local topography in the town itself slopes gently upwards away from the river.

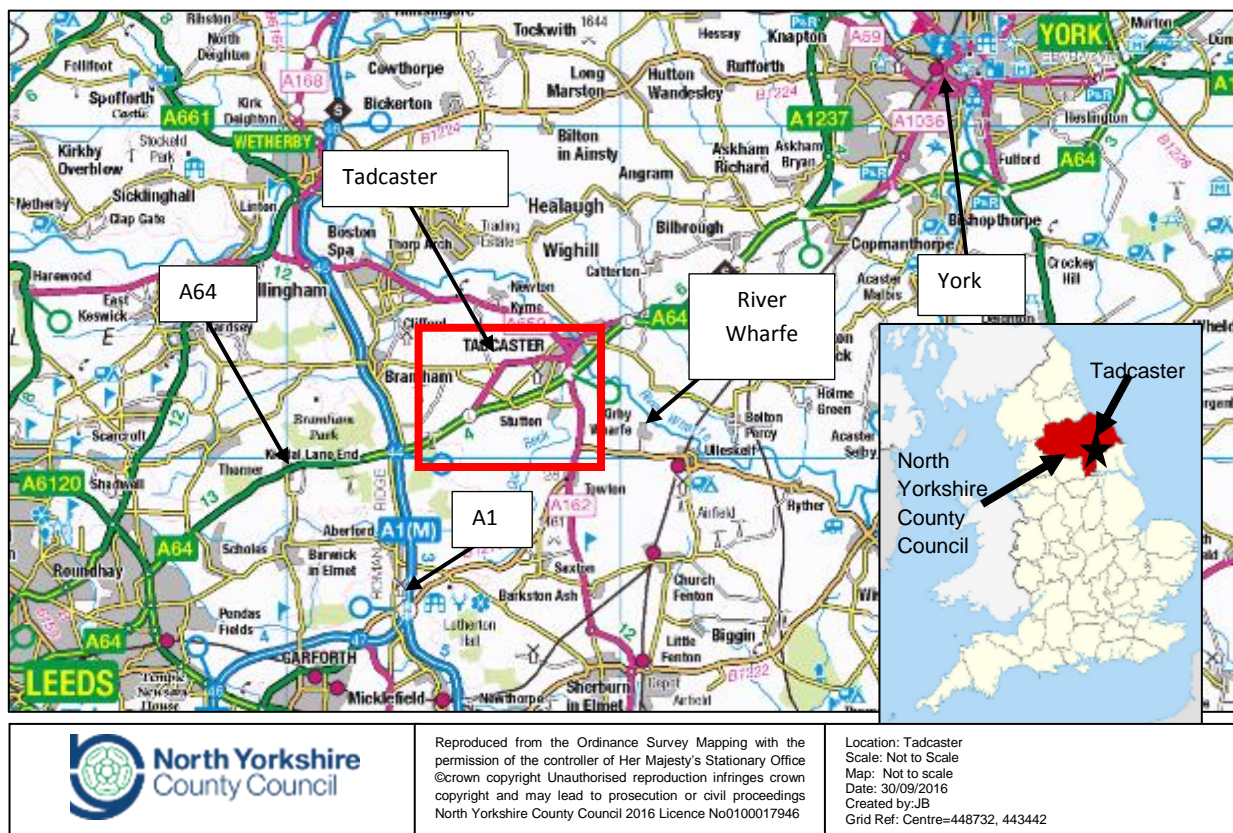


Figure 1.0: Tadcaster Location Map (Source: NYCC)

<sup>1</sup> 2011 Census



Tadcaster is situated on both banks of the Wharfe and is connected by the A569 road bridge. Bridge Street (A659) is located to the west of the bridge over the Wharfe, and Commercial Street (A659) is to the east. Mill Lane runs along the eastern side of the River Wharfe, joining the northern side of Commercial Street via a T junction. Church Yard is situated opposite St Mary’s Church. Kirkgate is also part of the A659 and joins Bridge Street’s northern side via a T junction. Bridge Street becomes High Street at the junction with Kirkgate.

Wharfe Bank Terrace faces the River Wharfe on the west bank of the river. It includes addresses both upstream and downstream of the bridge. Wharfe Bank is the area on the west bank of the river further downstream than Wharfe Bank Terrace. Some properties here are adjacent Tadcaster Ings.

The principal locations referred to in this report are shown in Figure 1.1.

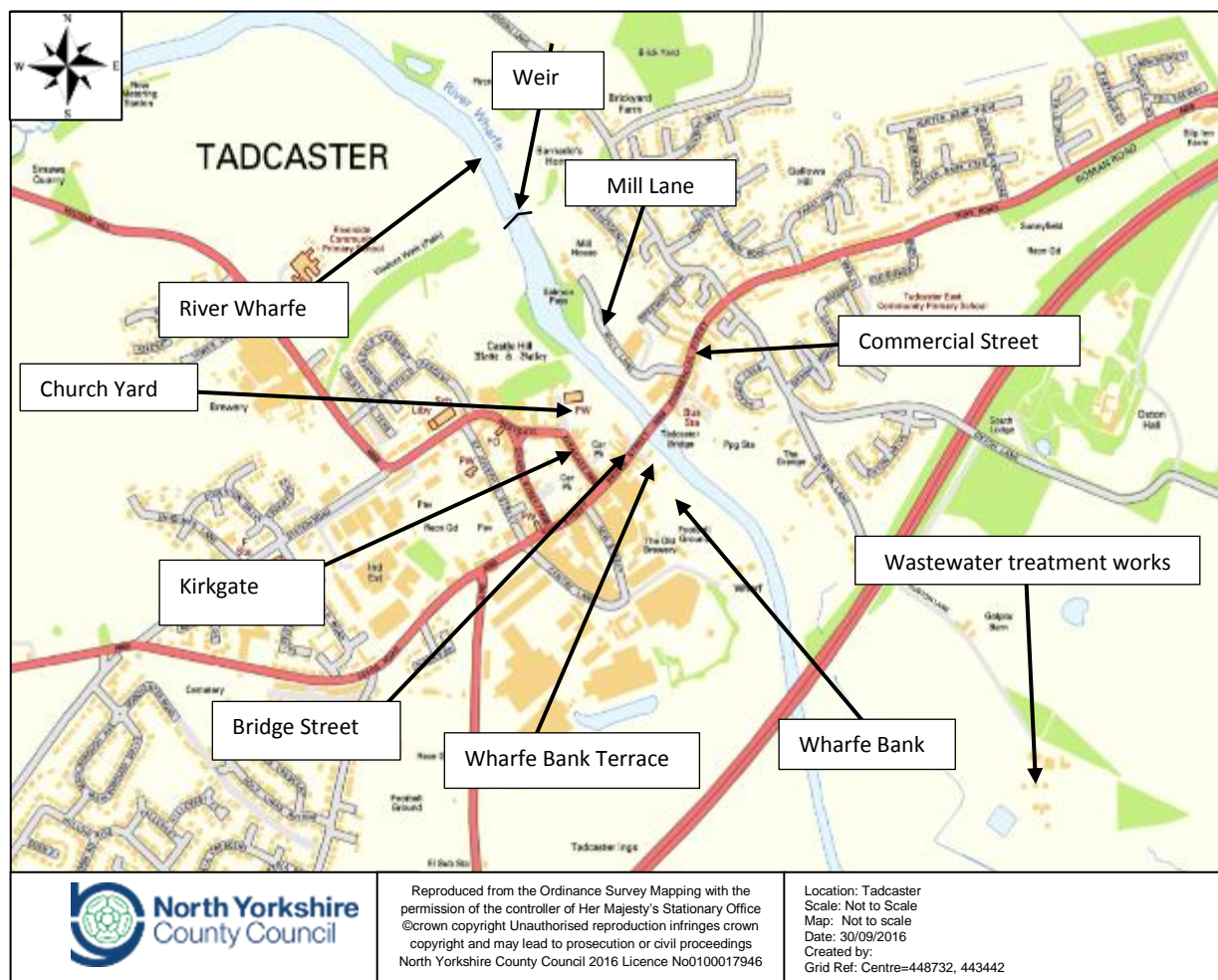


Figure 1.1: Tadcaster Local map (Source: NYCC)

## 1.5 The River Wharfe

The River Wharfe starts at the confluence of Oughtershaw Beck and Green Field Beck near Beckermonds, Langstrothdale, high in the Yorkshire Dales National Park. The river flows into the River Ouse near Cawood nearly 100km downstream. It has a catchment area of 815km<sup>2</sup> draining to Tadcaster.

River levels are gauged by the Environment Agency at Tadcaster (station ID: 8202), where the normal range is between 0.18m and 2.90m. This station is sited approximately 1.5km upstream of the A659 Tadcaster road bridge. According to the Environment Agency when the Wharfe at Tadcaster rises above 2.9m flooding from the river can be expected<sup>2</sup>.

The River Wharfe is tidal from where it joins the river Ouse back up to the weir located approximately 350m upstream of Tadcaster A659 Road Bridge<sup>3</sup>. Hence flood risk from the Wharfe is related to both river flows and tidal influence.

The River Wharfe is classified as a “main river” and as such the Environment Agency manages flood risk, maintaining and managing flood defences along the river as well as having the power to serve notice to any person or body requiring them to carry out necessary works to maintain flow.

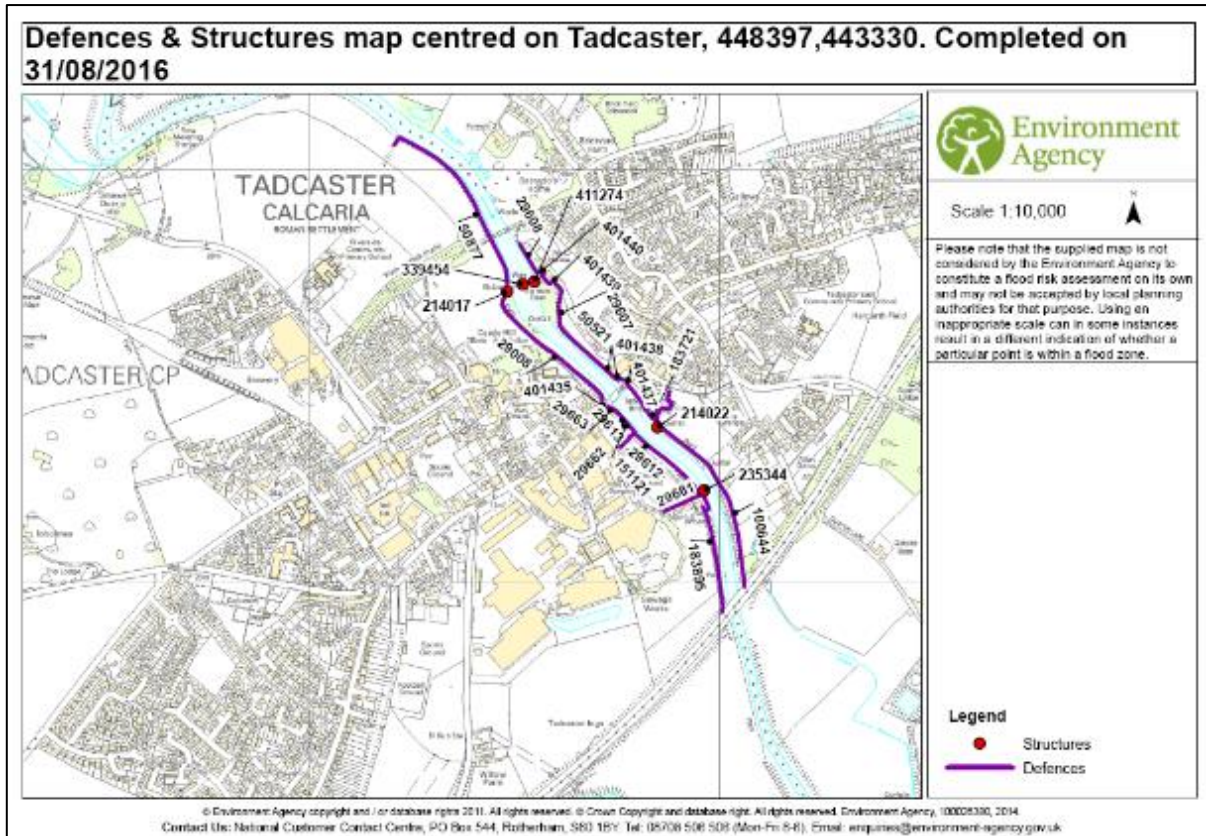
## 1.6 Flood Defences

There are a number of flood defences in and around Tadcaster which the Environment Agency manage to mitigate flood risk. There are flood defences on both sides of the River Wharfe through Tadcaster, as shown on Figure 1.2 on the following page. In addition there are washland areas or lngs which temporarily store floodwater both upstream and downstream of the town.

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<sup>2</sup> Environment Agency <https://flood-warning-information.service.gov.uk/station/8202?direction=u>

<sup>3</sup> <http://www.environmentdata.org/fedora/repository/ealit:1369/OBJ/19001165.pdf>

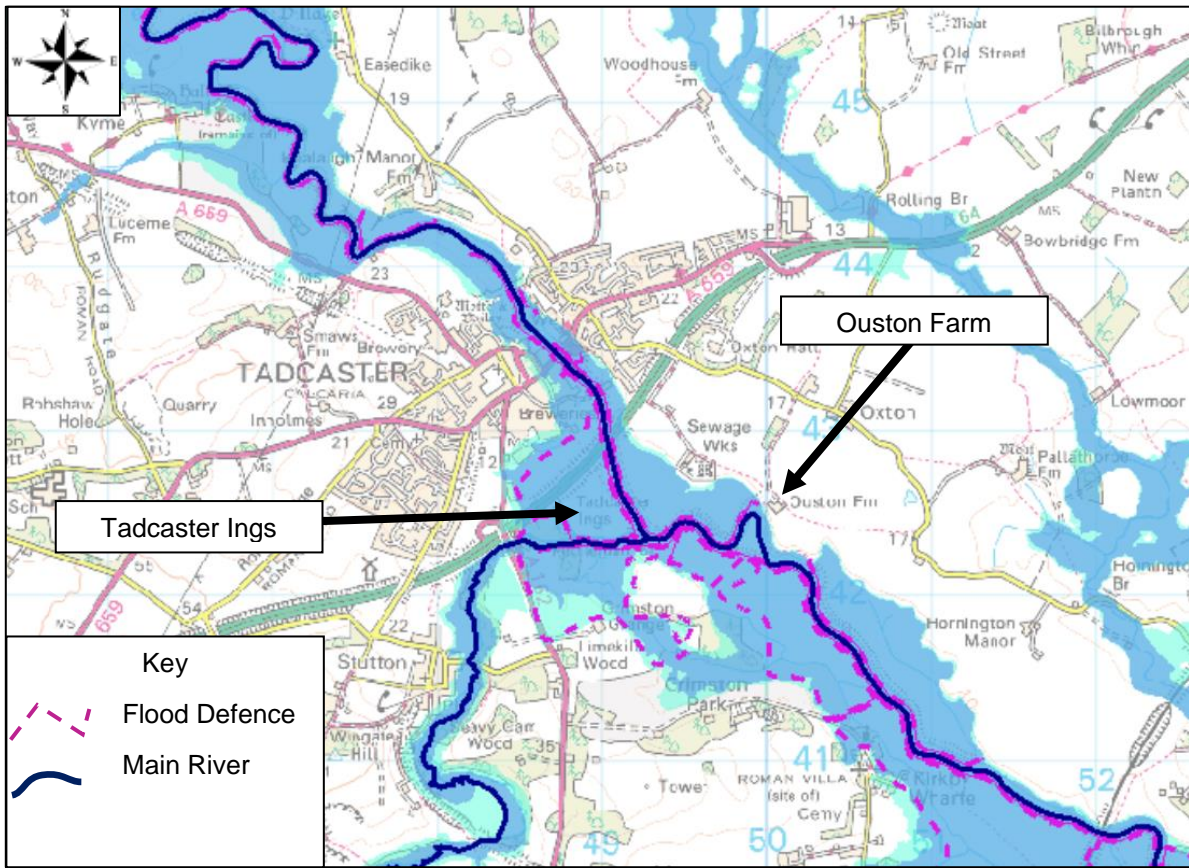


**Figure 1.2 Defences and structures map (Source EA)**

Looking downstream, on the right (west) bank the defences follow the river upstream and downstream of the road bridge, from Castle Hill at the upstream end to Cross Bank by Tadcaster Albion’s car park. Over this length the defences are raised earth embankments upstream of the bridge with a lower section of overtopping banks downstream of the bridge designed to allow Tadcaster Ings to fill.

On the left (east) bank the line of defences begin at a flood bank immediately downstream of the viaduct. Further downstream a sheet piled wall runs along the bank top in the vicinity of Sainsbury’s Supermarket on Mill Lane and ties into the upstream side of the bridge. There is another flood bank downstream of the bridge which finishes at the car park. Further downstream an overtopping bank providing limited attenuation follows the line of the eastern river bank as far as Ouston Farm.

Downstream of the town there are a series of washlands that store water in order to reduce flood levels, as shown in Figure 1.3. The Tadcaster Ings can regularly be seen holding water after periods of high river flow. An earth embankment surrounds the washlands south of Tadcaster.



**Figure 1.3 EA Flood Map for Tadcaster area (Source: Environment Agency)**

The flood defence assets in Tadcaster were constructed in the 1980s and offer protection against flood events with return periods of 25 – 30 years. The washland system downstream will be submerged in flood events of a magnitude greater than a 100 year return period<sup>4</sup>.

### 1.7 Tadcaster & Ulleskelf Bridges

Tadcaster Bridge is an historic nine arch masonry bridge which provides the only river crossing for local residents and vehicles between the two sides of the town. The partial collapse and closure of the bridge has required a 23km diversion route for vehicles to get from one side to the other. The bridge is a Grade II listed structure which was constructed in the 17th century and extended on its upstream face in the late 18th century to make it wider. Originally constructed with nine arches, the river channel under the bridge has narrowed over many years due to natural siltation and the reclamation of land and only seven arches remain visible. At the time of the flood three arches were fully blocked, three were partially blocked whilst three remained fully open and allowed the river to

<sup>4</sup> Discussion between EA and Mouchel

flow freely during normal conditions<sup>5</sup>. The York to Leeds railway bridge (NOC/17) at Ulleskelf is 5km downstream from Tadcaster. The bridge and adjacent structures are considered for the purposes of this report, as it has been suggested that alterations to the bridge may have had an effect on flood levels. In 2014, flood relief culverts (NOC/18 – 21) adjacent to the bridge were lined as part of maintenance works.

### 1.8 Reservoirs

There are four reservoirs operated by Yorkshire Water Services Limited (YWSL) that are hydraulically connected to the river Wharfe and Tadcaster. These are all on the River Washburn, 40km upstream, which discharges into the River Wharfe between Otley and Pool in Wharfedale. From the headwaters at Pockstone Moor the River Washburn and Capelshaw Beck flow directly into Thruscross Reservoir. Below here the river runs 3km before flowing into Fewston Reservoir and then on into the adjacent Swinsty Reservoir. Thruscross and Fewston Reservoirs are used for storage and to regulate the amount of water in Swinsty Reservoir, which is the only supply reservoir in the chain. The bottom reservoir is Lindley Wood, which supplies compensation flows to the river downstream<sup>6</sup>, as shown in Figure 1.4.

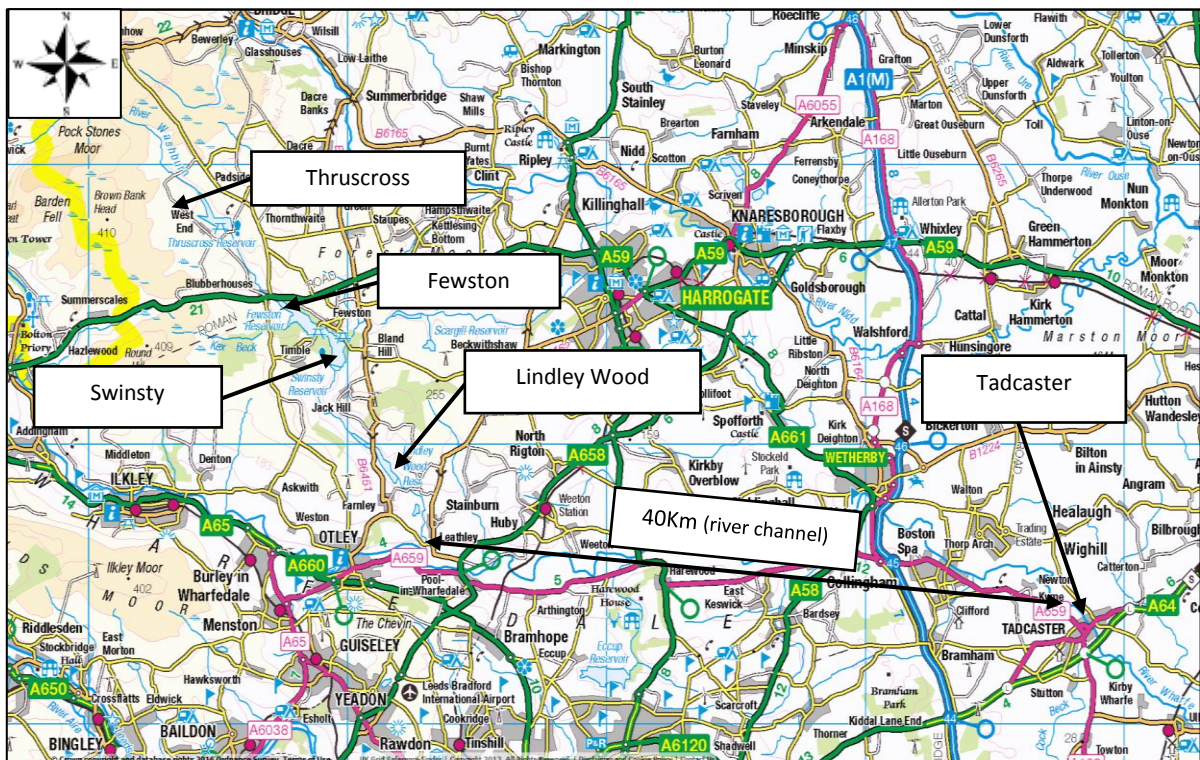


Figure 1.4 Locations of reservoirs with respect to Tadcaster (Source: NYCC)

<sup>5</sup> Historic England, Tadcaster Bridge, investigation, history and significance report, February 2016

<sup>6</sup> <https://www.yorkshirewater.com>

## 1.9 Highway Gullies

Local road gullies are owned and maintained by NYCC as the local Highways Authority. The gullies collect surface water from rainfall and are connected to the local public sewer systems, which are owned and maintained by YWSL.

In addition to collecting rainwater from the road, rain water downpipes from individual properties discharge in channels across the footpath and onto the highway on Bridge Street. Hence the highway gullies here are transferring both roof and road water into the surface water sewer as shown in Figure 1.5, this increases the volume of water discharged to the sewer.

Commercial Street, on the east of the river, starts at the junction of York Road, Wighill Lane, and Ouston Lane. From here the road falls towards the river, where there is an extensive area at a low level which includes Mill Lane and the bus station. The road level rises again as it crosses the river. There are highway gullies in the road to collect surface water.



**Figure 1.5 Bridge Street surface water components (Source: Google Maps)**

### 1.10 Public Sewers

YWSL operates a network of surface water sewers and combined sewers in Tadcaster, see figure 1.6. There is a surface water sewer network throughout the town that flows under gravity and into the River Wharfe via a series of outfalls on both banks of the river. This surface water system collects flow from highway gullies and rain water downpipes attached to properties<sup>7</sup>.

Combined flows from both sides of the river flow under gravity to the Britannia Sewage Pumping Station (SPS) and then forward for treatment at Tadcaster Waste Water Treatment Works approximately 1 km southeast of the town. Combined flows from west of the town are conveyed beneath the river Wharfe via a siphon to get to the SPS. The Britannia SPS is located on the east of the river adjacent the Bus Station. This has its own overflow which operates when inflows exceed the pumping capacity<sup>7</sup>.

In addition, there are two combined sewer overflows (CSOs), one on each side of the river which allow excess flows from the combined sewers to be discharged directly to the River Wharfe during high flows. Additionally there is the Brewery SPS which is a foul only system<sup>7</sup>.

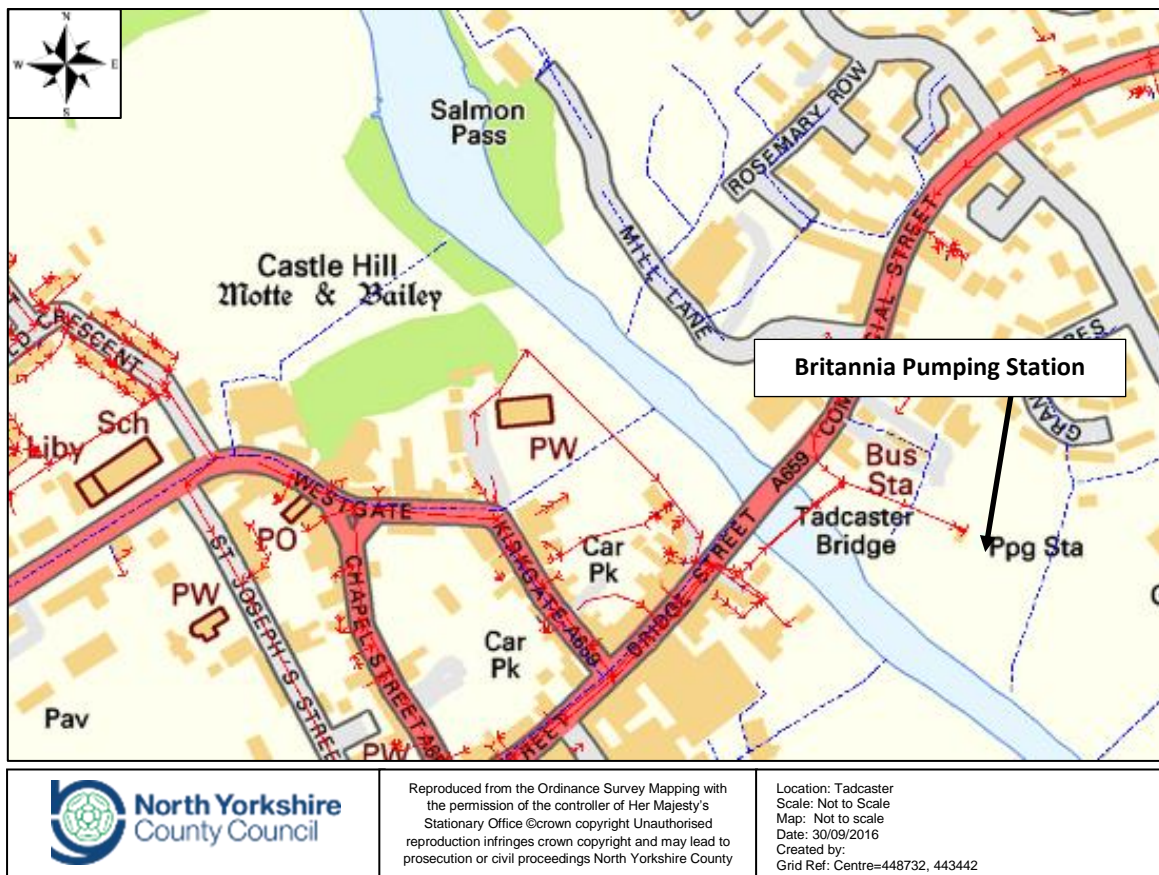


Figure 1.6 Sewer systems adjacent the River Wharfe in Tadcaster (Source: YWSL)

<sup>7</sup> Data provided by YWSL in response to S14 request

The surface water sewer is 450mm in diameter and takes surface water discharges from Bridge Street and the surrounding areas, to the upstream side of the bridge where it discharges through a non-return valve into the Wharfe<sup>7</sup>.

Surface water sewers bring flows together in Mill Lane and discharge through a non-return valve to the river Wharfe upstream of the bridge. A surface water sewer runs from Commercial Street through the bus station and discharges through another non-return valve into the river Wharfe downstream of the bridge<sup>7</sup>.

There are surface water sewers in Westgate and Kirkgate with outfalls to the river Wharfe on each side of St Mary's church. It has not been determined whether surface water from properties in Church Yard discharge to this surface water system. There is a combined sewer system in Church Yard that is conveyed parallel to the river and flows into the combined system in Bridge Street. A few properties on Church Yard, near its junction with Westgate, appear to be connected to the combined sewer on Westgate, which is then conveyed along Kirkgate before connecting in the Bridge Street combined sewer<sup>7</sup>.

There have been four recent incidences of flooding associated with the surface water and sewer system on Bridge St. In September 2012 and on the morning of December 26<sup>th</sup> 2015, surface water flooding occurred prior to flooding from the main river and coincided with very high river levels, which prevent the system from discharging. Two further incidences of flooding on Bridge St occurred, in August 2014 and again in August 2015. These were as a result of heavy and localised rainfall that exceeded the design capacity of the drainage network in the area. A detailed discussion of these events and the performance of the drainage infrastructure is beyond the scope of this report, however North Yorkshire County Council and Yorkshire Water Services Limited are aware of the significant impact these successive floods have had in Tadcaster and continue to work together on finding a long term solution.

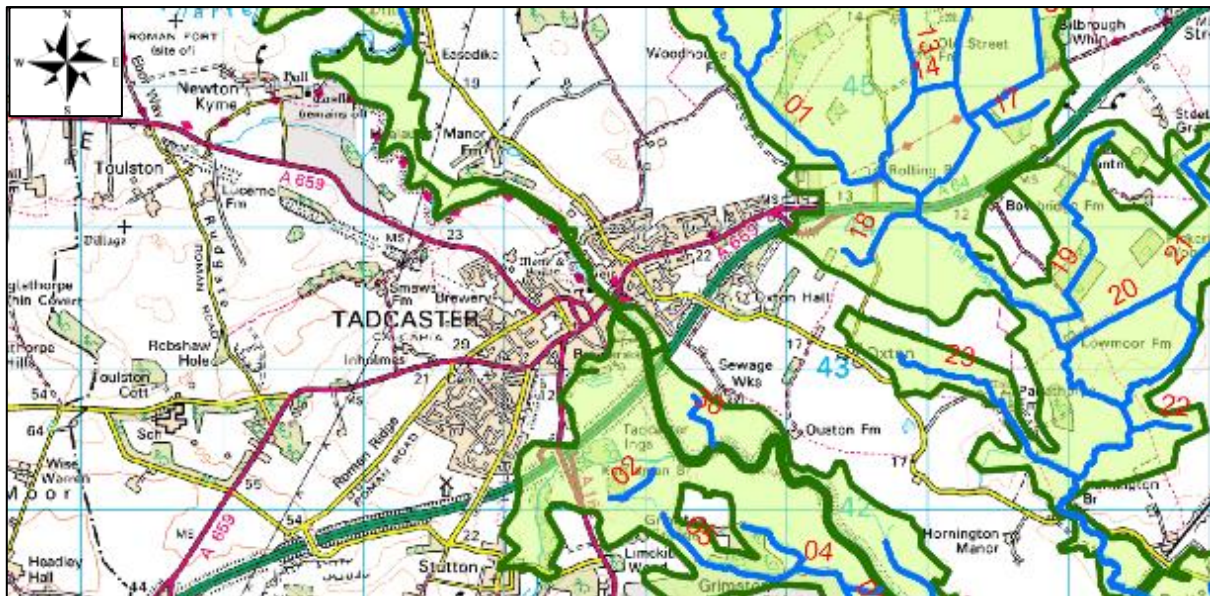
### **1.11 Internal Drainage Board**

Tadcaster is located adjacent to the Ainsty (2008) Internal Drainage Board (IDB) district. The board operates as the Land Drainage Authority within their district and is responsible for the management of water levels for the benefit of agriculture and mitigation of flood risk. The drainage board district includes Tadcaster Ings, as shown in Figure 1.7. The IDB's district includes areas both upstream and downstream of Tadcaster that are hydrologically linked with the section of the River Wharfe that flows through the town<sup>8</sup>.

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<sup>8</sup> IDB Mapping Tool





**Figure 1.7 Extents of Ainsty (2008) Drainage Board in Tadcaster (Source: Ainsty (2008) IDB)**

## 2 Flooding Incident

### 2.1 Antecedent Conditions

A data set from the National Climate Information Centre (NCIC) shows that in November 2015 the Wharfe Catchment experienced the second wettest November since 1909, reaching 238% of its long term average (LTA). This indicates that the ground was already saturated from rainfall in November, prior to the exceptionally wet December 2015.

In addition parts of the Wharfe catchment had already received approximately 2.3 times the December LTA rainfall even before rain started falling on Christmas Day and Boxing Day<sup>9</sup>.

Analysis of data from before this period shows that at the beginning of October the Pennine Hills were fully saturated, with the further rainfall in November and December ensuring that the saturation persisted leading up to Christmas<sup>9</sup>.

### 2.2 Reservoirs and Storage

There are washland areas and Ings upstream of Tadcaster which are designated as reservoirs and which fill in times of flood. Peak flows during the flood were higher upstream at Flint Mill (582m<sup>3</sup>/s) than in Tadcaster (480m<sup>3</sup>/s)<sup>9</sup>. Peak flow readings in flood conditions are not always accurate, and

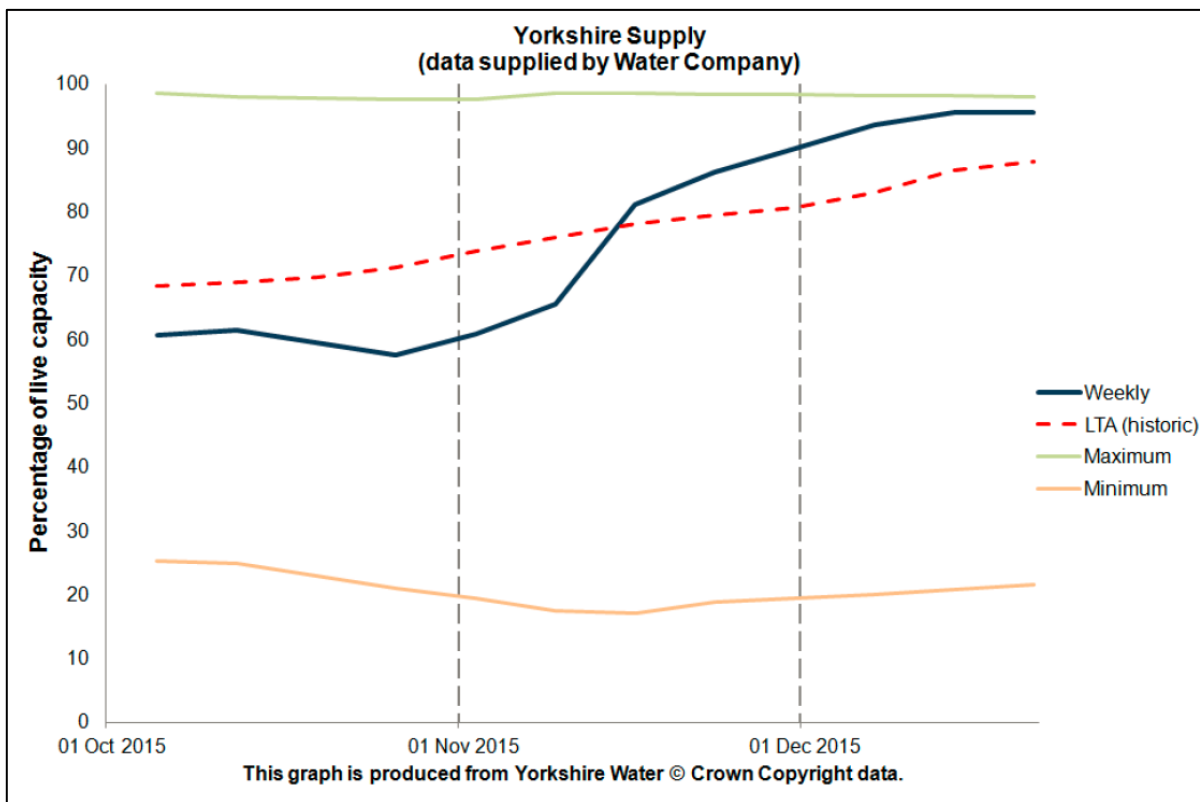
<sup>9</sup> Environment Agency, Hydrology of the December 2015 Flood in Yorkshire, 25th to 29th December 2015, April 2016

these figures should be treated with caution, however this could suggest that the Ings were still filling and had not reached capacity. There are no other structures or features in the catchment upstream of Tadcaster designed for the attenuation and storage of water for flood risk purposes.

There are a number of reservoirs constructed for the purpose of water supply within the catchment, however these are not designed to operate as attenuation structures with respect to flood risk.

YWSL supply stocks were below the long term average (LTA) leading into November, but the increased rainfall in November and December saw overall levels rise above the LTA and they were virtually full prior to the flood event (see figure 2.0 below) and remained so well in to March<sup>10</sup>.

YWSL has stated that no operational plans to facilitate the drawing down of reservoir levels during or prior to a flooding event exist in this catchment, and that no similar actions were carried out on this occasion.



**Figure 2.0 Antecedent reservoir stocks demonstrated by Yorkshire Supply (Source: YWSL)**

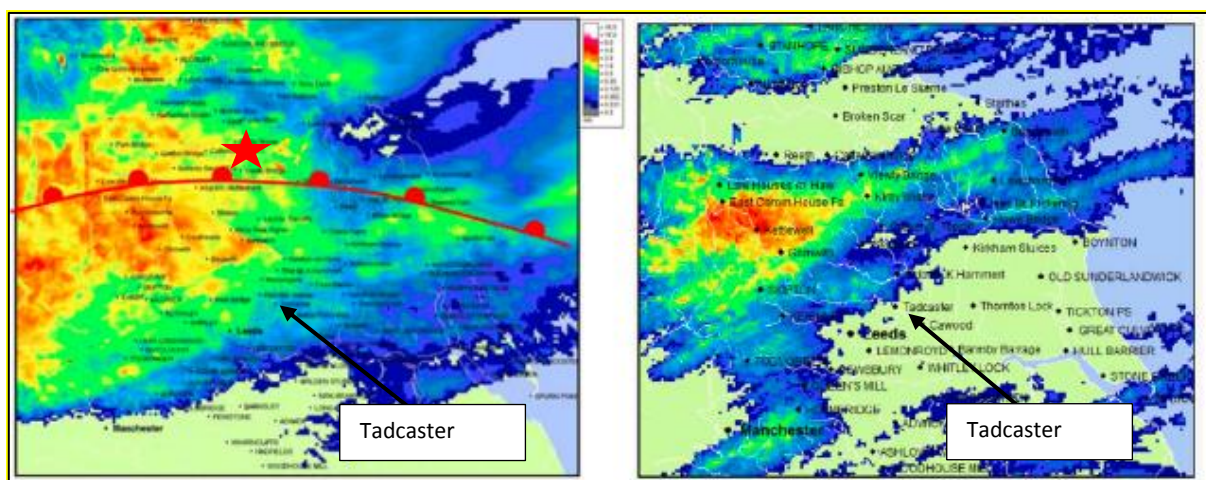
<sup>10</sup> Data provided by Yorkshire Water

### 2.3 Meteorological Conditions

The event was characterised by a slow moving low pressure system and warm frontal zone that immediately followed behind Storm Eva, moving across the region from the west. Storm Eva brought high winds and a band of rain which spread across the country on the 23rd & 24th December. The rainfall which caused the flooding was brought by a weaker low pressure system which came through on the 25<sup>th</sup> & 26<sup>th</sup> December following Storm Eva<sup>9</sup>.

A warm frontal zone passed over the UK during the morning of 25th December, bringing scattered showers with it, and by midday there was a blanket of rainfall covering Yorkshire. During the evening an occluded front had set over the North West and North East and it was this front which produced the more intense storms<sup>9</sup>.

There were two main pulses of heavy rainfall that led to the flooding experienced across Yorkshire. The first pulse occurred once the occluded front had formed during Christmas Day afternoon and evening. During this time the rain was mainly confined to the upper catchments of the Aire, Calder, Wharfe and Swale<sup>9</sup>. The second pulse came in the early hours of Boxing Day morning, and lasted for approximately 12 hours. (See figure 2.1 below).



**Figure 2.1 Radar image with overlaid front as of 18:00 on 25th December (left) and 01:00 on 26th December (right) Copyright Meteorological Office (Source: EA)**

## 2.4 Rainfall Data

The rainfall data recording by the tipping bucket rain gauge (TBR) network was analysed for a range of durations. Table 3.1 shows a selection of peak rainfall accumulations at different durations, their rainfall return periods, and the rainfall as a percentage of the December LTA<sup>9</sup>.

Catchment	Gauge Name	Location	Rainfall (mm) 1 <sup>st</sup> to 24 <sup>th</sup> December 2015	December LTA Rainfall (mm)	Rainfall 1 <sup>st</sup> to 24 <sup>th</sup> December 2015 as % of December LTA
Wharfe	Beckermonds	Beckermonds	462	195.0	237
	Littondale	Littondale	373.6	167.0	224
	Grimwith	Nr Grassington	209.2	121.9	172
	Thruscross	Nr Blubberhouses	161.6	119.0	136
	Otley	Otley	87.2	77.3	113
	Eccup	Eccup	77.2	75.4	102
	Bramham	Bramham	56.4	60.7	93

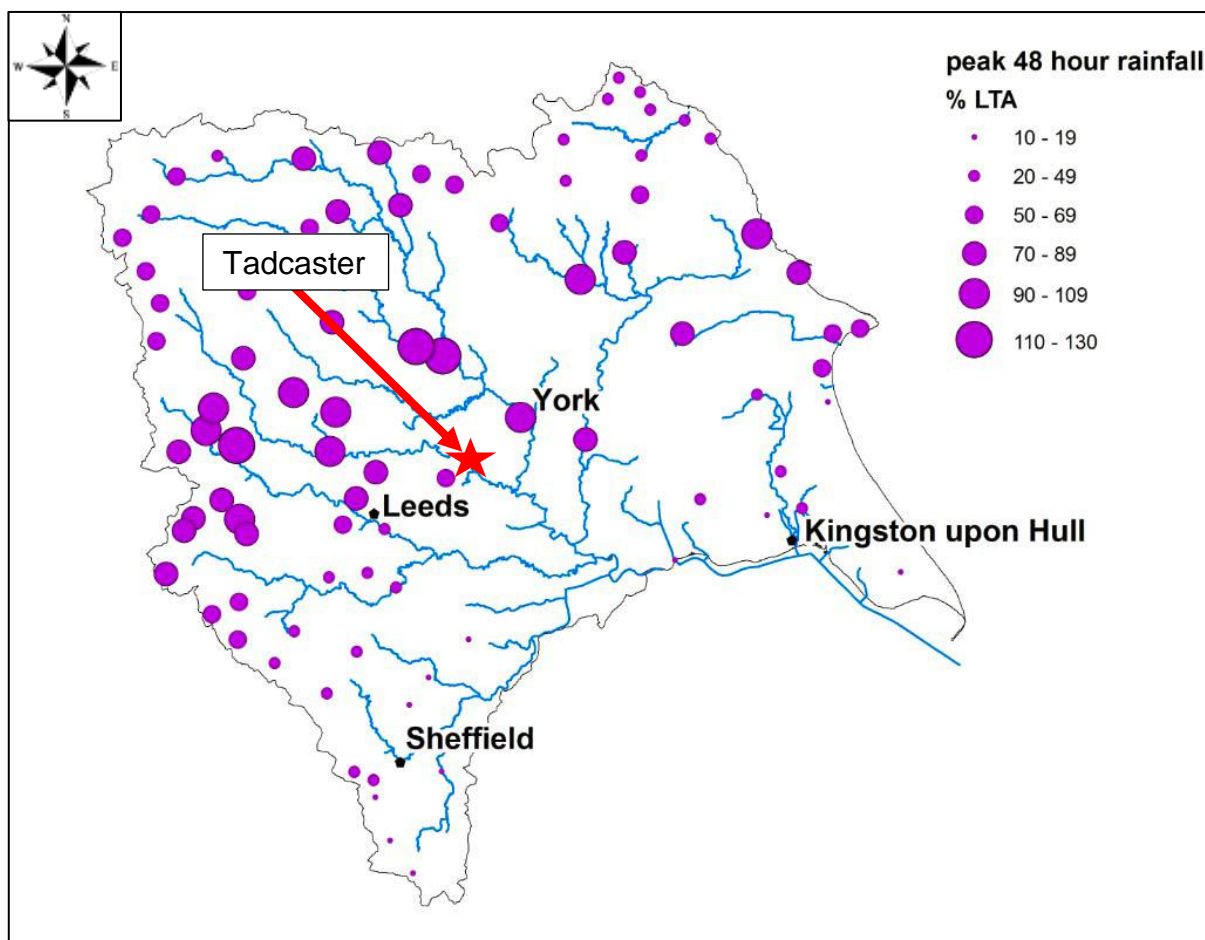
**Table 2.1 Total rainfall and percentage of LTA for 1st to 24th December 2015**

	WHARFE				
Peak rainfall	Beckermonds	Littondale	Grimwith Reservoir	Thruscross	Otley
<b>Accumulation (mm)</b>					
6 hour total	34.8	26	28.8	34.4	27.6
12 hour total	56.8	44.6	47.8	54.8	43.6
18 hour total	71.8	66	71	82.4	57.4
24 hour total	90.6	85.2	92.4	101.8	76.2
36 hour total	114.4	109	103.8	108.6	78.4
48 hour total	<b>115.8</b>	112.4	103.8	109.8	78.8
<b>Return period (years)</b>					

Peak 6 hour total	3	1	3	5	3
Peak 12 hour total	5	2	6	11	8
Peak 18 hour total	7	6	18	34	13
Peak 24 hour total	12	10	37	58	28
Peak 36 hour total	17	16	35	44	18
Peak 48 hour total	11	11	23	30	11
<b>% LTA</b>					
Peak 6 hour total	18	16	24	29	36
Peak 12 hour total	29	27	39	46	56
Peak 18 hour total	37	40	58	69	74
Peak 24 hour total	47	51	76	86	99
Peak 36 hour total	59	65	85	91	101
Peak 48 hour total	59	67	85	92	102
<b>December Total as % LTA</b>					
	212	290	252	225	211
Peak rainfall = return periods of 20 years and above are highlighted in red and percentage LTA of 50% and over are highlighted gold. December total = percentage LTA of 250% and over are highlighted amber					

**Table 2.2 Summary of rainfall statistics<sup>10</sup>**

A sustained rainfall event with peak intensity occurred over a 24 hour to 36 hour period. In the Wharfe catchment the most rainfall recorded over a 48 hour period was at Beckermonds. The highest return period was 58 years over a 24 hours duration at Thruscross and rainfall at Littondale and Grimwith was 75% to 100% of the December LTA. The combination of rainfall in the mid catchment and the total rainfall for the month reduced the storage capacity available in the catchment.



**Figure 2.2 Peak 48 hour rainfall 25th to 29th December 2015 as a percentage of December LTA**  
(Source: EA)

### 2.5 Radar Rainfall data

Data was available from Hyrad UKPP 1km 1hour accumulation radar in addition to TBR network. All of the data is copyright of the Meteorological Office<sup>10</sup>.

	Wharfe		
	Beckermonds	Grimwith Reservoir	Eccup
TBR (mm)	115.8	96.8	58.2
Radar (mm)	92.1	111.5	63.0
Difference (mm)	-23.7	14.7	4.8
% Difference	-20	15	8

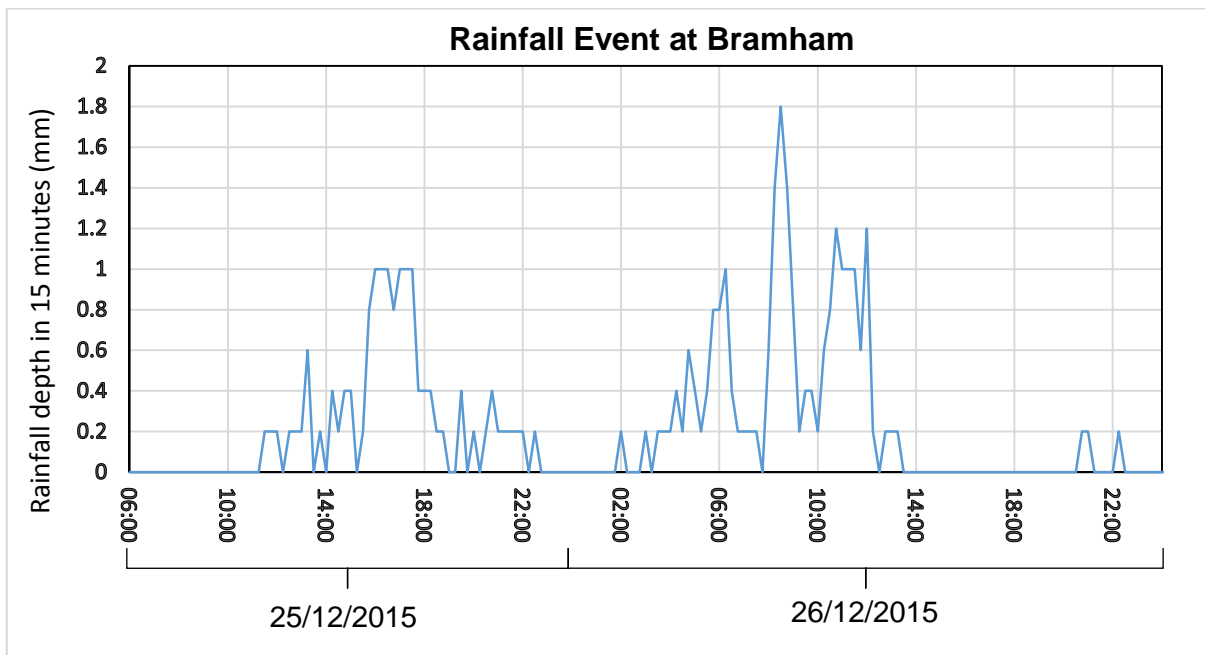
**Table 2.3 Comparison of Hyrad and TBR<sup>10</sup>**

Comparison of Hyrad and TBR data show reasonable correspondence between the two rainfall datasets. There is sufficient confidence to be able to use radar data as a guide to the finer scale distribution of rainfall during the event. This is important to help understand the scale of rainfall experienced where TBR sites are remote from flooded locations<sup>9</sup>.

YWSL has provided rainfall data in the Tadcaster area. This data shows that peak rainfall fell on Boxing Day producing a rainfall depth of 19.3mm in 9 hours, and a second lower peak on Christmas Day of 11.5mm in 6 hours.

Environment Agency tipping bucket rain gauge (TBR) rainfall data has been provided for Bramham. The rainfall data is illustrated in Figure 3.6. The data from the TBR shows two rainfall events, one on the 25<sup>th</sup> and the other on 26<sup>th</sup> of December 2015<sup>11</sup>. The rainfall event on the 25<sup>th</sup> started at 11:00 and finished at 23:00. The rainfall event on the 26<sup>th</sup> started at 02:00 and finished at 14:00 reaching a peak at 08:30.

Comparison of the data from Bramham with rainfall radar data from YWSL shows a good match with Bramham having a rainfall depth of 11.4mm on the 25<sup>th</sup> and 22.2mm on the 26<sup>th</sup> December. The two data sets show that although the rainfall duration at Tadcaster on Christmas Day was shorter than that at Bramham, the rainfall depths were similar. This illustrates the high rainfall intensity that was experienced at Tadcaster.



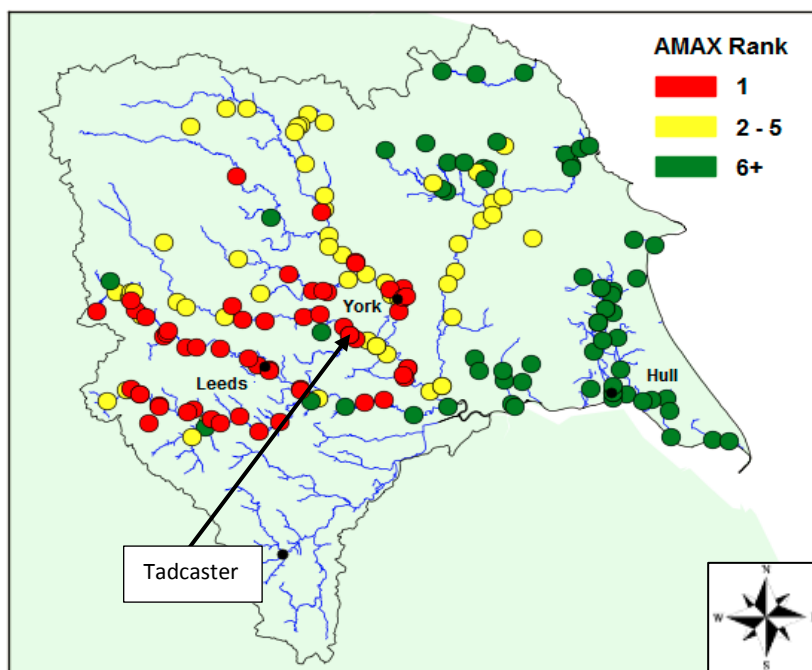
**Figure 2.3 TBR data for rainfall at Bramham**

<sup>11</sup> Hydrometric Data, Environment Agency

## 2.6 River Levels

Low flows dominated the late spring, summer and early autumn of 2015. Flows increased above normal in late November. Near continuous wet weather from November falling on already saturated ground ensured flows increased from “above normal” to “exceptionally high”. Immediately before Christmas day the Yorkshire Rivers were notably “high” or “exceptionally high”.

Peak river levels for this event are presented using an annual maximum (AMAX) rank order for EA gauging stations. The AMAX defines the highest peak value in each water year, which runs from October to September.



**Figure 2.4 AMAX rank, 25th to 29th December**

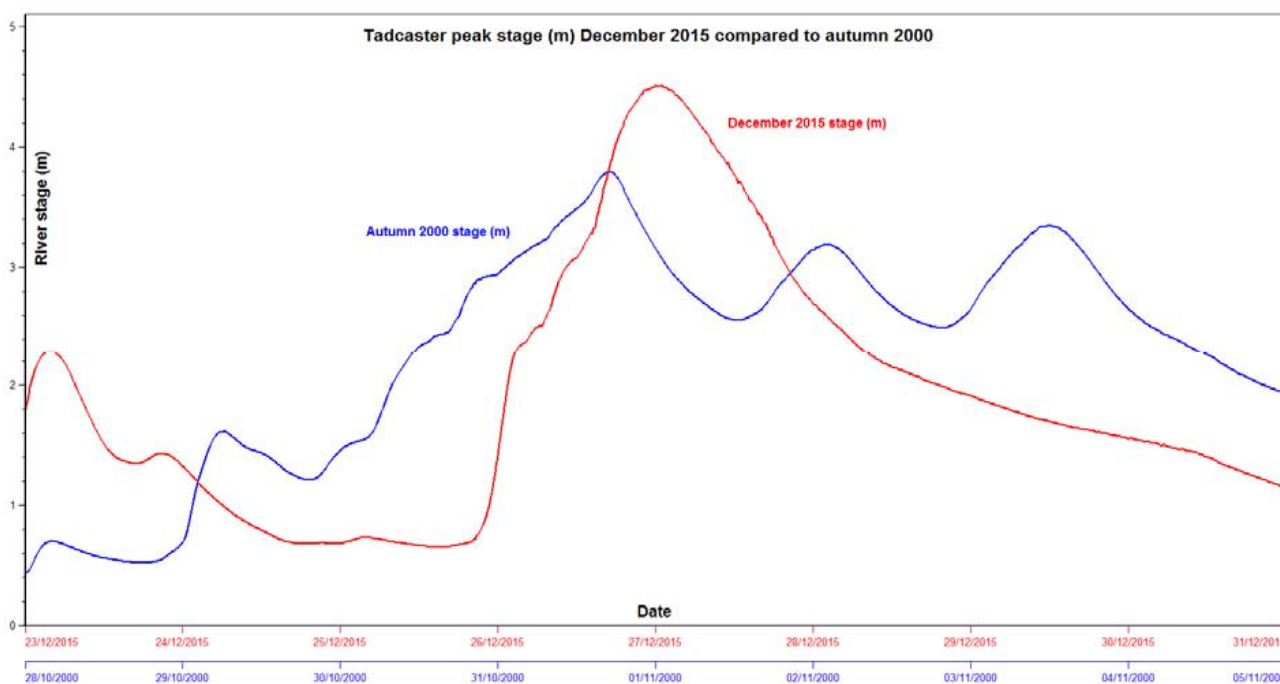
Figure 3.8 shows record peak levels along the west Pennine catchments, with near record peaks tracking northeast over North Yorkshire. The responses of the North Yorkshire Rivers (Wharfe, Nidd & Ure) was that river peaks occurred in the middle and lower reaches of their catchments<sup>9</sup>.



Catchment	Gauge name	Peak stage (m)	Time and Date		Rank (in record)	Record Length	Current or Previous highest	
Wharfe	Addingham	2.463	07:30	26 Dec	5	43	2.541	Jan 1982
Wharfe	Collingham	5.246	18:30	26 Dec	1	26	4.704	Autumn 2000
Wharfe	Tadcaster	<b>4.51</b>	<b>01:00</b>	<b>27 Dec</b>	1	27	3.79	Autumn 2000

**Table 2.4 AMAX level for key gauges on The Wharfe**

The severity of the December 2015 levels compared to the previous major event in autumn 2000 is demonstrated at the Tadcaster (Wharfe) flow gauge as shown in Figure 2.5. Water levels 0.7m higher than in autumn 2000 were recorded and the A659 Tadcaster Bridge was severely damaged. In addition the River Wharfe rose much faster at Tadcaster than in 2000<sup>9</sup>.

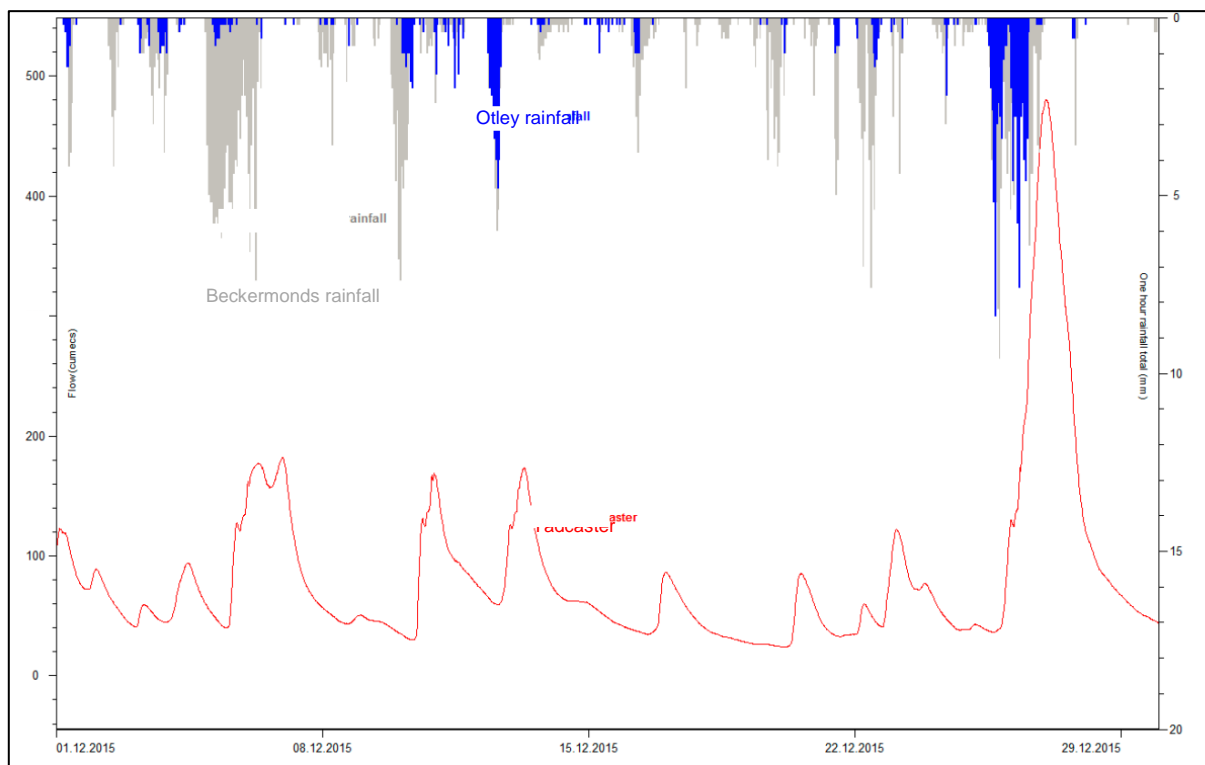


**Figure 2.5 Peak stage comparison for Tadcaster (Source: EA)**

## 2.7 River Response Wharfe catchments

The mid catchment rainfall on Boxing Day in the Wharfe catchment was proportionately more significant than that over the Pennines. The river levels in the mid and lower catchments were

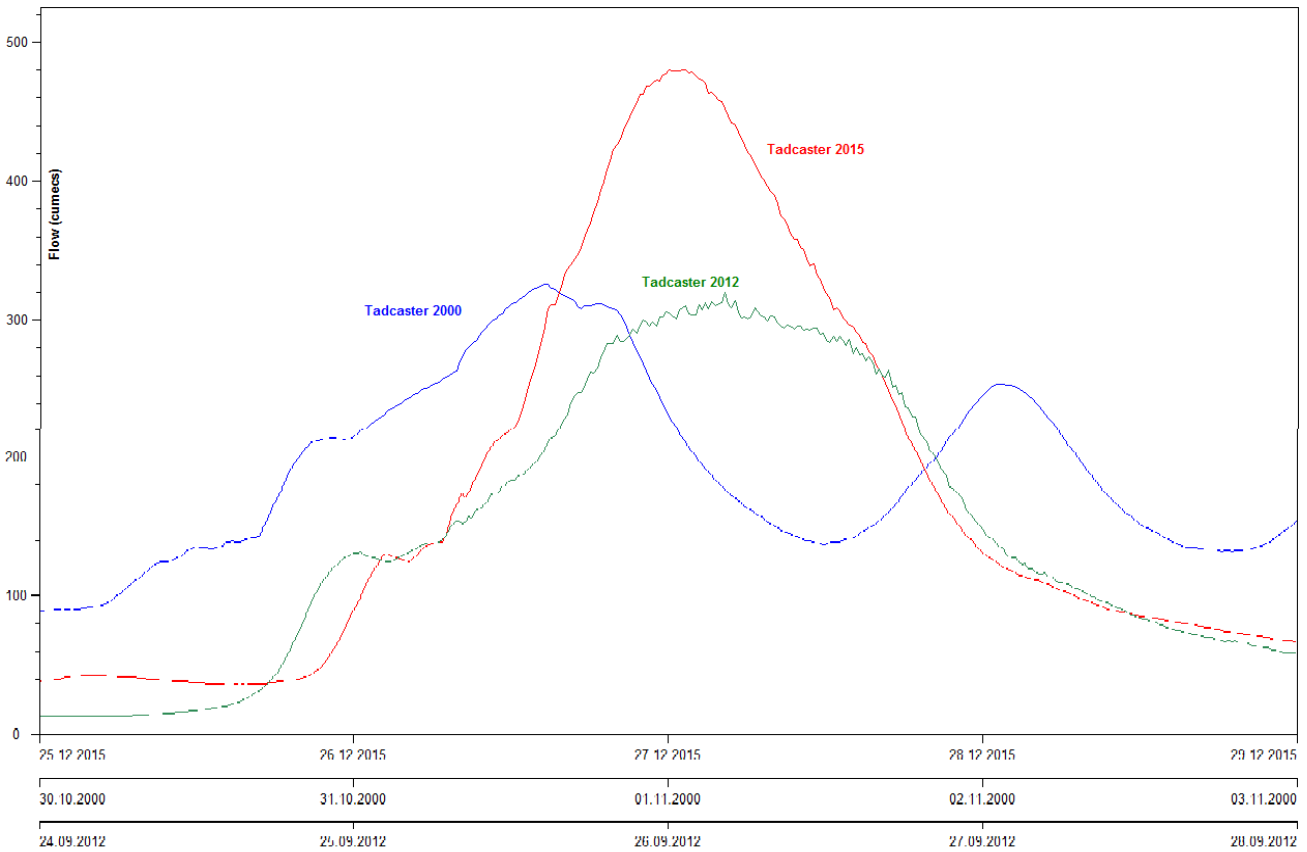
exceptional with the Wharfe catchments seeing some of their highest recorded levels. These high levels in the mid and lower catchments are likely to be as a result of peak flows from upstream coinciding with still intense rainfall and the capacity of the catchment to move water being exceeded<sup>9</sup>. On the Wharfe, mid catchment rain gauges at Grimwith, Thruscross and Otley recorded particularly intense rainfall. At Otley the average total December rainfall was recorded in one 36 hour period<sup>9</sup>.



**Figure 2.6 Wharfe at Tadcaster response to December rainfall (Source: EA)**

Figure 2.6 shows river flows at Tadcaster, rainfall response at the mid catchment rain gauge at Otley and the upper catchment rain gauge at Beckermonds during December<sup>9</sup>.

In December 2015 flow at Tadcaster increased more quickly than, and exceeded, past events. Figure 2.7 below shows a comparison of the flood events of 2000, 2012 and 2015 in Tadcaster. In 2015 the river rose faster, and to a higher level, than in previous flood events. This was due to a combination of intense rainfall, high flows arriving from upstream and the catchment being saturated.



**Figure 2.7 Wharfe at Tadcaster comparison of peak events**

## 2.8 River Flows & Return periods

River flows are measured in cubic metres per second (m<sup>3</sup>/s). Flow measurements become increasingly uncertain at higher flows, and hence can limit the number of sites for which flow frequency calculations can be made.

The EA has adapted a four category system to indicate accuracy of the sites. Based on these there are some sites whose flow measurements must be treated with caution.

Not applicable to high flows	Flow estimate has been extrapolated beyond the calibrated range for the gauge; or a site is not designed, or is unable to be used, to calculate high flows.
Rating review required to calculate flows	Rating is currently not able to be used to calculate flow for this event without further review.
Acceptable at high flows, with caution	Rating can be used to calculate high flows but may not be applicable or may need additional information for this event.
Good at high flows	Rating can be used to calculate flows for this event.

**Table 2.5 EA categories indicating accuracy of flow measurements**

River flow estimates have been made for sites where the flow estimates are considered significantly robust to determine using the Flood Estimation Handbook (FEH) methods. These estimated return periods are provided with comment regarding data quality in Table 2.6.

Gauge name	Peak stage (m)	Highest check gauging (m)	Rating equation status	Peak Flow (m <sup>3</sup> /s)	Comment
Flint Mill	3.743	2.47	Acceptable at high flows, with caution	582	Treat with caution. Large extrapolation of rating and there have been no high flows gauged for a number of years
Tadcaster	4.51	3.74	Ultrasonic, acceptable at high flows, with caution	480	Ultrasonic bypassed - flow peak is an estimate of flow measured through ultrasonic plus additional flow in floodplain

**Table 2.6 December 2015 flow and data quality<sup>9</sup>**

Although peak rainfall accumulation varied over the Yorkshire area, this rain fell onto saturated ground and into rivers that were already high. The subsequent peak flow return period estimates are considerably higher when compared to the rainfall return period estimates and illustrate the significant role of antecedent conditions in this event<sup>9</sup>.

Gauge Name	Peak Flow (m <sup>3</sup> /s)	Time and Date		Rank in record	Return period (years)
Addingham	386	07:30	26 Dec	4=	10 - 15
Flint Mill	582	20:00	26 Dec	1	100 +
Tadcaster	480	16:30	26 Dec	1	100

**Table 2.7 December 2015 Peak Flow return period estimates**

NYCC highways commissioned an assessment of the hydrology and hydraulics of the River Wharfe in order to assess the flow regime as part of the bridge reconstruction. As part of that assessment an estimate of the return period was made based on both historical and gauged data. This estimate gives

a return period in the broad range of 200 – 220 years. Another estimate has been produced by the National Hydrological Monitoring Programme, run by the Centre for Ecology & Hydrology and the British Hydrological Society. Their estimate, based on flows at Flint Mill upstream from Tadcaster, gives a return period in excess of 200 years.

## 2.9 Event Timeline

A timeline setting out the sequence of key events has been drawn together from local sources and the event logs of the emergency responders, and is presented over the page:



**Figure 2.8 Surface water ponding on Bridge St, 26/12/15 Source: Richard Rafferty**

<b>Thursday 24<sup>th</sup> December, Christmas Eve</b>		
11:00	Flood Advisory Service (FAS) teleconference	Teleconference to update Risk Management Authorities (RMA's) on developing situation across the region. Next meeting agreed for 11:00 on 26/12.
<b>Friday 25<sup>th</sup> December, Christmas Day</b>		
13:50	Flood alert received by Tadcaster Flood Action Group (TFAG)	TFAG commence monitoring of river levels in Tadcaster.
20:00	Sandbagging & door knocking	TFAG & volunteers commence sandbagging vulnerable properties, and knocking on doors to alert residents that there was a risk of imminent flooding.
<b>Saturday 26<sup>th</sup> December, Boxing Day</b>		
02:00	Sandbagging & monitoring	Deployment of sand bags in Tadcaster continued until 2am. TFAG maintain hourly checks through the night.
06:00	Surface water beginning to build up	Additional sand bags deployed.
07:34	RMA's receive "Red" Flood Guidance Statement (FGS)	The Flood Forecasting centre issue a "Red" FGS, meaning there is a high likelihood of serious flooding.
08:00	Operation "Tanner" commences	Police duty "Silver" commander notified of serious impact of flooding across the county, who assumes responsibility and commences the Police's operational response.
08:30	Fire Service assistance requested	Members of TFAG monitoring the situation notice water has almost reached the top of the road drains. Fire Service attend and deploy portable 3 inch pump.
09:11	North Yorkshire Local Resilience Forum (NYLRF) declare a "Critical" incident	RMA's and operational responders informed that there was now a "critical" incident in progress.
10:23	Decision taken to close Tadcaster Bridge	Police Duty "Silver" Commander receives information raising concerns for the structural integrity of the bridge, the decision to close it is taken.

11:00	Bridge St is closed to traffic	Water starts to spread across Bridge St. Police assisted by T FAG volunteers close the road.
11:40	Water continues to spread along Bridge St	By 11:40 water has reached the Tadcaster Business Centre.
12:00	NYLRF Tactical co-ordination group (TCG) convened	TCG convened in response to seriousness of flooding across the county, including concerns for Tadcaster bridge. TCG remains operational for the duration of the event.
12:30	Environment Agency (EA) deploy pump	The EA bring a large mobile pump to Tadcaster and are operating it by 12:30, to clear the standing water from Bridge St.
13:00	Additional sand bags deployed, and properties evacuated	Police evacuate Sainsburys and properties on Mill Lane. Additional sand bags deployed to Wharfe Bank Terrace, the Doctor's Surgery, Medical Centre and businesses on the east side of the river.
14:30	TCG "Silver" Command order closure of bridge	Bridge is closed, initially by the police blocking off before NYCC arrive to secure.
14:45	NYCC Highways close bridge	Safety fencing preventing pedestrians and vehicles from using the bridge is erected by 15:00.
16:30	Surface water clears	The surface water flooding on Bridge St has largely receded by 16:30, with a small area remaining outside number 9.
17:05	Further evacuations	Decision taken to evacuate properties in the vicinity of the bridge. Evacuations completed within an hour. Some residents decide to stay and their details are recorded.
17:20	River Wharfe floods Tadcaster	At around 17:20 the river rises above the level of the flood banks and begins to flood Tadcaster on both the east and west side of the river.
18:15	Mobile pump on Bridge St switched off	The EA pump on Bridge St is no longer effective as the street becomes inundated with flood water from the main river.
18:49	Flood levels continue to rise	Water now extends up Bridge St as far as The Angel public house.

19:01	Flood levels continue to rise	The flooding has now reached the crossroads by the NatWest bank. Water is now above the threshold of The Angel.
19:04	The Angel evacuated	The pub is now being flooded, and people are evacuated.
19:45	Flood levels continue to rise	Kirkgate is now impassable and the road is closed.
20:15	Horses rescued	Simon from Sam Smiths arrives to remove the brewery's horses, accompanied by the Police.
<b>Sunday, 27<sup>th</sup> December</b>		
00:53	Flood levels continue to rise	Flood water now extends as far as Costa Coffee and Sam Smith's offices.
01:30	TFAG & Police monitoring	TFAG and the Police monitor the flooding throughout the night. At 01:30 an inspection is made of St Mary's church.
02:00	TCG "Silver" command meet	Overnight meeting to co-ordinate evacuations and response across county.
08:00	TCG "Silver" command meet	Further meeting to co-ordinate cross county response.
09:00	Strategic co-ordinating group (SCG – "Gold" command) agree strategy	Cross county strategy agreed.
10:48	Flood levels in Tadcaster begin to recede	Levels start to fall back slowly. By 10:48 it has fallen back to the corner of NatWest and The Angel.
11:03	Fire Service in attendance	The Fire Service are in attendance at 11:03.
12:46	Water rescue equipment deployed	Water rescue equipment arrives to assist in evacuation of some residents who had stayed behind.
23:00	Flood levels gradually recede	Throughout the day flood levels gradually fall back. By 23:00 flood still extends as far as Barclays Bank on Bridge St.



<b>Monday, 28<sup>th</sup> December</b>		
00:01	Flood water continues to recede, damage assessments commence	TFAG and Police make inspections of properties through the night as flood water recedes.
01:49	Damage assessments on east side of river	Flood damage assessed on east side of river. TFAG inspect Sainsburys and The Swan public house.
07:00	Team Rubicon arrive in Tadcaster	Team Rubicon – ex-military disaster response volunteers – set up operations at “The Ark”. Engage in co-ordination of volunteers and donations of equipment, make risk assessments and commence building clearances.
08:20	Further assessments and clear up begins	Selby DC provide skips and waste lorries and the clear out of flood damaged properties begins. Clear up continues through the day.
13:30	Prime Minister briefed	Prime Minister briefed on the situation by local M.P. Nigel Adams during visit to Church Fenton.
<b>Tuesday, 29<sup>th</sup> December</b>		
10:00	Clean up operation in progress, Floods Minister makes inspection	Team Rubicon assist Selby DC, TFAG and local volunteers with clean up. Floods Minister Rory Stewart meets local volunteers and residents, announces immediate government aid.
15:00	Secretary of State makes inspection	Greg Clark, Secretary of State for Communities & Local Government & Nigel Adams M.P meet with local business owners and emergency responders.
16:57	Tadcaster bridge beginning to fail	TCG “Silver” command receive report from officer on the scene, of “water bubbling” from the bridge. Bridge has remained closed throughout the incident.
17:07	Further reports of issues with bridge	Police receive further reports that the bridge is beginning to collapse.
17:08	Decision taken to order further evacuations	Concerns about gas leaks on the partially collapsing bridge lead TCG “Silver” Command to order further evacuations.
17:20	SCG “Gold” Command informed of bridge collapse by TCG “Silver” Command	Presence of gas mains and cables across bridge identified.

17:27	TFAG contact emergency services	Town Emergency Plan is initiated and Riley Smith Hall opened. Police cordon set up to keep people away from the vicinity of the bridge.
17:30	National government informed of bridge collapse in Tadcaster	Cabinet Office Briefing Room (COBR) informed of collapsing bridge by SCG "Gold" Command.
17:47	"Severe" Flood Warning issued	At the request of SCG "Gold" Command a severe flood warning is issued, to inform people of imminent danger of the bridge collapse and associated gas leak.
18:00	TFAG informed by Police that bridge has collapsed	Area is cordoned off and under control of the Police.
18:41	SCG "Gold" Command contact TCG "Silver" Command	Progress report requested on status of evacuation and potential gas leak.
22:43	Further calls for information	Work continues through the night to understand the full implications of bridge collapse.
<b>Wednesday, 30<sup>th</sup> December</b>		
00:01	Further work on bridge	Work continues throughout the day to make the bridge safe and manage critical issues arising from its' collapse.
06:00	Clear up continues	TFAG, Team Rubicon and other volunteer groups continue clear up work with Selby DC, clearing debris and co-ordinating donations.
12:00	Further inspection by senior government & E.A. executives	Liz Truss, Secretary of State for the Environment, Food & Rural Affairs makes an inspection with Toby Willison, Executive Director of Operations at the E.A.
<b>Thursday, 31<sup>st</sup> December</b>		
09:30	SCG "Gold" Command stood down	All critical incidents cross county have been managed. The incident is over and recovery phase begins.

**Table 2.8: Event Timeline**

## 2.10 Flood Forecasting

The forecasting of increases in water level and hence the scale of flooding is determined by the Environment Agency by reference to weather forecasts, rainfall, river level and flow data in the river catchments.

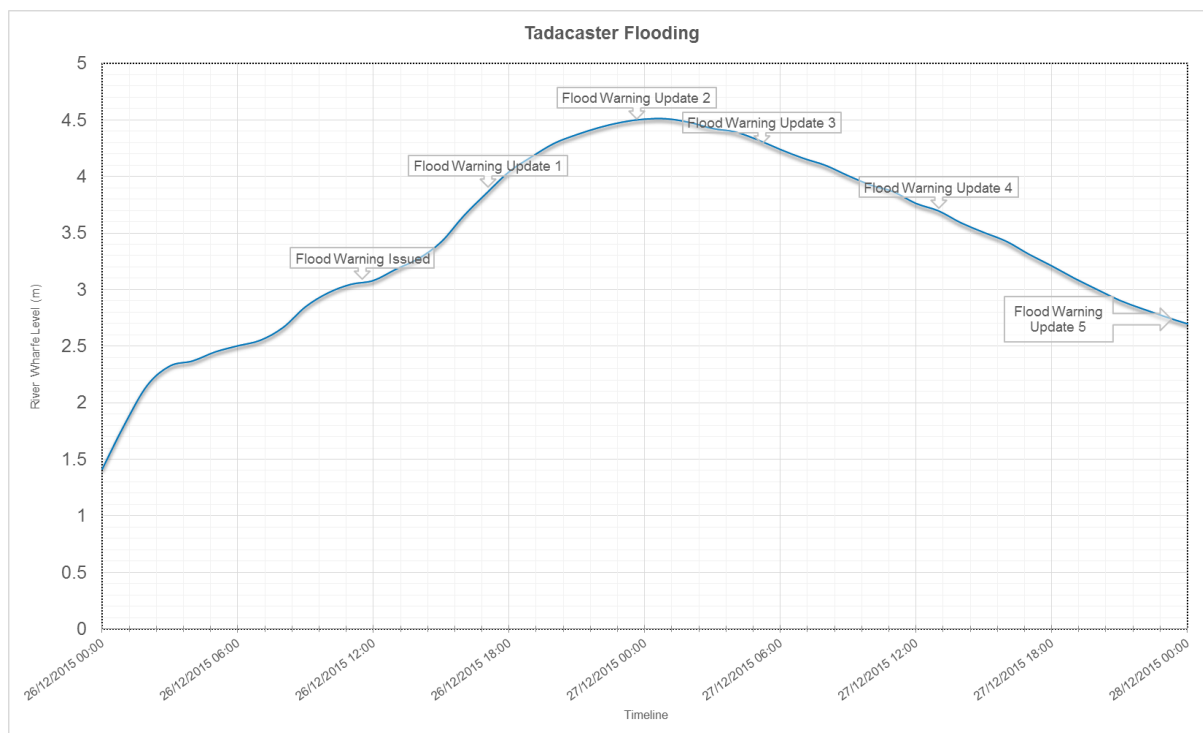
## 2.11 Flood Warnings

The Environment Agency has confirmed that a series of warnings and updates for Tadcaster were issued from Christmas Day onwards as described in Table 2.9 below.

Status of warning	Comments	Date	Time
Flood Alert	<p>A Flood Alert has been issued by the Environment Agency for the Tidal River Wharfe. Flooding is possible for The River Wharfe from Tadcaster to the confluence with the River Ouse including Cock Beck. Low lying land and roads will be affected first.</p> <p>This flood alert has been issued in response to forecast rain in the area from the 25th into the 26th December. We are issuing this earlier than normal so that people can be prepared as possible, as the catchment is already saturated and river levels remain sensitive to any significant rainfall. Our staff are monitoring the situation closely and this will continue throughout this period. Flood warnings will be issued if necessary.</p>	25/12/15	12:27
Flood Warning	A flood warning has been issued for the River Wharfe at Tadcaster. The current river level at Tadcaster is 3m and rising.	26/12/15	11:27
Flood Warning update (1)	A flood warning has been issued for the River Wharfe at Tadcaster. The current river level at Tadcaster is 3.86m and rising. Further rainfall this evening may see levels rise further. We will update this message as new forecast information becomes available. Please ensure that you keep up to date with the current situation for your area, further information is available on <a href="http://www.gov.uk/flood">www.gov.uk/flood</a> .	26/12/15	17:21
Flood Warning update (2)	<p>The flood warning for the River Wharfe at Tadcaster remains in force.</p> <p>The current river level at Tadcaster is 4.47m and will remain high throughout the night, we do not anticipate levels to rise much further.</p> <p>We will update this message as new forecast information becomes available.</p>	26/12/15	23:42
Flood Warning update (3)	<p>The flood warning for the River Wharfe at Tadcaster remains in force due to high river levels throughout the catchment in response to recent heavy rainfall.</p> <p>The current river level at Tadcaster is 4.3m and falling slowly.</p> <p>Our Incident Response teams are on 24 hour duty and we will update this message accordingly.</p>	27/12/15	05:11
Flood Warning update (4)	<p>The flood warning for the River Wharfe at Tadcaster remains in force.</p> <p>The current river level at Tadcaster is 3.7m and is continuing to fall slowly.</p> <p>No significant rainfall is forecast for the next couple of days.</p>	27/12/15	13:01

	Our Incident Response teams are on 24 hour duty and we will update this message accordingly.		
Flood Warning update (5)	The flood warning for the River Wharfe at Tadcaster remains in force.  The current river level at Tadcaster is 2.75m and is continuing to fall slowly.  No significant rainfall is forecast for the next couple of days.  Our Incident Response teams are on 24 hour duty and we will update this message accordingly.	27/12/15	23:18
Warning no longer in force		28/12/15	09:45
No Warning		29/12/15	10:07
Severe Flood Warning	This severe flood warning has been issued due to the structural failure of Tadcaster Bridge over the River Wharfe in Tadcaster.  Significant flooding is expected in the Tadcaster area. Those in this area are advised to evacuate immediately.  The situation is serious and there is a significant risk to life. Please follow the advice of the emergency services and officials in the area.  Part of the ancient bridge in the centre of the town collapsed into the River Wharfe this evening after it was closed amid safety concerns.	29/12/15	17:47

**Table 2.9 Summary of Flood Warnings for Tadcaster**



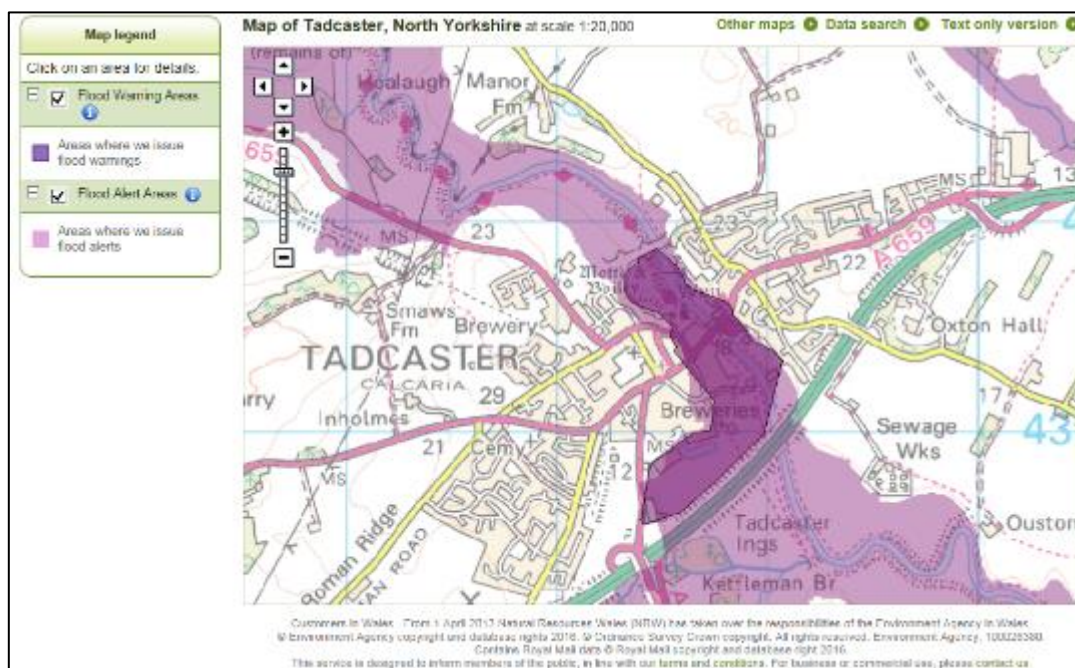
**Figure 2.10 Tadcaster flood warning against water level (source: EA)**

Figure 2.10 above shows when Flood Warnings and Updates were given out in relation to river levels. A Flood Alert for Tadcaster was issued at 12:27 on Christmas Day. Members of the public signed up to the flood warning service would not normally receive or rely on Flood Alerts, but the alert was picked up by professional partners and the Tadcaster Flood Action Group. The first Flood Warning was issued at 11:27 the following day, 26<sup>th</sup> December. Flood Warnings are issued to members of the public who are signed up to the service for a particular area, when property is expected to flood and people need to take action.

Following the first warning, information was updated regularly on the EA's website and for people calling in to the Flood Line. The first Flood Warning Update was sent out at 17:21 on the 26<sup>th</sup> December giving further information to people who were signed up for the service. At the time of the first update the river was at about 3.86m and beginning to come over the flood banks. The 2nd flood warning update was issued at 23:42 on Boxing Day, when the river was at a level of approximately 4.45m and well over the level of the town's defences.

Further updates were issued, at 23:42 on the 26<sup>th</sup> December and over the course of the following day as the river remained in flood. The Flood Warning was no longer in force at 09:45 on the 28<sup>th</sup> December.

At 17:47 on the 29<sup>th</sup> December, a Severe Flood Warning was issued at the request of "Gold" Command to warn people of the imminent risk of the bridge collapsing and associated gas leak.



**Figure 2.11 Flood warning zones for Tadcaster (Source: Environment Agency)**

The EA reported that within the Tadcaster Flood warning area there are 72 properties registered and 70 of these were successfully contacted. The two properties that could not be contacted successfully had not updated their current contact details after a change of phone number or email address.

The EA also report that their incident room opened on Christmas Day and remained open until the 12<sup>th</sup> January 2016. From the 25<sup>th</sup> to 27<sup>th</sup> December there were 124 staff working round the clock to respond to further flooding and keep the public informed. During that period the Incident Room issued 77 alerts and warnings across North Yorkshire, via 161 messages to 8742 properties.

## **2.12 Severe Flood Warning**

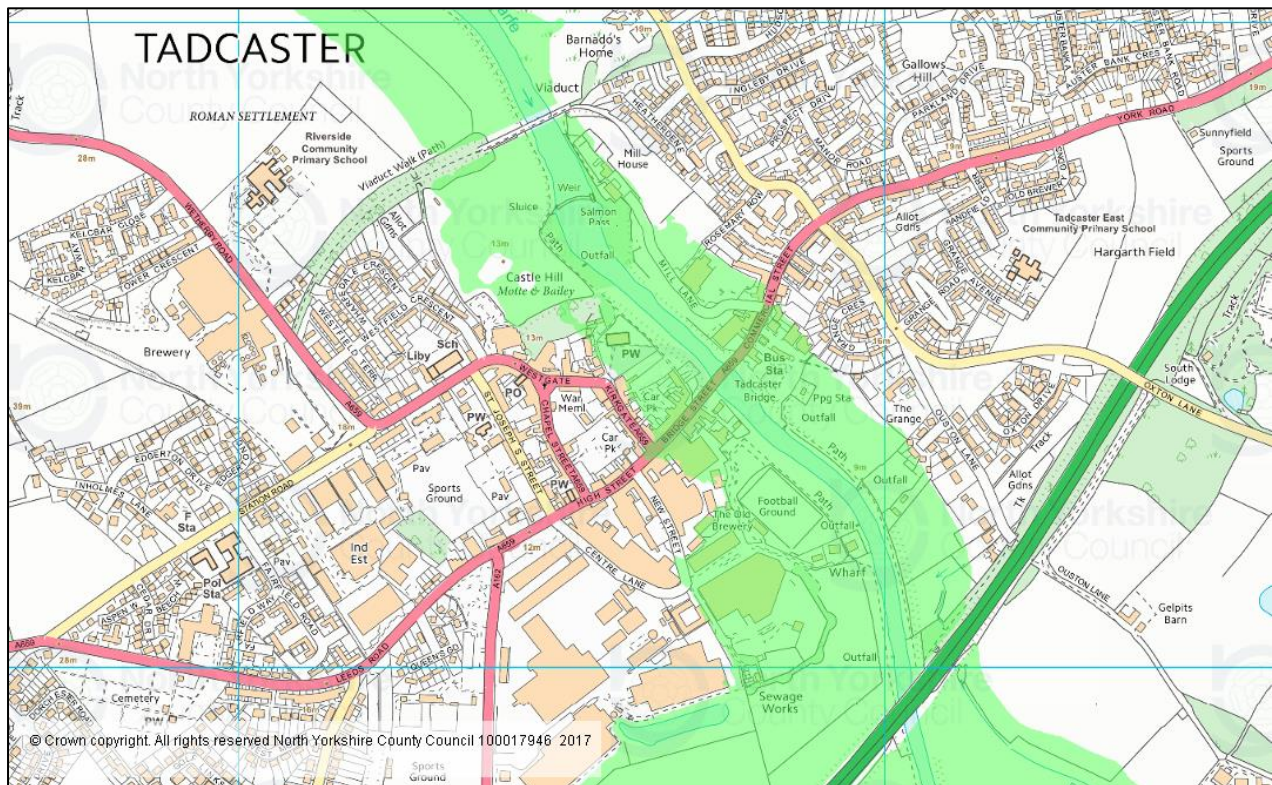
The severe flood warning sent out at 17:47 on the 29<sup>th</sup> December was issued at the request of the Gold Command. The method was used because it was an established warning system that covered the areas of Tadcaster that needed to be informed about the anticipated collapse of the bridge and gas leak associated with it. Although it was titled a Severe Flood Warning the enclosed text clearly set out the situation unfolding in the town, the potential consequences and the need for evacuation, as shown in Table 3.7 on the previous page.

## **2.13 Summary of Flooded Locations**

A total of 79 residential and commercial properties were flooded in Tadcaster. Included within this list are a Health Centre, a Doctors surgery and St Mary's Church. The following list shows the street names that were affected:

- Wharfe Bank Terrace
- Bridge Street
- Commercial Street
- Crab Garth
- Mill Lane
- Wharfe Bank
- Beech Close
- Church Street
- High Street

The extent of the flooded area through Tadcaster is shown shaded green, below in figure 2.12.



**Figure 2.12 extent of flood through Tadcaster (Source: NYCC/EA)**

## 2.14 Emergency Response

The organisations that attended Tadcaster during the flooding, the clean-up or during the collapse of the bridge included:

- Tadcaster Flood Action Group
- Tadcaster Town Council
- Selby District Council
- NYCC – Highways and Bridges
- NYCC – Emergency Planners
- North Yorkshire Police
- North Yorkshire Fire & Rescue
- The Environment Agency
- Team Rubicon
- Serve On
- British Gas
- Military

## 2.15 Flood Defences

Over time, there has been some minor settlement of the defences from their designed levels. This amounts to a few centimetres on the sheet piled wall on the left bank, and a few millimetres of the earth embankment on the right bank<sup>12</sup>. It should be noted that the flood levels experienced in Tadcaster were nearly 0.7m higher than the level of the flood defences and there is no suggestion that this settlement contributed to the scale or duration of the flooding. At the time of the flooding, the town's defences were part way through a programme of refurbishment to bring them back up to their designed levels. No significant defects to the town's flood defence assets had been reported prior to the flooding, and no significant damage to them was observed after the event.

## 2.16 Tadcaster and Ulleskelf Bridges

Concerns have been raised that the condition of the main Tadcaster Bridge contributed to the extent and depth of flooding experienced in Tadcaster, because 6 of the 9 arches on the bridge had become either fully or partially blocked over the years. A report prepared for North Yorkshire County Council's (NYCC) Bridges & Design Services indicates that had bed levels been lowered in the partially blocked arches to allow more flow through, the impact on flood levels and velocity through the bridge would have been negligible<sup>13</sup>. This is because the water level downstream of the bridge, and not the bridge itself, was the main factor governing water levels upstream. For the exercise, a computer model of the bridge was constructed, and a simulation was run with both the existing state of the arches and a hypothetical scenario where the 2 arches either side of the 3 clear arches were cleared to the lowest currently existing level. From the report:

*"Changes to arches*

*The bed levels in opening 2 and 6 were lowered so that the opening of each of the arches was increased (Figure 4-10). For each archway the bed level was lowered to match the lowest bed level in the existing situation, providing a realistic estimate of what may be achievable with bed lowering.*

*Lowering the arches led to no difference in the modelled water levels or velocity through the bridge. This is because the water levels upstream of the bridge are largely controlled by those downstream of the bridge (modelled headloss across the structure around 0.20m for the Boxing Day flood)."*<sup>13</sup>

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<sup>12</sup> Environment Agency, Asset Information Management System data

<sup>13</sup> JBA Tadcaster Bridge, Hydrology & Hydraulic Report, June 2016



The York to Leeds railway flood relief culverts, 5km downstream at Ulleskelf, had some maintenance work carried out in 2014, principally re-lining of the flood relief and Dorts Dyke culverts. The work had consent from the IDB for the Dorts Dyke and adjacent culverts but progressed without the formal consent of the Environment Agency being in place. Network Rail carried out a modelling exercise to determine the effects of the works. As a result of this modelling, a very minor increase in flood risk locally in Ulleskelf was identified. Network Rail initiated a scheme to rectify the situation. The proposed solution was still being developed at the time of the flood, but has now been implemented. The severity of the flooding which occurred on Boxing Day 2015 was such that any increase in flood level at Tadcaster due to the re-lined flood relief culverts at the bridge at Ulleskelf would have been insignificant. In response to NYCC's request for information about the potential effect of the bridge works at Ulleskelf on the flood in Tadcaster, the Environment Agency gave the following statement:

*“On discovery of unconsented works to line flood flow culverts under the East Coast Mainline at Ulleskelf, the Environment Agency requested Network Rail to carry out modelling to quantify the perceived impacts on flood risk. This modelling confirmed a small increased local flood risk to Ulleskelf (West End) on a scale of millimetres and appropriate actions were taken by the Agency to ensure that this was remedied. The remedial works were carried out after the 2015 Boxing Day flood event. However, the Agency does not believe that the situation at Ulleskelf made any significant or measureable contribution to flooding extent or severity at Tadcaster in 2015 due to the small scale of local impact, the 5km distance upstream to Tadcaster and the scale of the flood event in question.”<sup>14</sup>*

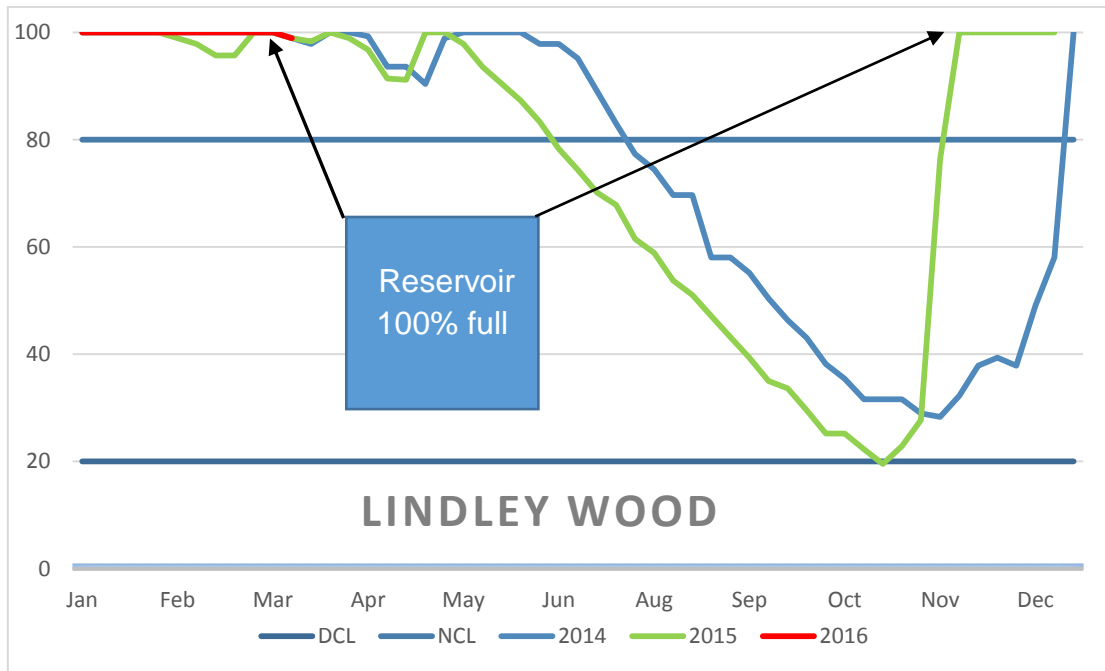
## 2.17 Reservoir Operation

There have been claims that YWSL released additional flows to the River Washburn from their reservoirs on the Washburn Valley, and this contributed to the speed with which the river rose and the scale of the flooding. YWSL has confirmed that it did not operate the reservoirs to release water during the flood event. The reservoirs were already full due to the exceptionally wet two months leading up to Boxing Day 2015 and were overtopping via their fixed spillways, in accordance with reservoir safety requirements, from the point at which they were full in early November. Records from

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<sup>14</sup> Environment Agency response to NYCC request for further information on the effect of culvert re-lining

YWSL show how all the Washburn Reservoirs were full by mid November 2015, and were still full through to March 2016, as can be seen in Figure 2.13 below.



**Figure 2.13 Historic reservoir levels at Lindley Wood (source: YWSL)**

Rainfall runoff in the Washburn catchment would have passed through the reservoirs, with some degree of attenuation, before contributing to the flows in the River Washburn and onwards into the River Wharfe. It should be noted that the Washburn sub-catchment forms only a small proportion of the overall catchment of the River Wharfe.

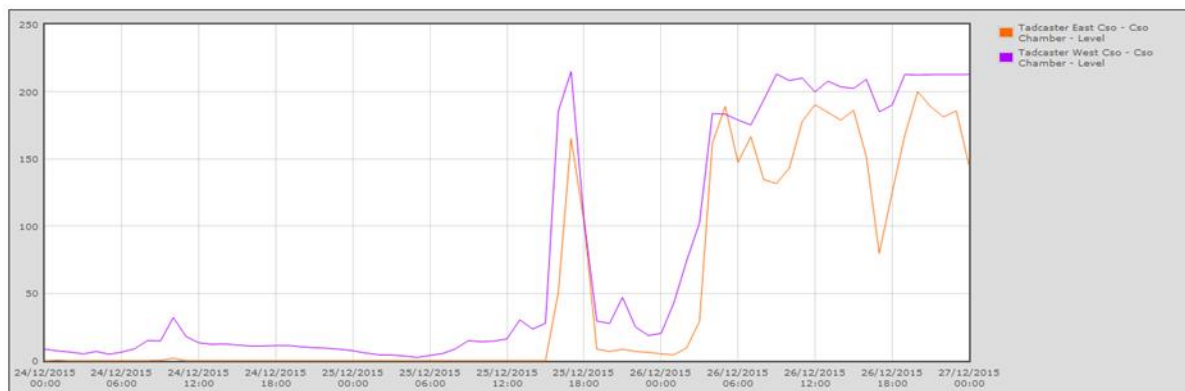
### 2.18 Highways Gullies

As described above, the ponding of water in the road at Bridge Street and Commercial Street indicated that the Highway gullies did not have sufficient capacity or a free outlet to enable them to drain rain water from the road.

### 2.19 Public Sewers

During the course of the flood event the three Combined Sewer Overflows (CSOs) and the pumping station continued to operate. Records provided by YWSL show during this period their systems became inundated either by rainfall or river water and remained at high level until water levels had

dropped. Telemetry for the Britannia Sewage Pump Station (SPS) overflow (CSO) for this time is not available. It has been reported that the overflow from the SPS would have been active due to the conditions, and SPS telemetry is showing the wet well and storm tanks to be full.



**Figure 2.14 Graphs showing CSO levels from YWSL**

Telemetry shows the pumping station becoming inundated with flow as levels start to increase from the 26th onwards. The Brewery SPS was reported to have flow inundation on the foul only line.

Over the Christmas period Britannia SPS was inundated with flood water and temporarily lost power. Once flood waters receded YWSL attended site with a generator and got the SPS operational until full power was restored by the power company. Since the event, YWSL have reviewed their Vulnerable Asset Plans and invested £4M in new mobile pumps and temporary defences.

### **3 Risk Management Functions carried out during the flood event**

#### **3.1 RMA Responsibilities**

##### **3.1.1 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 has developed a National Flood and Coastal Erosion Risk Management Strategy for England – ‘Understanding the Risks, Empowering Communities, Building Resilience.’

This national strategy outlines the EA's strategic functions as:

- Ensuring that flood risk management plans (FRMPs) are in place and are monitored to assess progress. The plans will set out high-level current and future risk management measures across the catchment.
- Publishing and regularly updating its programme for implementing new risk management schemes and maintaining existing assets.
- Supporting Risk Management Authorities' understanding of local flood risk by commissioning studies and sharing information and data.
- Supporting the development of local plans and ensuring their consistency with strategic plans.
- Managing and supporting Regional Flood and Coastal Committees and allocating funding.

The EA's operational functions are/include:

- Risk-based management of flooding from main rivers including permissive powers to do works including building flood defences.
- Regulation of works in main rivers through the consenting process.
- Regulation of reservoirs with a capacity exceeding 10,000m<sup>3</sup>.
- Working with the Met Office to provide severe weather warnings – available to Risk Management Authorities.
- Provide warning of flooding on main rivers.
- The maintenance and operational management of main river assets including flood defences.
- Statutory consultation to the development planning process.
- The power to serve notice on any person or body requiring them to carry out necessary works to maintain the flow in main rivers.

'Main Rivers' are defined through an agreed map which is updated annually. These tend to be the larger rivers in the country, though some smaller watercourses in sensitive locations are also defined as 'Main Rivers'.

The EA are also category 1 responders regarding flood risk (Civil Contingencies Act 2004). They are required to warn and inform of flood risk.

### 3.1.2 Water Company

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.

### 3.1.3 North Yorkshire County Council (NYCC)

NYCC, as Lead Local Flood Authority, has flood risk management functions which include (but are not limited to);

- Provision of a Local Flood Risk Management Strategy (LFRMS).
- Designation and maintenance of a register of structures or features that have a significant effect on flood risk.
- 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.

Roadside gullies are subject to routine maintenance in accordance with the NYCC Highway Asset Management Plan. The frequency of cleaning is dependent on an evidence based categorisation of risk, determined by factors relating to the consequence of failure and a range of other operational factors. NYCC are investigating drainage improvements in critical locations with a history of flooding.

### **3.1.4 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 centres 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 Planning Unit provides support to the District Council.

### **3.1.5 Internal Drainage Board**

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.

### **3.1.6 All Risk Management Authorities**

All RMAs under the Flood and Water Management Act (2010) have a responsibility to cooperate and coordinate with regards to their flood risk management functions, including raising awareness of flood risk and the sharing of information.

### 3.1.7 Riparian Owners

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.
- 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>

## 3.2 Actions and Responses to December Floods

All risk management authorities involved have undertaken appropriate actions in response to the floods:

### 3.2.1 North Yorkshire County Council as Lead Local Flood Authority

The Flood Risk Management (FRM) Team provides an overarching view on flood risk management activities within the county. The FRM team has undertaken the following activities:

- Supported the residents in Tadcaster in obtaining Flood Resilience Grants.
- Local area officers have coordinated with other Risk Management Authorities to investigate the flooding that occurred in Tadcaster.
- Initiated investigations into the surface water flooding which has affected the Bridge St area.
- Surveyed the surface water sewer.

- Engaged with EA, YWSL and the local community to adopt a multi-agency response to flooding in Tadcaster.
- Investigations into the potential for making improvements to the surface water drainage system are ongoing.

### **3.2.2 North Yorkshire County Council as Emergency Planning Authority**

North Yorkshire County Council emergency planning unit is responsible for preparing communities for emergencies including flood events. Since December 2015 NYCC Emergency Planning unit has worked with the community to:

- Establish a community emergency plan.
- Create a pump plan, to support the deployment of the 2 pumps gifted to the community by Heineken and the Tadcaster Freemasons.
- Provided advice, guidance and support for promoting resilience to businesses and residents in Tadcaster.
- Worked closely with the town to assist in the recovery process.
- Supported the community flood fair.

### **3.2.3 North Yorkshire County Council as Highway Authority**

The Highway Authority carries out regular maintenance of the highway drainage system. NYCC highway authority has undertaken the following activities;

- Undertaken maintenance activities such as jetting and repair of gully pots post flood event in Tadcaster.
- Monitoring and inspection of Tadcaster A659 bridge to assess structural integrity.
- Carried out a historical assessment, to understand the bridge's heritage and method of construction.
- Undertaken a hydrological and hydraulic assessment of the River Wharfe through Tadcaster.
- Engaged with the community through public meetings and attending the Tadcaster Flood Fair.
- Installed a temporary pedestrian bridge which was opened within 7 weeks of the main bridge collapsing, and maintained it until the main bridge re-opened in February 2017.
- Installed a temporary pedestrian route across the viaduct while the temporary bridge was under construction.
- Provided a free shuttle bus service to transport people from one side of the town to the other.
- Developed and delivered a community engagement strategy to ensure that residents and businesses were kept fully informed while the bridge was being repaired.



- Secured an additional £1.4M to fund improvements to the bridge, alongside the £3M provided by Government for the basic repairs.
- Works have been undertaken to underpin the bridge structure. The bridge has been reconstructed and widened to improve the space for vehicles and increase safety for pedestrians. The bridge reopened in February 2017.



*Figure 3.0 Temporary Footbridge*

### **3.2.4 The Environment Agency**

The EA will continue with their program of inspections and maintenance of flood defences around Tadcaster. The Environment Agency has undertaken the following activities:

- Provided flood warnings and updates prior to, and during the flood.
- Deployed a large mobile pump, and monitored flood defences during the flood.
- Carried out a Hydrological assessment of all the Flooding in Yorkshire in December 2015.
- Produced a mapped outline of the flood.
- Reviewed their hydraulic model of the River Wharfe.
- Reviewed and updated where necessary the triggers for flood warnings for communities upstream of Tadcaster.
- Is investigating options for flood alleviation in Tadcaster and the Lower Wharfe villages with a view to securing funds for future schemes.

- Commenced a review of the Lower Wharfe washlands and flood storage areas, with a view to optimising their operation.
- Advised and granted permission for NYCC to carryout repairs and strengthening works on Tadcaster Bridge and install a temporary footbridge to re-connect the town.
- Made regular contact with the team carrying out the works and adopted a pragmatic approach to permitting.
- Provided regulatory support to NYCC with their works to return Tadcaster Bridge to service.
- Met regularly with professional partners to better understand flood risk on the River Wharfe and seek opportunities to work together.
- Engaged with the community, through attendance at the TFAG organised flood fair, through writing the “Wharfe – Keeping you Informed” document and other activities.
- Worked with TFAG to provide a river level gauge.

### **3.2.5 Yorkshire Water Services Ltd**

YWSL has undertaken the following activities:

- Brought in a generator to provide temporary electrical power to Britannia SPS during the flood.
- Refurbishment of the electrical panels and pumps at Britannia SPS after the event.
- Jetting of the combined and surface water sewers in the areas of Tadcaster that had been flooded.
- Carried out checks to the flap valves on the surface water sewer.
- Carried out routine maintenance work of combined, surface water, siphon and CSO outfall.
- Engaged with NYCC, EA and TFAG to explain the operation of the Washburn Valley Reservoirs and have provided historic records and data to demonstrate that they were all full, that no additional releases of water were made and that they were all overflowing before Christmas Day.
- Supported TFAG by providing a stand at the Flood Fair.
- Across Yorkshire, YWSL has invested £4M in new mobile pumps and temporary flood defences that can be deployed to protect assets such as pumping stations.
- Reviewed and updated Vulnerable Asset Plans.
- Have commenced work on an Integrated Catchment Model of Tadcaster’s drainage system, which will increase RMA’s understanding of flood risk in the town and support investment case development.

### 3.2.6 Selby District Council

Selby District Council has undertaken the following activities:

- Supplied sandbags prior to the flood.
- Provided flood clean up grants to affected properties.
- Sent affected households clean up packs.
- Facilitated a substantial post flood clear up, by providing skips and bin lorries – with operatives volunteering over an extended period of time – diverting collection crews whilst maintaining service performance across the rest of the District.
- Provided financial support, by implementing a Council Tax and Business Rate rebate scheme for affected properties.
- Supported TFAG to develop the Community Emergency Action Plan, by providing local storage facilities.
- Assisted businesses, in particular food businesses by giving hygiene and sanitisation advice through Environmental Health Officers.
- Provided car parking and storage facilities for contractors rebuilding the bridge and building the temporary footbridge.

### 3.2.7 Tadcaster Flood Action Group

The Tadcaster Flood Action Group has undertaken the following activities:

- Organised a Flood Fair to raise awareness and improve resilience in the town.
- Acquired pumps for the east and west of Tadcaster and developed pumping plans for their use.
- Installed a digital camera to enable remote monitoring of river levels.
- Acquired and arranged local storage of materials to help the community in the event of another flood.
- Developed a Community Emergency Action Plan.
- Carried out a post flooding insurance survey.
- Ongoing liaison with Risk Management Authorities.
- Preparation of flood prevention packs for distribution to ground floor properties that flooded in December 2015.
- Seeking approval for implementing water safety management on the Wharfe. Proposing to place life buoys on galvanised posts near the banks.

### **3.2.8 National Government**

The scale of the flooding across the whole of the north of England led to a number of responses from the Government:

- Provided local authorities with funding to provide emergency grants of £500 per household, for emergency accommodation and clean up.
- Through local authorities, made grants of £5,000 per household available to improve flood resistance and resilience.
- Provided additional funding equivalent to £2,500 per business affected to local authorities.
- Suspended Council Tax and Business Rates for affected properties.
- Made the bridge reconstruction a National Priority Project, and immediately allocated £3M for the project.

## **4 Conclusions & Recommendations**

### **4.1.1 Conclusions**

#### **4.1.2 Cause of Flooding**

The serious flooding experienced in Tadcaster in December 2015 was a result of a pulse of heavy rainfall in the mid catchment which coincided with a flood peak coming downstream from the upper catchment. The rain fell on to ground which was already saturated, causing the Wharfe to rise rapidly and to a higher level than has been recorded previously. Estimates of the return period for the flood event in Tadcaster range from 100 – 220 years.

#### **4.1.3 Flood Defences**

The level of the flood defences in Tadcaster was not sufficient to contain the volume of water which came through the town in the flood. The river rose to a level approximately 0.7m over that of the defence's height. The defences performed their function, their condition and the minor settlement they have experienced were not a factor in the extent and depth of the flooding. The standard of protection they afford is low with an estimated 25-30 year return period.

#### **4.1.4 Surface Water**

Initial surface water flooding on Bridge St was caused by the inability of the drainage and sewer network to cope with the volume of rain which fell on the town. Rising river levels reduced the ability of the network to discharge through the outfall by the bridge. Investigations into the network's capacity and performance are ongoing.

#### **4.1.5 Reservoir Operation**

Investigations by YWS and the EA show that the operation of the Washburn reservoirs had no impact on the flooding in Tadcaster on Boxing Day 2015, or that they could be operated in such a way as to be a factor.

#### **4.1.6 Reservoir Storage**

It has been suggested that the reservoirs could be operated in such a way as to provide a greater degree of protection from flooding. It should be noted that the successive nature of the rainfall events which preceded the floods gave little opportunity to do this. Furthermore the small percentage of the catchment which passes through the reservoir system and their distance upstream from Tadcaster limits the scope of the reservoirs to provide flood protection. A national screening exercise has been undertaken to review the potential of reservoirs across the country to provide flood protection, and the Washburn Valley Reservoirs have been discounted.

#### **4.1.7 Effect of the Bridges on Flood Levels**

Flood levels in Tadcaster were not significantly influenced by the partial blockage of some of the arches on the bridge. The main factor controlling the water level upstream of the bridge was the water level downstream of the bridge. The flood was so significant that the bridge was effectively "drowned out" – even if the bridge was not there, the extent, duration and depth of flooding in Tadcaster would have been almost the same as which occurred. The culvert relining works on the railway bridge at Ulleskelf had a negligible effect also.

#### **4.1.8 Flood Warnings**

The rainfall which caused the flooding fell predominantly over the mid-catchment, meaning there was less time to issue the first Flood Warning than usual for Tadcaster. There were still 6 hours between the first Flood Warning and the river starting to flood in the town. This would normally be sufficient for people to make preparations though it should be noted that some people may have been unable to react to the Flood Warning, because the event occurred over the Christmas period. The Environment Agency has already initiated a review of warnings and trigger levels.

### **4.2 Recommendations**

#### **4.2.1 Improved Defences**

An improved system of flood defences in Tadcaster is a priority for the town. The current level of protection is low and whilst the rainfall preceding the flood was unusual, the risk of a repeat event remains. The Environment Agency are continuing the work to prepare a bid for funding for an improved flood defence scheme. If the bid is successful all authorities, interested parties, local businesses and the community will need to co-operate to secure any additional funds required, in order to provide the highest achievable standard of protection for a scheme acceptable to the community.

#### **4.2.2 Resilience**

Resilience and the ability to recover quickly from flooding will continue to play an important role in Tadcaster. There has been a strong uptake of the grant scheme but no doubt more can be done. NYCC, YWSL, the EA and TFAG should work together to review the current level of resilience and identify opportunities for improvement.

#### **4.2.3 Drainage**

There are no practical drainage arrangements that could cope with a main river flood of the magnitude seen in 2015. However, NYCC and YWSL should continue to investigate options for improvements which could mitigate against more frequent surface water flood events. It is vital that the existing drainage infrastructure performs as well as it can. NYCC & YWSL should continue to regularly inspect and maintain the highway and public sewer systems, and the EA continue their programme of inspections along the main river. Particular attention should be

paid to the condition of the various outfalls into the river, and the relevant responsible parties notified of any blockages or impediments to their operation.

#### **4.2.4 Community Preparedness**

It is important that Tadcaster maintains a level of awareness and preparedness. TFAG can play a vital role in achieving this and NYCC, the EA & YWSL should continue to offer practical and financial support to this effect.

## **5 Progress**

Progress has been made in the period since the flooding, and it is heartening to see the degree of commitment and involvement from the community. All risk management authorities have undertaken appropriate actions in response to the floods: Selby District Council were active in response to the floods and the subsequent clear up. The EA has reviewed and updated their flood warning triggers where appropriate; are preparing a bid for funding for an improved flood defence scheme and are reviewing how the Lower Wharfe Washlands and flood storage areas operate. The EA has overseen a national screening programme to examine which reservoirs have the potential to provide flood attenuation, concluding that the Washburn valley reservoirs are too far upstream to provide any significant benefit. The EA are also producing a revised model of the Lower Wharfe. NYCC has rebuilt and made improvements to the bridge using funding from Department for Transport and the York, North Yorkshire and East Riding LEP totalling £4.4m. NYCC administered the Government's Resilience and Resistance grant scheme, uptake of which has been strong in the area - to date over £130,000 has been spent on individual property level protection measures in and around Tadcaster. YWSL has cleared, maintained and repaired assets and are engaged in ongoing work to investigate the potential for improvements. Heineken and the Tadcaster Freemasons have kindly donated pumps to the community, and there are new and improved pump and emergency plans in place. Tadcaster Flood Action Group has been instrumental in improving awareness and resilience and has procured a digital camera to monitor water levels which anyone can view. TFAG has also been instrumental in the development of the community emergency plan; through the preparation of flood packs for vulnerable properties and by organising events and disseminating information. It is undoubtedly true that Tadcaster is better prepared for flooding through the actions and activities of TFAG.

In the wider catchment, a new Wharfe Flood Partnership has been set up, which all risk management authorities are participating in to co-ordinate Flood Risk Management activities

throughout the catchment. Many thousands of trees have been planted in the Upper Wharfe Catchment, and research is ongoing to determine the efficacy of this approach.

NYCC would like to place on record our appreciation and thanks, to all the organisations and their staff who helped to manage the flood response and subsequent recovery. More importantly we pay tribute to the volunteer groups and the un-sung heroes in the community, who stepped forward both in the flood itself and throughout the subsequent period. The spirit, effort and resolve shown by the community and people of Tadcaster are truly the pride of Yorkshire. It is incumbent on all authorities to work together, to harness this energy and help make Tadcaster the showcase for Yorkshire it can be.



**Figure 3.1 Re-opening of Tadcaster Bridge**