# FLOOD INVESTIGATION REPORT

**Under Section 19 of the Flood and Water Management Act 2010**

## South East Leeds

**8th & 10th August 2014**

**Prepared by**

**Flood Risk Management Team**

**City Development Directorate**

**Leeds City Council**

**July 2015**

**IMPORTANT NOTICE**

This report does not constitute and should NOT be regarded as an acceptance of any legal liability

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## Executive Summary

This report examines the flooding of 8th and 10th August 2014 as a result of sustained intense rainfall on the Friday evening and again on the Sunday afternoon. This rainfall occurred in the South East of the District – with the worst effects in the areas of Allerton Bywater, Garforth, Kippax and Micklefield.

On Friday 8th August, the rainfall was in the order of a 1:200 or 0.5% (source: FEH) chance of occurring in any one year and was, therefore, an extreme event. The resulting flooding affected around 100 houses internally and a further 300+ externally - with a large number of highways, gardens and open spaces also flooded.

Such extreme rainfall was always going to cause issues and flooding was likely.

By the early hours of the following morning most of the floodwater had dissipated but, for those properties internally flooded, it left devastation, with many households evacuating their properties not for the first time.

Unfortunately this isn't the first incident in this part of Leeds, there have been a number of flood incidents over the last 10 years and though the Council has taken a number of measures to reduce flood risk, there is much that might still be done.

This investigation has considered a number of locations where flooding occurred and makes initial suggestions of potential issues that might be addressed to reduce the risk/impact of future flooding. A table of possible works is included in Appendix I – these will need further assessment to determine the feasibility of the works and the likely benefit that they will provide.

It is suggested that the Council, in partnership with other agencies, takes account of the information contained with this report and examines what can be done to mitigate/minimise future flood risks.

Although it is unlikely that flooding can ever be prevented during such intense/extreme rainfall events, it is important that all measures are examined that may reduce the risk and impact of such severe damage.

## 1. Introduction

1.1 During the week commencing 4th August 2014 there were a series of warnings of rainfall that could lead to a risk of flooding. These related to Friday 8th August and Sunday 10th August – the later with regard to ex-Hurricane Bertha that was crossing the Atlantic.

1.2 Unfortunately these warnings were very widespread, covering most of England, and the Risk Level was at Yellow, which is low. Therefore, no specific measure could be put in place; however FRM did check known high risk flood locations around the District.

1.3 Around 4pm on Friday 8th August, FRM received their first call regarding flooding, from Kippax. By the time the member of staff arrived on site, further calls had come in from the area.

1.4 Over the next 9 hours staff were out on site in the South East of the district providing support to a multitude of residents who were either flooded or at high risk of being flooded.

1.5 This was a severe flooding event with in excess of 80mm of rainfall in many areas within a period of 5 hours. This equates to a storm in excess of a 1:200 or 0.5% (source: FEH) chance of occurring in any year.

1.6 The communities affected by this event included Aberford, Allerton Bywater, Garforth, Kippax, Methley, Mickletown, Micklefield, Swillington and Woodlesford – all in the SE of the district.

1.7 This report examines the various circumstances that led to the flooding suffered in the most severely affected of the above communities, i.e. Allerton Bywater, Garforth, Kippax & Micklefield – some have been split down into sub-sections of these communities due to the widespread and severe nature of the flooding (see figure 1).

1.8 Some initial findings have been used to outline potential works that might be carried out to mitigate the effects in the future.

1.9 It is recognised that this is not an exhaustive list of the flooding locations but it does cover the majority of the worst affected areas.

1.10 Investigations continue and these will be taken account of during further assessment of the causes and potential mitigation measures.

1.11 In most cases it is believed that the floodwater emanated from several sources **-** including open watercourses, culverted watercourses, public sewers, private drains, highway drains, groundwater and overland flows.

1.12 All these communities have a variety of drainage types/systems, the state of which is variable. The key elements of this drainage are:

- **Adopted Sewers** – these are the responsibility of Yorkshire Water and are typically designed to cope with a 1:30 or 3.3% chance of flooding in any one year. Therefore, they are unlikely to be able to cope in such severe events as occurred on August 8th and 10th. However, during the investigations a number of issues have been found with these systems – YW have been informed of these.
- **Highway Drainage** – typically these are gullies connected to YW's sewers. The general view of the public is that *there are insufficient gullies and they are not maintained properly*. The reality is that, although there are some issues with the gullies, in such extreme events they are never going to cope. Furthermore, whilst ever they drain to YW's sewers they will be constrained by the capacity of those sewers. In fact in many locations the gullies provided an outlet for surcharging sewers.
- **Private drains and sewers** – these are the responsibility of the individuals whose properties they serve and, typically, they are not capable of coping with such an extreme event. To compound matters, they are often surcharged with water from the main drainage systems.
- **Main Rivers** – these are watercourses that have been classified as main rivers. As with all watercourses, the responsibility for maintenance of main rivers lies with the Riparian Owners (landowners on either bank) but under the control of the Environment Agency. During this localised event, even though it was extreme, the major rivers were not adversely affected but some of the local ones were overwhelmed by the sheer volume of flow. Worst affected were those sections that have been culverted.
- **Ordinary Watercourses** – these are watercourses other than those classified as main rivers. Again, they come under Riparian responsibility but the Council has permissive powers over them. As with smaller main rivers, the Ordinary Watercourses were generally overwhelmed by the volume of the flows – with culverted lengths being the worst affected.
- **Overland Flow** – in order for water to drain into one of the above systems it has to flow over the surface on which it falls until it is picked up in a formal system – this could be a roof, road, other hard surface or green area. The extreme nature of the rainfall meant that in many cases this run-off was unable to enter the formal system and therefore the flow continued, building up to the point that massive flows occurred and flooded out numerous properties.

1.13 Most of these communities have a long history of flooding and many households have been flooded out on at least one previous occasion.

1.14 Within this report, there are measures outlined that could be taken to mitigate the risks that these communities face. It may not be possible to stop flooding but it is important that an examination is carried out of works that might reduce the risk and/or impact.

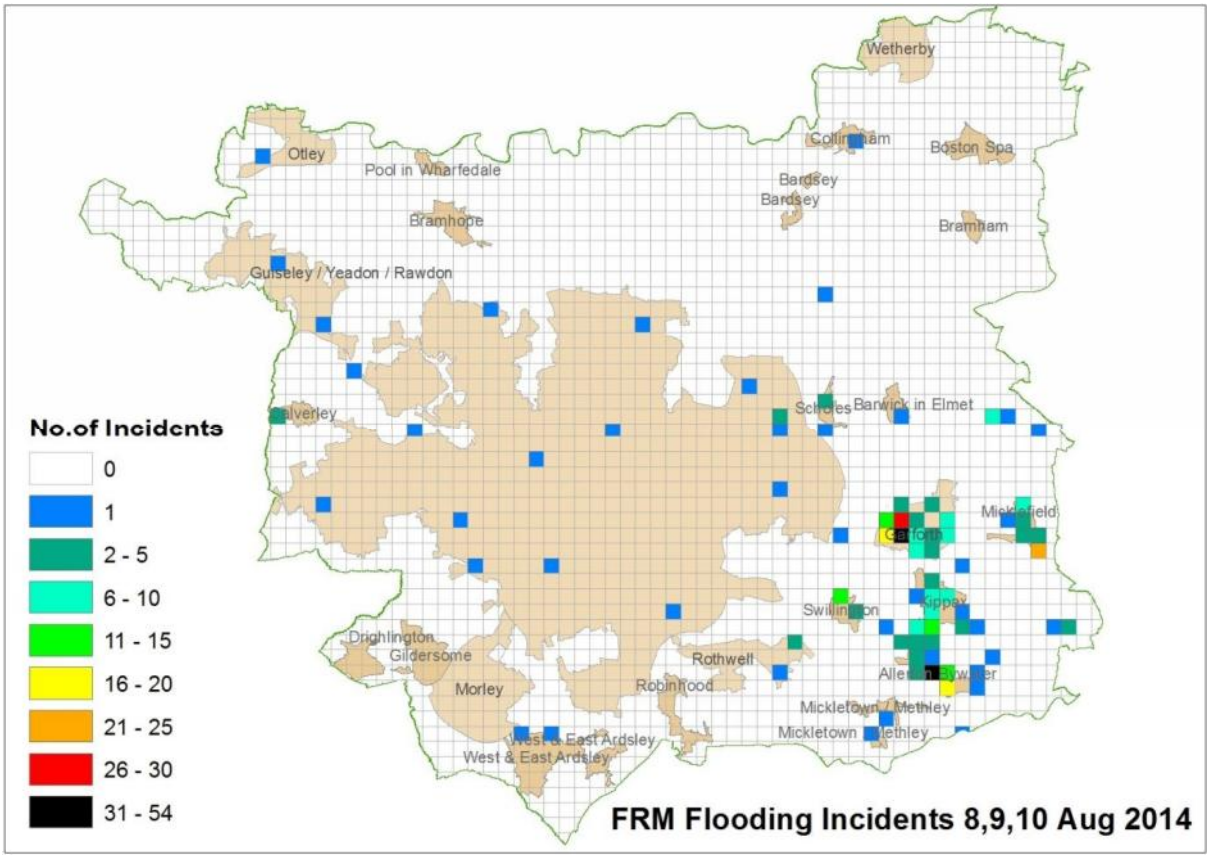



Figure 1, flooding incidents by frequency and location (per 500x500m square)
Note highest frequency in Allerton Bywater & Garforth

## 2 Rainfall

2.1 On August 8th 2014 Yorkshire experienced localised storms that tracked northwards into the Northumberland, Durham and Tees area. This low pressure system arrived 2 days prior to the remnants of Hurricane Bertha which swept across the Atlantic and into Europe. The timings and intensities of these storms varied as 2 weather fronts collided over Halifax and south Leeds, continuing in a northerly direction.

*("Contains Environment Agency information © Environment Agency and database right")*

2.2 Localised flash flooding affected the south east of Leeds over the weekend of the 8th - 10th August. Some exceptional rainfall events occurred; with over a month's rainfall accumulation recorded at Allerton Bywater on the evening of Friday 8th August 2014 (compared to the Met Office 1981–2010 England E & NE average for August of 69.2 mm). See table 1. This was then followed by the remnants of ex-Hurricane 'Bertha', as the depression passed over the UK on the 11th bringing strong winds and yet more heavy rain. The progress of the storm was widespread, affecting parts of the south-east, the Midlands, north-west and north-east of England.

2.3 According to the national Met Office UK review for August, "heavy showers and thunderstorms broke out widely in the afternoon with the heaviest in Humberside and Yorkshire. Rainfall overall was 157% of average, but some areas that were affected by localised intense downpours during the month saw more than twice the average rainfall." See graph 1.

2.4 Quantitative data on the rainfall has been gathered from 6 local rain gauges and visual representation from Meteorological Office regional radar. The local rain gauges give relatively accurate point rainfall data at strategic sites which are placed around the Leeds District. The radar data is less accurate but does show the spatial variation of rain intensity across the catchment region. The data from each of these sources is shown below:

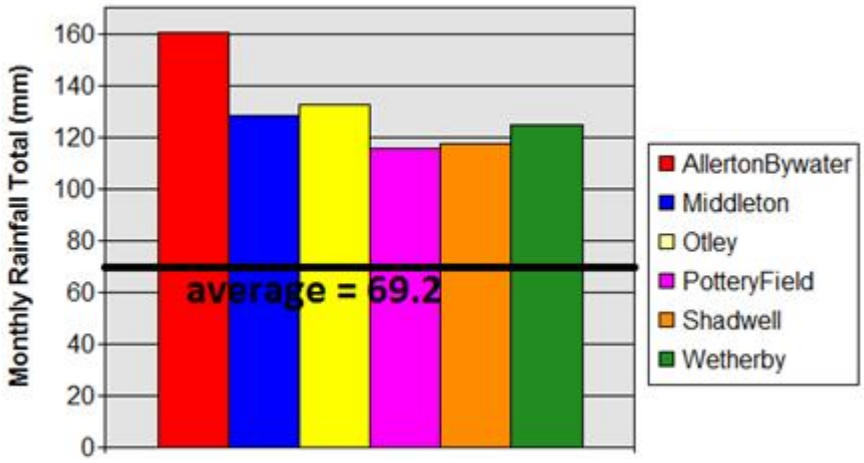
| FRM Rain Gauge data (mm) | Allerton Bywater | Middleton | Otley | Pottery Fields | Shadwell | Wetherby |
|---|---|---|---|---|---|---|
| Fri, 8/8/2014 | 83.2 | 25.4 | 16.2 | 30.6 | 27.4 | 45.2 |
| Sat, 9/8/2014 | 0 | 0 | 0 | 0 | 0 | 0.2 |
| Sun, 10/8/2014 | 31.0 | 30.6 | 20.6 | 21.4 | 24.0 | 24.4 |
| **Weekend Total** | **114.2** | **56** | **36.8** | **52** | **51.4** | **69.8** |

Table 1: Rainfall totals for the weekend of the 8th - 10th Aug (source: LCC rain gauges)

## 2.5 **FRM Rain Gauge data:**

### 2.5.1 August Monthly Rainfall Totals

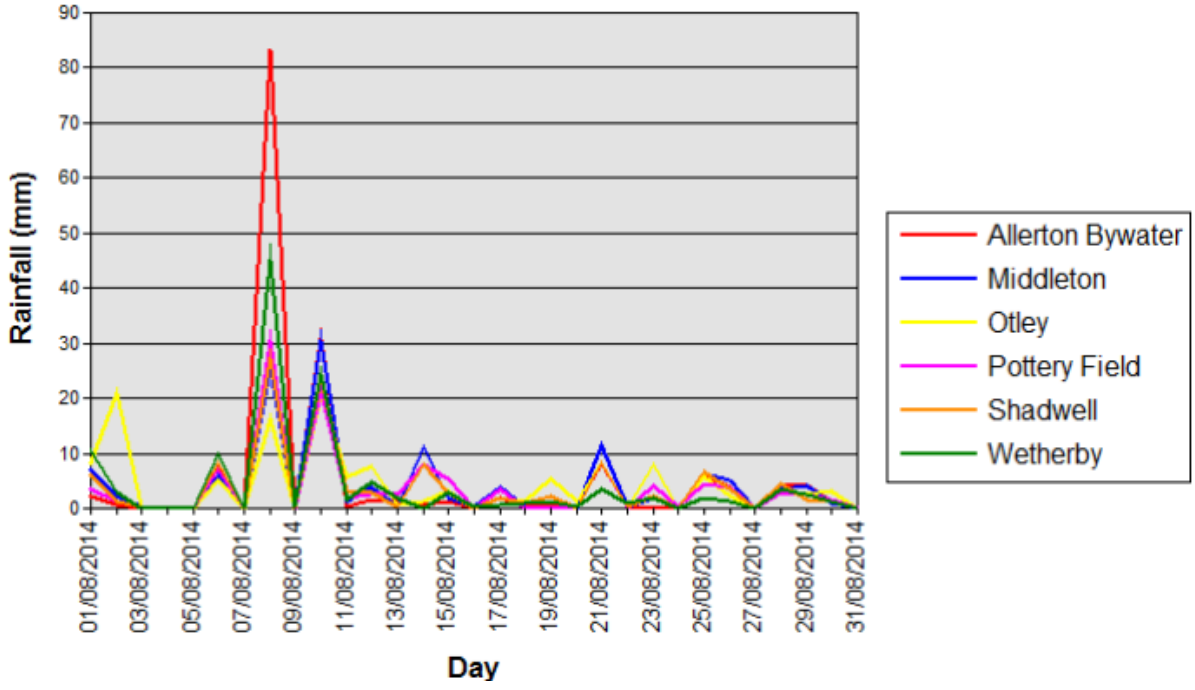
More than twice the average rainfall fell in some parts of Leeds during August. See graph 1 below.




Graph 1: Monthly rainfall totals across Leeds (source: LCC rain gauges)

### 2.5.2 Daily Rainfall Totals

The highest daily rainfall total recorded during the month was 83.2 mm at Allerton Bywater**,** the majority of which fell over a 5 hour period on the Friday evening of August 8th 2014. See graph 2 below.




Graph 2: Daily rainfall totals across Leeds (source: LCC rain gauges)

2.5.3 Exceptional Rainfall (i.e. >10mm during any 15 min period)

Exceptional rainfall events occurred on Friday at Allerton Bywater (16:00, 18:15, 18:45, 19:00) and at Pottery Fields (18:45). Figures indicate that this was between a 1 in 100 year (or 1%) and 1 in 200 (or 0.5%) year return period event (source: FSR & FEH). However, in some isolated areas this may have been an even greater event.
***(Note:** the return period is based on historical data, but historical information offers no guarantee of future rainfall patterns especially in these times of uncertainty due to global warming & climate change)*

2.5.4 Meteorological Office Radar

Met Office radar clearly concurs with the data obtained from LCC rain gauge weather stations, indicating the worst affected areas to the east of the Leeds District. See figures 2 and 3 below.

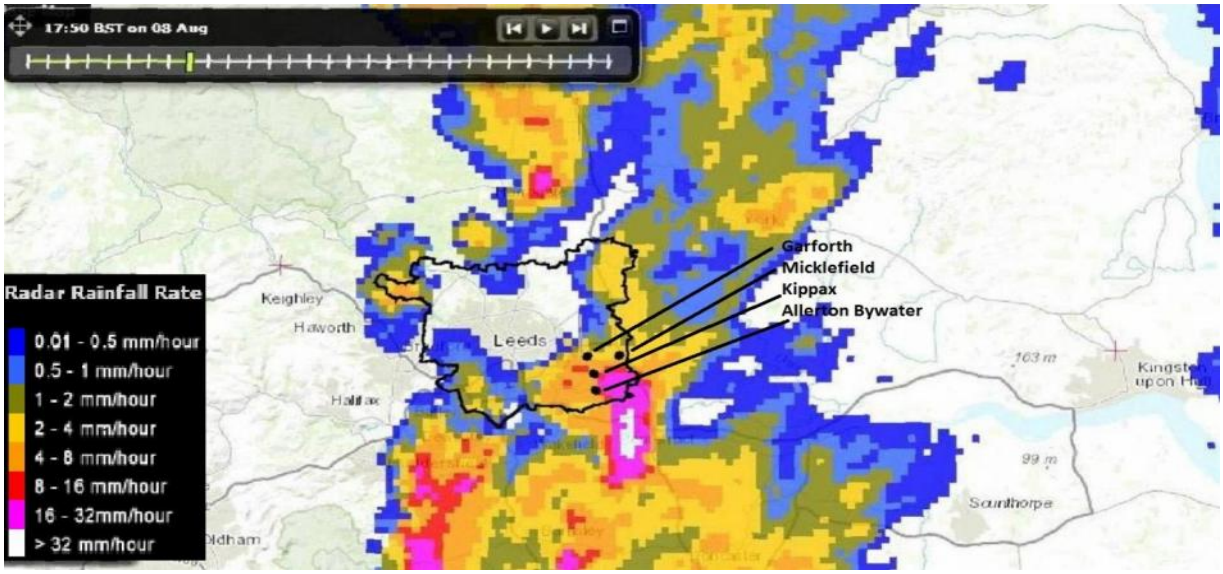



Figure 2: Radar Rainfall Rates at 17:50, 8/8/2014 - Met Office.
(Note that the approximate Leeds district boundary has been superimposed in black)

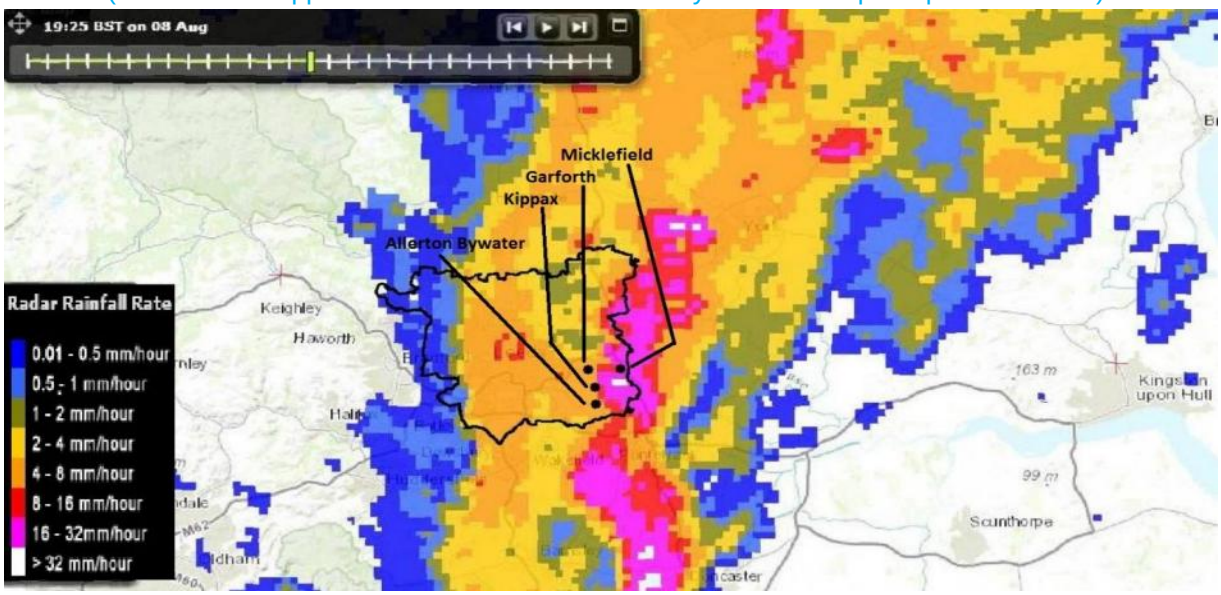



Figure 3: Radar Rainfall Rates at 19:25, 8/8/2014 - Met Office
(Note that the approximate Leeds district boundary has been superimposed in black)

# 3 Flood Investigation

3.1 The flooding locations covered by this report focus primarily on properties affected either by internal flooding or at imminent threat of being internally flooded, i.e. the most severely affected, and are summarised below in table 2:-

| | |
|---|---|
| **Allerton Bywater** | **99** |
| 1 - Internal flooding (inc. occupied cellar) | 22 |
| 2 - Imminent threat of internal flooding (e.g. underdrawings) | 77 |
| **Garforth** | **119** |
| 1 - Internal flooding (inc. occupied cellar) | 34 |
| 2 - Imminent threat of internal flooding (e.g. underdrawings) | 85 |
| **Kippax** | **41** |
| 1 - Internal flooding (inc. occupied cellar) | 28 |
| 2 - Imminent threat of internal flooding (e.g. underdrawings) | 13 |
| **Micklefield** | **42** |
| 1 - Internal flooding (inc. occupied cellar) | 18 |
| 2 - Imminent threat of internal flooding (e.g. underdrawings) | 24 |

Table 2: Number of priority 1 & 2 incidents for most severely affected areas

## 3.2 **Allerton Bywater**

Brief description of flooding event

3.2.1 Extensive surface water (pluvial) flooding covering the central area of Allerton Bywater.

3.2.2 Streets known to have been worst affected at this time were:

Barnsdale Road, Blands Avenue, Blands Crescent, Carlton View, Doctors Lane, Grove Villas, Highfield Crescent, Hirst Street, Hollinhurst, Leeds Road, Manor Park Avenue, Park Lane, Prince Street, Robinson Street, Station Road, Westfield Avenue, Westfield Bungalows and Westfield Terrace.

3.2.3 It is reported that at least 22 properties in Allerton Bywater were flooded internally during the rainfall event of the August 8th and 10th 2014. Flood depths internally were in the order of up to 300 mm. See figure 4 below for plan of Allerton Bywater showing incidents relating to culvert position and low lying ground and figure 5 showing flood damage to homes.

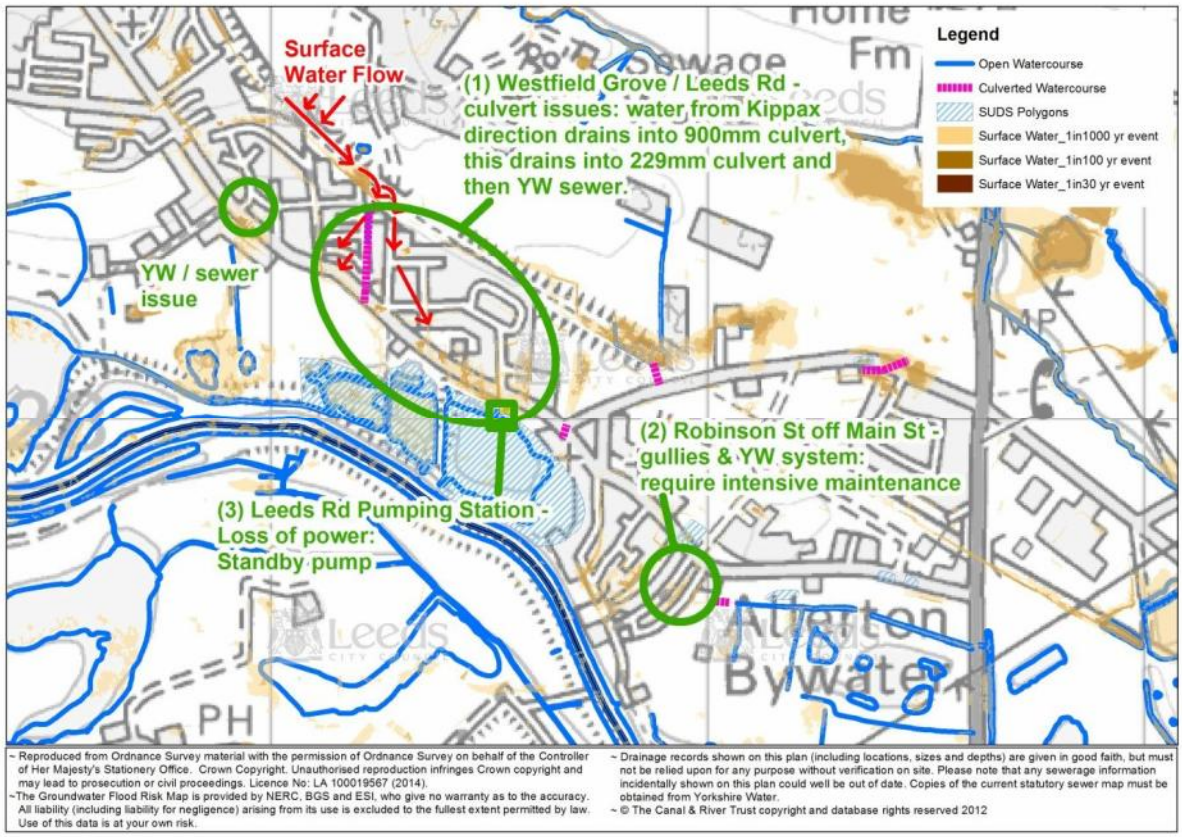



Figure 4: Plan of Allerton Bywater showing incidents relative to culvert position (shown pink) and low lying ground (shown in browns).
[Whilst detailed information has been recorded, due to the restrictions imposed by the Data Protection Act flooding locations have been aggregated so as not to identify individual properties]

Figure 5: Flood damage to homes in Allerton Bywater. Note tide mark along back wall

3.2.4 Countless properties suffered flooding to gardens as shown in figure 6 below.

Figure 6: Flooded gardens in Allerton Bywater

3.2.5 The floodwater came from the extreme volume of water of overland run-off, with surcharged combined sewers, surface water sewers, private drains, highway gullies, culverted watercourses and open watercourses. Several sizeable lakes developed to depths up to 400mm, notably surrounding the Community Centre and in low lying areas of Leeds Road.

Flood History

3.2.6 The Allerton Bywater area has a long history of flooding problems stretching back many years, and some residents are severely impacted because their homes, gardens or streets are subject to frequent inundation. Most recently, many properties were flooded internally in the summer of 2012 requiring a major pumping exercise to afford some relief as shown in figure 7 below.

Figure 7: historic flooding in 2012 off Main Street, Allerton Bywater. Several pumps were required to reduce water levels.

3.2.7 Much of the flooding has in the past been attributed to fluvial (river) flooding as opposed to pluvial (surface water) flooding. On this occasion however, the flooding was wholly caused by surface water and occurred some distance away from the River Aire and river flood plains. Most of the specific incident locations are also new to FRM.

Existing Drainage System, Allerton Bywater

3.2.8 Several piped and open drainage systems are present in the vicinity of the flooding that occurred on August 8th. These are shown below in figure 8.

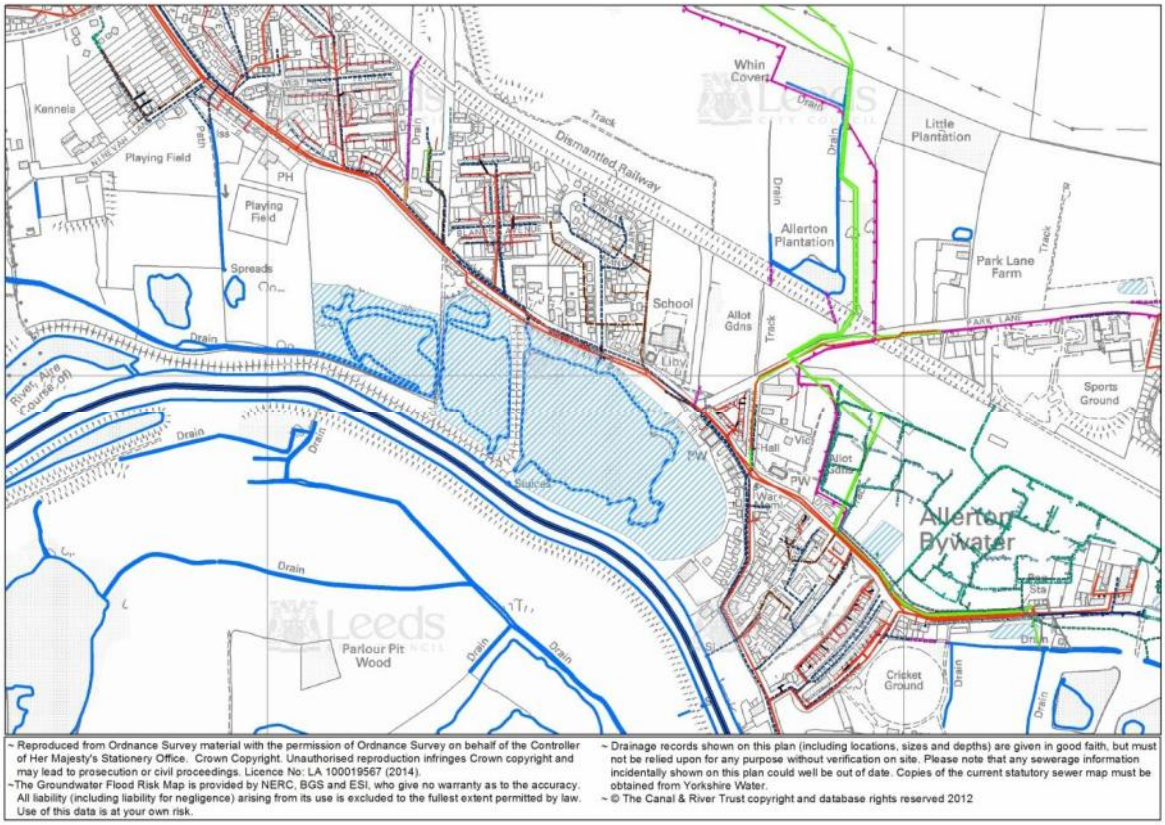



Figure 8: Extract from Leeds City Councils Geographic information system (GIS), drainage asset register showing public combined sewers (red), public surface water sewers (blue dash), becks/rivers (solid blue), culverted watercourses (pink & brown) and Highway Drainage (Turquoise), note road gullies omitted for clarity

3.2.9 Due to the widespread nature of the flooding in Allerton Bywater, it is not appropriate or within the scope/timescale of this report to discuss the detailed layout of the existing drainage system relative to each affected street (see paragraph 1.11 above).

Summary of findings

3.2.10 Performance of the open watercourse (off Westfield Bungalows)

From resident eye witness accounts and observations on the night by FRM staff, the watercourse did come out of its channel due to the throttling effect of the downstream 229mm culvert. This allowed immense volumes of floodwater to escape and gravitate overland to low lying areas in this densely populated area of Allerton Bywater. The resultant overland flow flooded all in its pathway and was compounded by additional flow contributions from other surcharged drainage systems, paved areas, developed areas and run-off from any open spaces caused by saturated land as shown in figure 9. Visual inspection by Leeds City Council surveyors has revealed no blockages or defects.

Figure 9: overland flood water from open watercourse surcharge heading towards Leeds Road

3.2.11 Performance of the culverted watercourse

Due to overwhelming water surcharge pressure, immense volumes of flood water escaped and gravitated overland to lower lying residential areas. The resultant overland flows flooded all in their pathway and were compounded by additional flow contributions from other surcharged drainage systems, paved areas, developed areas and run-off from any open spaces caused by saturated land. Internal inspection by CCTV of the riparian culverted section by Leeds City Council surveyors has revealed no blockages or defects.

### 3.2.12 Performance of the combined sewers

Due to overwhelming water surcharge pressure, numerous manhole covers were blown off, allowing immense volumes of flood water to escape and gravitate to, and flood low lying areas. Any drainage system connected to the sewer network would consequently experience similar surcharge/overload conditions depending on relative levels. See figure 10 below.

Figure 10: surcharging YW manholes, Allerton Bywater

### 3.2.13 Performance of the surface water sewers

Due to overwhelming water surcharge pressure, numerous manhole covers were blown off, allowing immense volumes of flood water to escape and gravitate to, and flood low lying areas. Any drainage system connected to the sewer network would consequently experience similar surcharge/overload conditions depending on relative levels.

### 3.2.14 Performance of the highway drainage

Road gullies in general were not functional, regardless of their service condition, at peak flows due to the surcharge conditions of receiving drainage systems, but the extreme nature of this rainfall event would have far exceeded the design criteria for the highway drainage. The resultant overland flows were a contributory factor to flooding as can be seen in figure 11.

Figure 11: Leeds Road flooding at junction with Doctors Lane, Allerton Bywater

Discussion and possible causes

3.2.15 The primary cause of the flooding was by surface water (pluvial flooding) flooding. Causing many drainage systems to be surcharged, watercourses, culverts, public sewers/manholes, private drains and road gullies from the extreme volume of water. See figure 12.

Figure 12: flooding along Leeds Road, Allerton Bywater

3.2.16 This overload of the drainage systems mentioned above was itself caused by extreme surface water runoff from the rural areas occupying higher ground to the North West of Allerton Bywater to the north of the redundant railway embankment.

3.2.17 The railway embankment acts as a buffer but flows are then concentrated and channeled towards the residential areas by 1) a 900mm dia culvert under the railway embankment and 2) Doctors Lane (see figure 11 above).

3.2.18 The primary cause of localised flooding along Highfield Drive was the extreme volume of water, which appears to have been exacerbated by the capacity of the public combined and surface water sewers. See figure 13.

Figure 13: Highfield Drive flooding

3.2.19 The primary cause of localised flooding along Robinson Street (see figure 14) was the extreme volume of water, which appears to have been exacerbated by the capacity of the public combined / surface water sewers and road gullies. Upon inspection, there were no issues with the open watercourse beck outfall adjacent to Robinson Street.

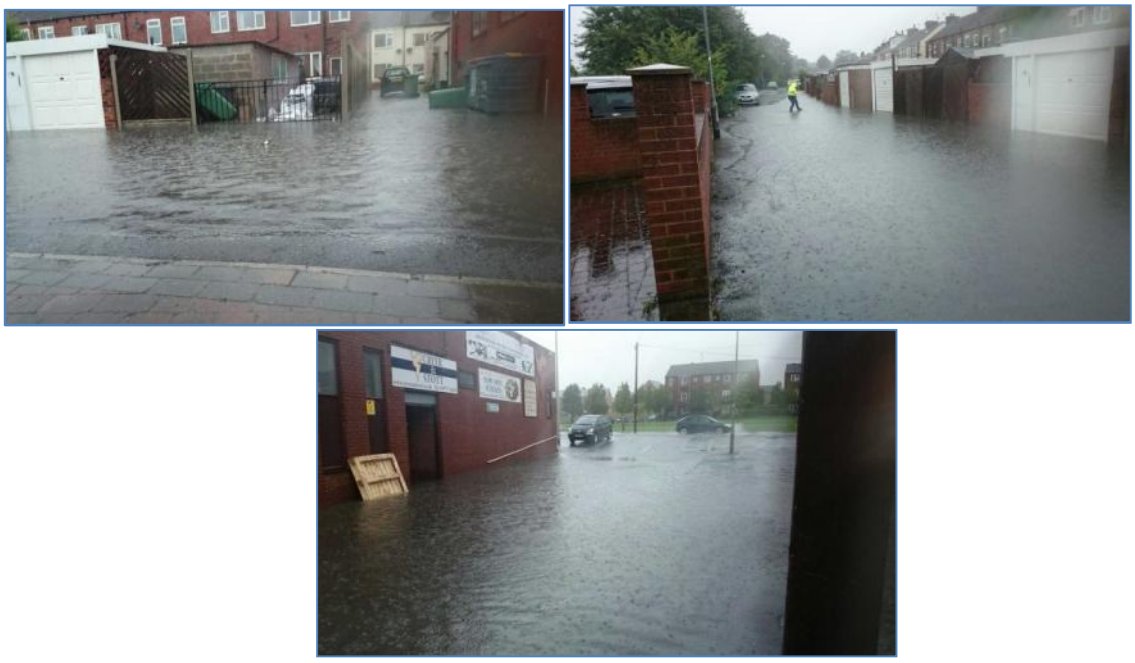


Figure 14: Robinson Street flooding

3.2.20 The primary cause of localised flooding at the junction of Leeds Road and Manor Park Avenue (LCC Pumping Station) was the extreme volume of water, which appears to have been exacerbated by potential problems associated with the failure of the pumping station. The pumping station tripped out following a local electrical supply failure. It was reset the following day and the internal control panel has been subsequently reconfigured. See figures 15 and 16.

Figure 15: Leeds Road and Manor Park Avenue (LCC Pumping Station)

Figure 16: FRM Contractors pump Leeds Road flood into adjacent flood plain to reopen road, Friday evening, August 8th

3.2.21 In summary, the storm that occurred in Allerton Bywater on August 8th and 10th was of exceptional intensity and exceeded current or historic design standards for all sections of drainage infrastructure and that substantial and localised flooding would have occurred irrespective of the condition or state of operation of the existing drainage network.

## 3.3 **Garforth**

Brief description of flooding event

3.3.1 Extensive surface water (pluvial) flooding covering the major part of Garforth.

3.3.2 Streets known to have been worst affected at this time were:

Alandale Crescent, Alandale Drive, Ashlea Close, Bar Lane, Barleyhill Crescent, Barleyhill Road, Beech Grove Terrace, Bluebell Avenue, Church Lane, Conisborough Lane, Derwent Avenue, Fairburn Drive, Farfield Court, Fidler Close, Fidler Lane, Fidler Terrace, Firtree Avenue, Grange Avenue, Greensway, Highfield Drive, Hillside, Kingsway, Knightsway, Lidgett Lane, Lindsay Road, Long Meadows, Lowther Road, Ludlow Avenue, Lyndon Avenue, Main Street, Montague Crescent, Moorland Terrace, New Sturton Lane, Ninelands Lane, Oak Crescent, Oak Road, Poplar Avenue, Queensway, Ringway, Rydal Avenue, Selby Road, Severn Drive, Spring Mead Drive, Strawberry Avenue, Summerhill Road, Wakefield Road, White Rose Avenue and Windsor Green.

3.3.3 It is reported that at least 34 properties in Garforth as a whole were flooded internally during the rainfall event of the 8th and 10th August 2014. Flood depths internally were in the order of 200 mm. Some ground/basement floors are believed to have been rendered uninhabitable and substantial remedial works were necessitated, including the total removal of floorboards, joists, plasterwork, etc., with some residents having sought temporary accommodation until their houses have been dried out and repaired. See figure 17 showing incidents relative to culvert position and low lying ground and figure 18 showing photos of flood damage in West Garforth.

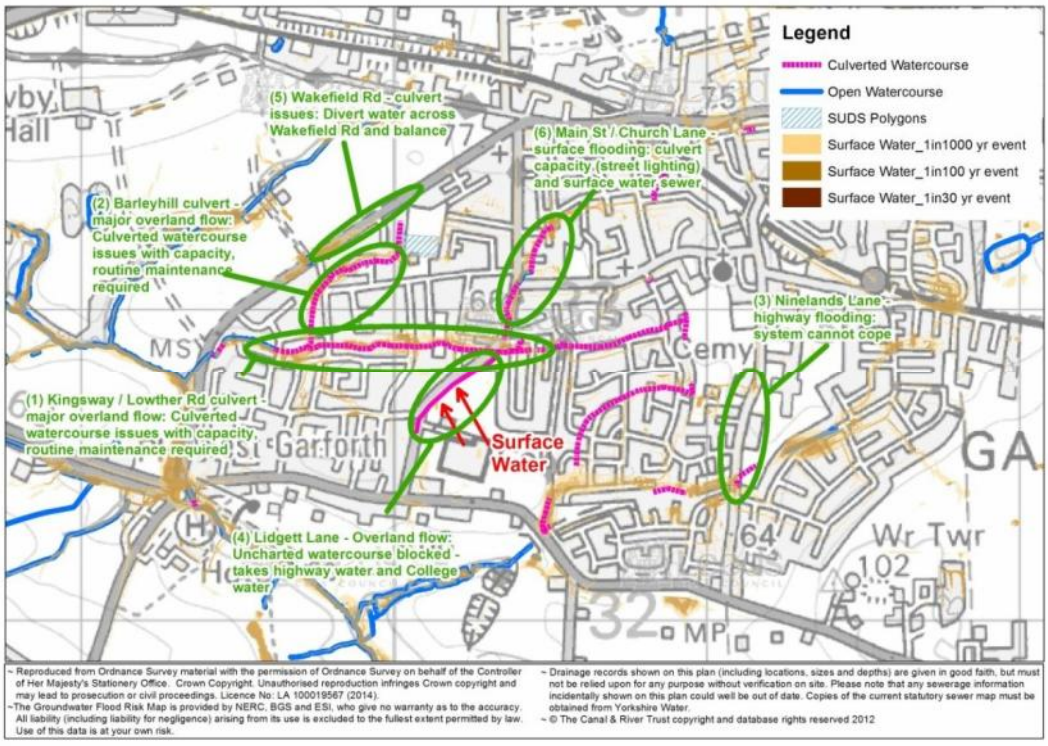



Figure 17: Plan of West Garforth showing incidents relative to culvert position (shown pink) and low lying ground (shown in browns)
[Whilst detailed information has been recorded, due to the restrictions imposed by the Data Protection Act flooding locations have been aggregated so as not to identify individual properties]

Figure 18: Flood damage to homes in West Garforth

3.3.4 Countless properties suffered flooding to gardens. See figure 19 below.

Figure 19: Flooded gardens in West Garforth
[reproduced by kind permission of the Garforth Flood Group]

3.3.5 The floodwater came from the extreme volume of water of overland run-off, with surcharged combined sewers, surface water sewers, private drains, highway gullies, culverted watercourses and groundwater. Several sizeable lakes developed to depths up to 600mm, notably the residential gardens off Kingsway, Allendale Drive and Barleyhill Road.

3.3.6 Property level flood resilience measures were only partially successful. Residents noted that property level protection resisted flood waters entering property through air bricks and door/patio openings, but such was the ferocity and prolonged nature of this rainfall event, flood water infiltrated into properties through walls, floors and service entry points in a manner that was virtually impossible to guard against. See figure 20 below.

Figure 20: Flood gates in position during flood event and afterwards in West Garforth [reproduced by kind permission of the Garforth Flood Group]

## Flood History

3.3.7 The West Garforth drainage area has a long history of flooding problems going back to the 1980s, and many residents are severely impacted because their homes, gardens or streets are subject to frequent inundation. Notably, many properties were flooded internally in June 2007.

3.3.8 The cause of flooding has in the past been attributed to the inadequacies of the surface water drainage system. The bulk of the flow entering the culverts is from YW public surface water sewers and LCC highway drains. See figure 21 below for plan of existing drainage system in West Garforth.

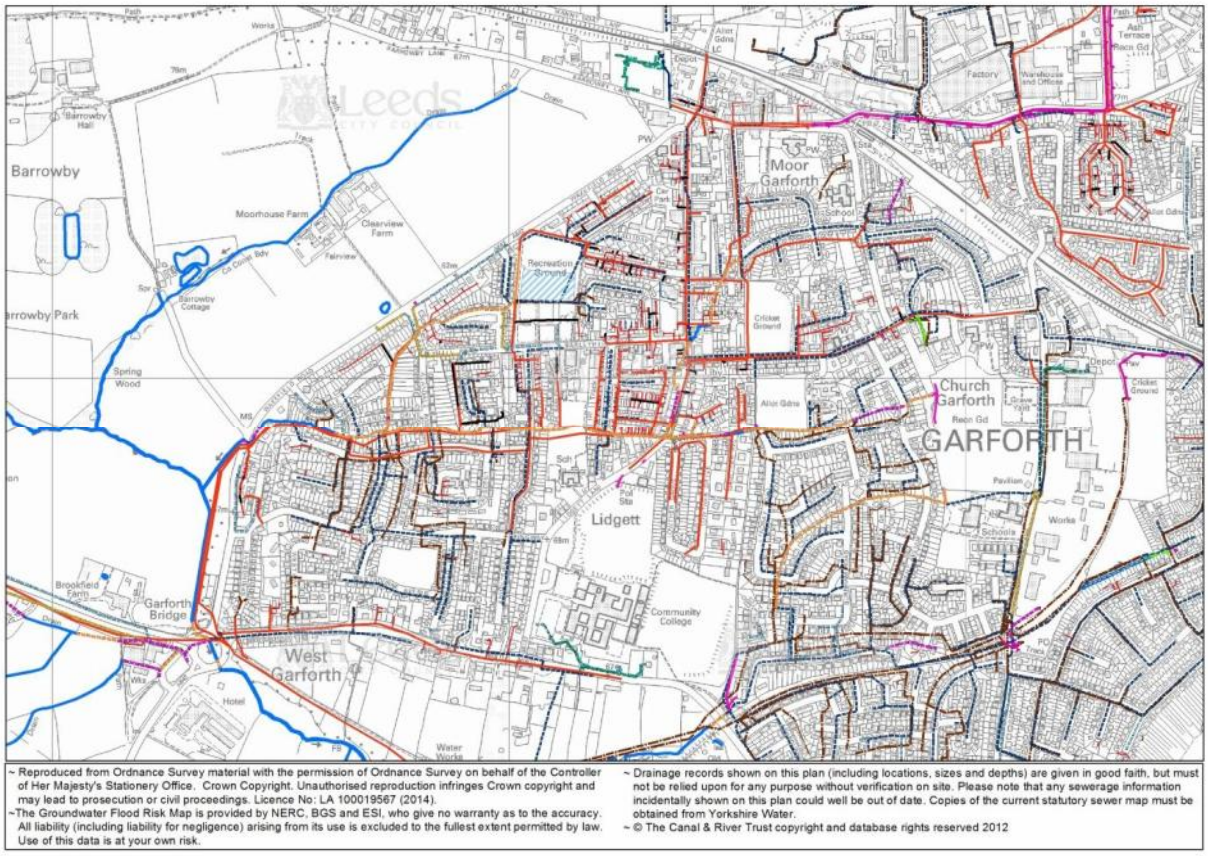



Figure 21: Extract from Leeds City Councils Geographic information system (GIS), drainage asset register showing public combined sewers (red), public surface water sewers (blue dash), becks (solid blue), culverted watercourses (pink & brown) and Highway Drainage (Turquoise), note: road gullies omitted for clarity

Existing Drainage System, West Garforth

3.3.9 The backbone of the drainage infrastructure is a system of inadequate, riparian-owned, culverted watercourses, principally passing through hundreds of private properties (see figure 26 below).

3.3.10 West Garforth has grown substantially since the 1950s. The open channel watercourses have been covered over or culverted in a piecemeal fashion and the associated drainage infrastructure has often been connected to these culverts, seemingly without regard to capacity limitations.

3.3.11 A thorough examination of historical maps in West Garforth has been undertaken to demonstrate the anathema of riparian ownership and the problematic issues it presents.

3.3.12 Figures 22 - 25 show the GIS record of the position of the existing open watercourses (in blue) and culverts (in pink) superimposed on a historical Ordnance Survey 1:2500 scale map. It can be seen that the culverts predominately coincide with previous open channel natural watercourses.

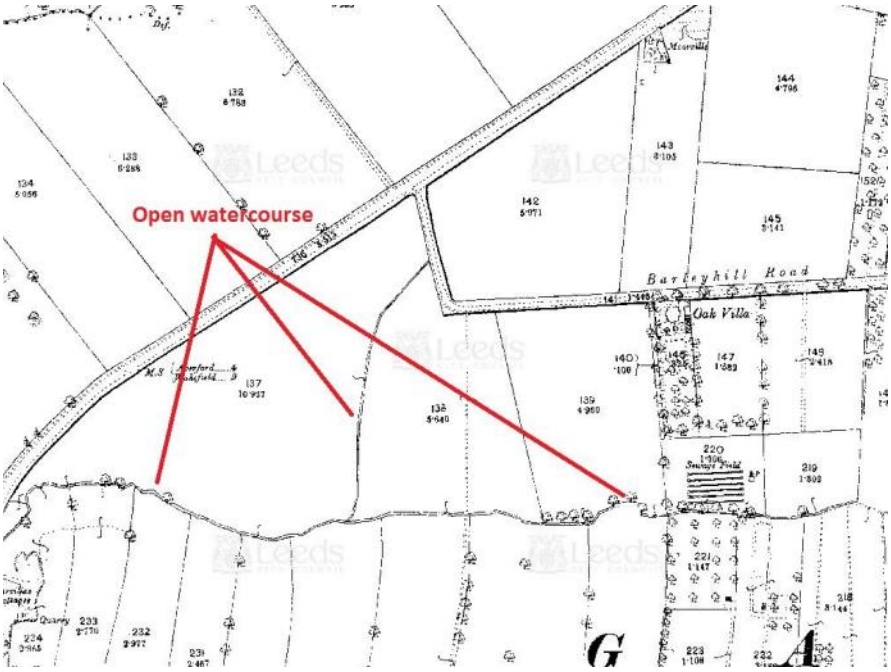



Figure 22: OS 1880 1:2500 map showing open channel in West Garforth

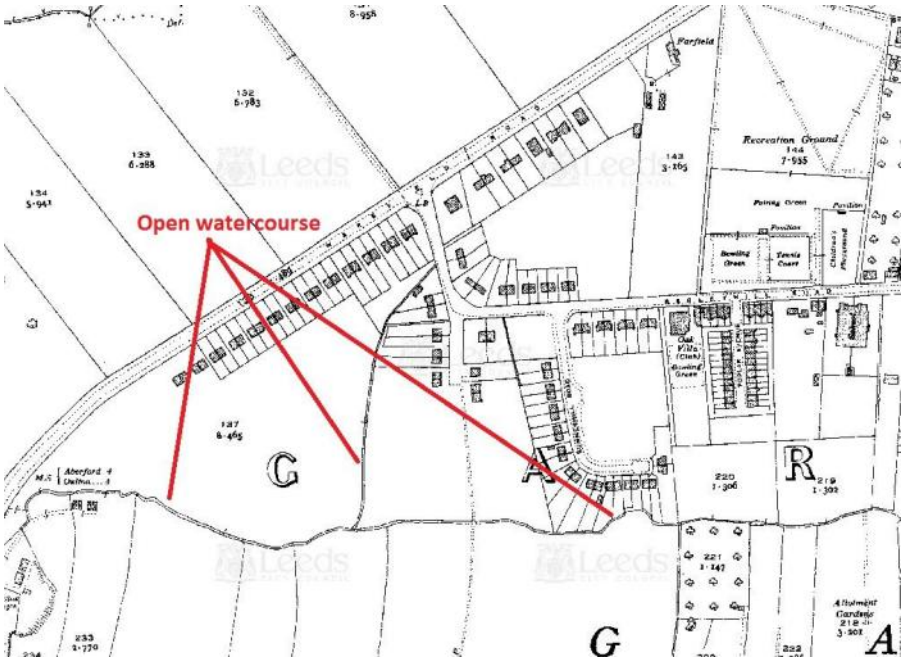



Figure 23: OS 1930 1:2500 map showing development starting in West Garforth

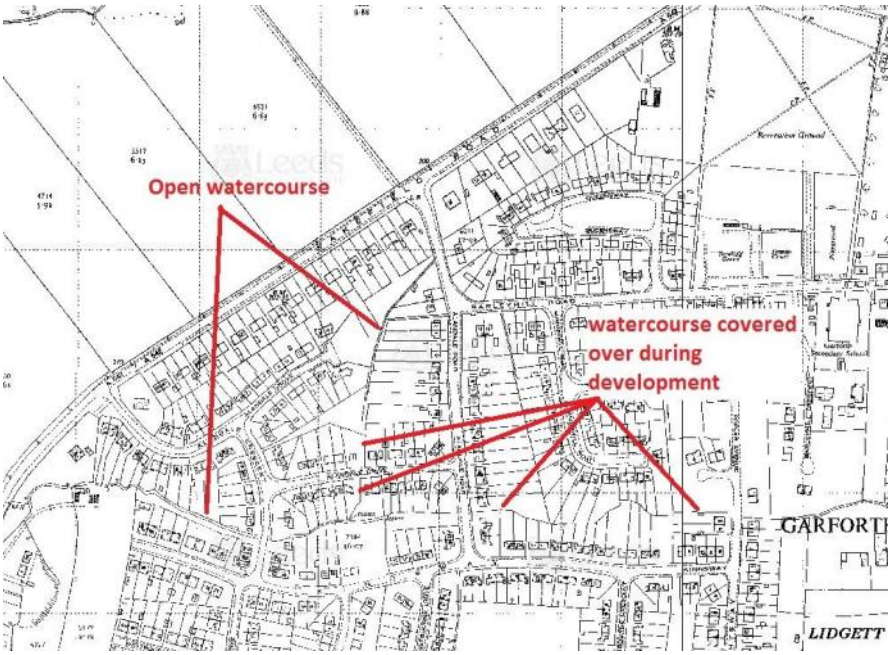


Figure 24: OS 1950 1:2500 map showing major development of West Garforth

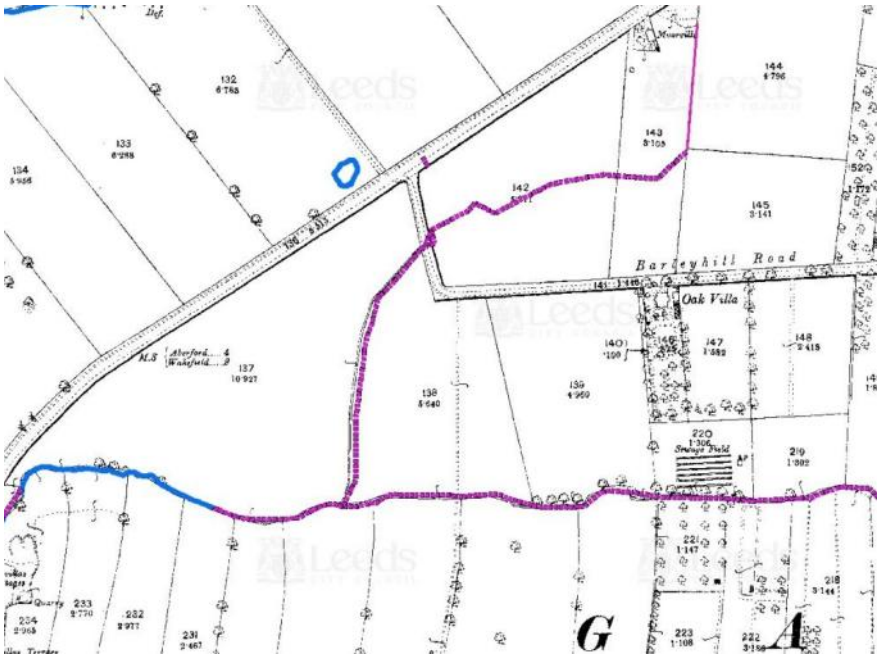


Figure 25: Coincidence of current culverts with the open watercourses of 1880

3.3.13 The following contemporary plan (figure 26) clearly demonstrates the magnitude of the problem with some 237 individual parcels of land made up of;

- 195 (82%) separate, privately-owned land parcels
- 27 (12%) LCC land parcels
- 15 (6%) LCC sections of adopted highway

The Council has riparian responsibilities for those lengths of open channel or culverted watercourse that pass through land that it owns. In West Garforth, this means mainly those lengths of culvert that pass under adopted highways and parcels of LCC land, some of which have shared responsibilities with adjacent private land.

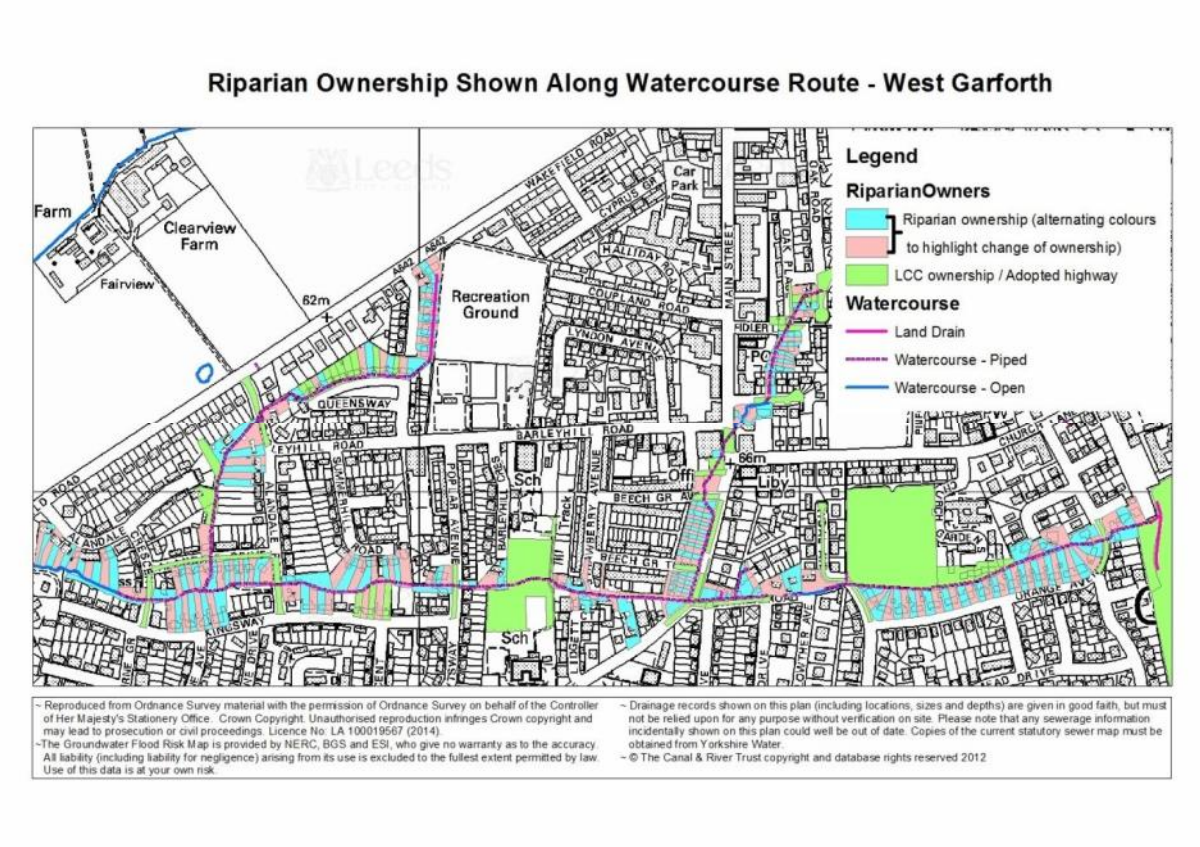



Figure 26: Riparian ownership along watercourse route in West Garforth

3.3.14 The riparian owners (the owners of the land that the watercourses – culverted or otherwise - run through) are responsible for ensuring that watercourses are free of impediments to flow. They have no explicit duty, however, to upsize inadequate culverts.

3.3.15 It is clear that though riparian owners of culverts, in West Garforth as elsewhere, are responsible for keeping their culverts free of impediments to flow and that a notice can be served under the Land Drainage Act, 1991, Section 25, requiring them to carry out remedial works. Most owners are not aware of the presence of a culvert running through their property at all, or their duties and responsibilities as riparian owner. It is equally clear, that most owners are in no position, financially or practically, to undertake such work. In many cases, owners do not even have access to the culvert in their garden. Furthermore, they have neither the resources nor the powers to construct comprehensive improvement works. This is typical of many urban watercourses throughout Leeds, particularly those that have been culverted.

3.3.16 Performance of the open watercourse (off Kingsway)

From resident eye witness accounts and observations on the night, by FRM staff, the watercourse did not overtop its banks and remained in channel. See figure 27 below.

Figure 27: photograph taken on the evening of August 8th 2014 showing watercourse in channel

**3.3.17 Performance of the culverted watercourse**

Due to overwhelming water surcharge pressure, numerous manhole covers and some frames were blown off the culverted watercourse, allowing immense volumes of floodwater to escape and gravitate to low lying areas. The resultant overland flows flooded all in their pathway and were compounded by additional flow contributions from other surcharged drainage systems paved areas, developed areas and run-off from open spaces, caused by saturated land. See figure 28 below.

Figure 28: Surcharged culvert, flood water pathway following line of the culvert overland & downhill towards Kingsway and the Alandales

3.3.18 Most unusually, floodwater was also observed escaping under some force from beneath pavements from pressurised sections of culvert in between manhole locations, lifting whole sections of footway in the process. See figure 29 below.

Figure 29: Water escape under pressure along line of culvert

3.3.19 CCTV investigations have revealed a number of partial blockages, including a lamp column through the culvert (Lidgett Lane) and a third party service pipe through the culvert (Alandale Crescent). See figure 30 below. The lamp column was removed within 48 hours of discovery, the 150mm service pipe will take longer to divert. Other minor routine obstructions in the form of gravels and silts were also revealed by CCTV investigation – these have been removed.


Figure 30: Photograph showing new lamp column installed through the culvert main line (Lidgett Lane) and service pipe through culvert (Alandale Crescent)

3.3.20 Any drainage system connected to the culvert network would consequently experience similar surcharge/overload conditions.

3.3.21 Performance of the combined sewers

Due to overwhelming water surcharge pressure, numerous manhole covers were blown off, allowing immense volumes of floodwater to escape and gravitate to low lying areas. The resultant overland flows flooded all in their pathway and were compounded by additional flow contributions from other surcharged drainage systems, paved areas, developed areas and run-off from any open spaces caused by saturated land. Any drainage system connected to the sewer network would consequently experience similar surcharge/overload conditions as demonstrated below in figure 31.

Figure 31: Internal flooding caused by sewer surcharge and overload
[reproduced by kind permission of the Garforth Flood Group]

3.3.22 Performance of the surface water sewers

Due to overwhelming water surcharge pressure, numerous manhole covers were blown off, allowing immense volumes of floodwater to escape and gravitate to low lying areas. The resultant overland flows flooded all in their pathway and were compounded by additional flow contributions from other surcharged drainage systems, paved areas, developed areas and run-off from any open spaces caused by saturated land.

3.3.23 Performance of the highway drainage

Road gullies in general were not functional regardless of their service condition, due to the surcharge conditions of receiving drainage systems, but the extreme nature of this rainfall event would have far exceeded the design criteria for the highway drainage. The resultant overland flows flooded all in their pathway and were compounded by additional flow contributions from other surcharged drainage systems, paved areas, developed areas and run-off from any open spaces caused by saturated land. See figure 32 below.

Figure 32: Grange Avenue, road gullies totally overwhelmed
[reproduced by kind permission of the Garforth Flood Group]

3.3.24 Discussion and possible causes

Although many long-term residents do not recall previous flooding of this magnitude (many say it even surpassed 2007), it should be noted that most of the affected flood area falls within low lying areas. In most cases it has been shown (see 3.3.12) that these areas predominately coincide with previous open channel natural valleys, watercourses and later culverts.

These areas are identified as susceptible to surface water flooding as indicated by the Environment Agency's flood risk model (see figure 33 below).

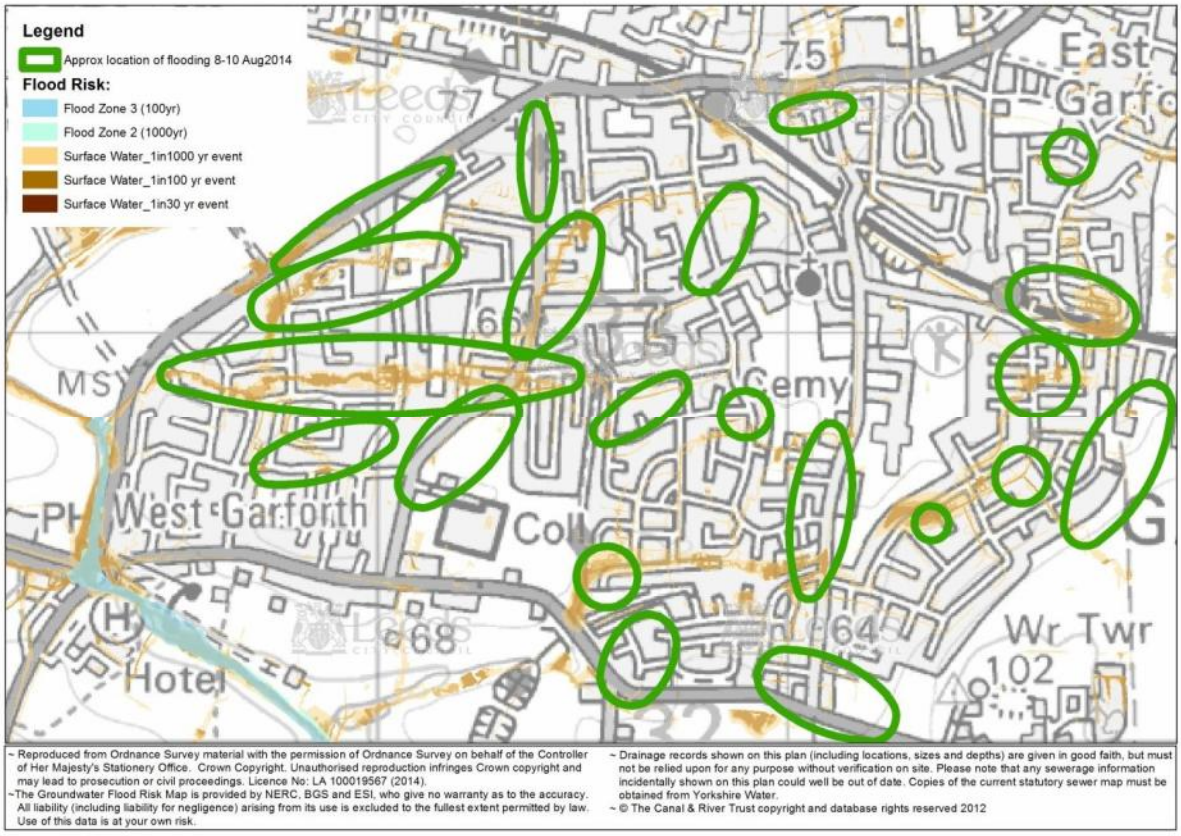



Figure 33: incidents related to topography and flood risk zones
[Whilst detailed information has been recorded, due to the restrictions imposed by the Data Protection Act flooding locations have been aggregated so as not to identify individual properties]

3.3.25 It is unlikely that there will be any statutory revision to clarify riparian owners' duties or that maintenance responsibility would be transferred, with appropriate funding, to a capable organisation/agency, but this is a countrywide issue that should be raised at a national level.

3.3.26 The cause of the flooding was the extreme volume of water leading to surface water (pluvial flooding) flooding. Which appears to have been exacerbated by: (i) surcharged manholes, and road gullies and (ii) supplemented by extreme surface water runoff from the developed areas of Garforth occupying higher ground. There is insufficient information to determine the proportionate share of these sources.

3.3.27 The performance of some culverted watercourses was compromised by partial blockages.

3.3.28 The performance of Yorkshire Water assets has yet to be verified / assessed.

3.3.29 An uncharted and dysfunctional drain along Lidgett Lane, south of Lowther Avenue, contributed to the formation of a lake at the junction of Lowther Avenue and Lidgett Lane, which had to be controlled by WY Police on the night of 8 August. See figure 34 below.

Figure 34: photographs of dangerous lake at the junction of Lowther Avenue and Lidgett Lane

3.3.30 The lake above, was compounded by a connection from adjacent playing fields and this is the subject of further investigation. See figure 35 below.

Figure 35: photograph of connection from Garforth Community College playing fields, Lidgett Lane

3.3.31 In summary, the storm that occurred in Garforth on August 8th and 10th was of exceptional intensity and exceeded current or historic design standards for all sections of drainage infrastructure and it is certain that substantial and localised flooding would have occurred irrespective of the condition or state of operation of the existing drainage network.

## 3.4 **Kippax**

Brief description of the flooding event

3.4.1 There was extensive surface water (pluvial) flooding and some localised watercourse/beck (fluvial) flooding covering sections of the district of Kippax. A significant ‘sink hole’ was created by escaping floodwater resulting in the protracted closure of a main road (B6137) into Kippax as can be seen in figure 36.

Figure 36: sink hole below B6137, Kippax

3.4.2 Streets known to have been worst affected at this time were:

Brigshaw Lane, Bula Close, Ebor Mount, Gibson Lane, Green Lane, Kempton Road, Leeds Road, Longdike Lane, Moorleigh Close, Park Avenue, Pondfields Drive, Ramsden Street, Selby Road, Station Road, The Drive, The Square, Valley Road, Westfield Lane and Woodlands Grove.

3.4.3 It is reported that at least 28 properties in Kippax as a whole were flooded internally during the rainfall event of the 8th and 10th August 2014. Flood depths internally were in the order of up to 300 mm. See below figure 37 for a plan of Kippax showing incidents relative to culvert position and low lying ground and figure 38 showing the damage caused by the floodwater.

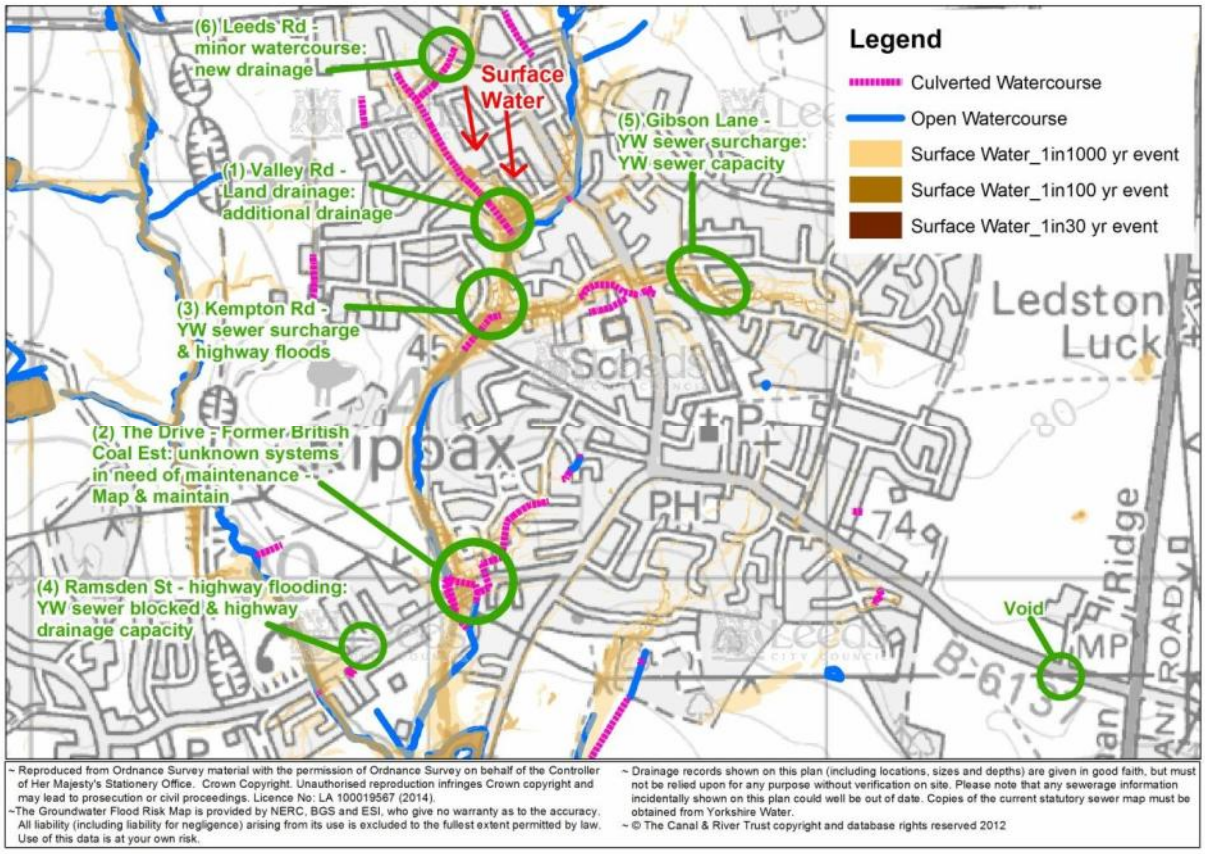



Figure 37: plan of Kippax showing incidents relative to culvert position (shown pink) and low lying ground (shown in browns)
[Whilst detailed information has been recorded, due to the restrictions imposed by the Data Protection Act flooding locations have been aggregated so as not to identify individual properties]

Figure 38: photographs of Fire Service attending flood victims, and devastation caused by internal flooding in Kippax

3.4.4 Countless properties suffered flooding to gardens. See figure 39 below.

Figure 39: flooded gardens in Kippax

3.4.5 The floodwater was caused by the extreme volume of water from overland run-off, which appears to have been exacerbated by surcharged combined sewers, surface water sewers, private drains, highway gullies, , culverted watercourses and open watercourses. Several sizeable lakes developed to depths up to 1000mm, notably Gibson Lane, Brigshaw Lane, Leeds Road and Valley Road. See figure 40 below.

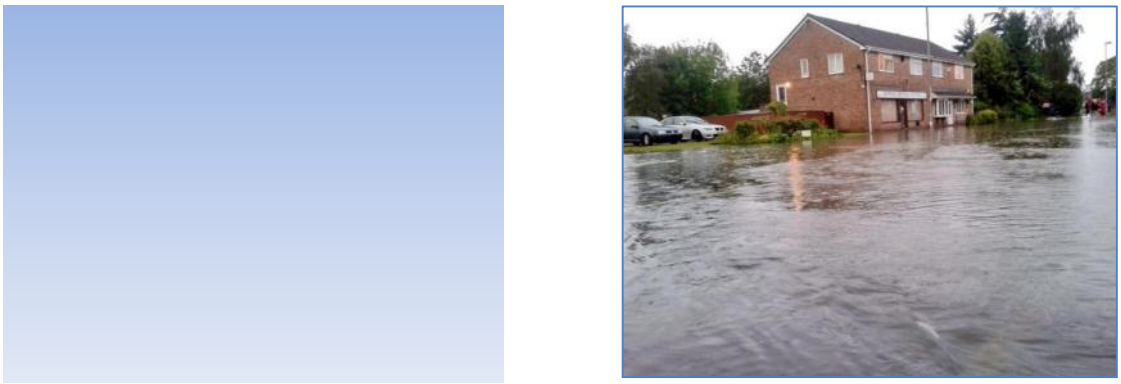


Figure 40: Brigshaw Lane and Gibson Lane, Kippax

Flood History

3.4.6 The Kippax area has a long history of flooding problems stretching back many years, and some residents are severely impacted because their homes, gardens or streets are subject to frequent inundation.

Existing Drainage System, Kippax

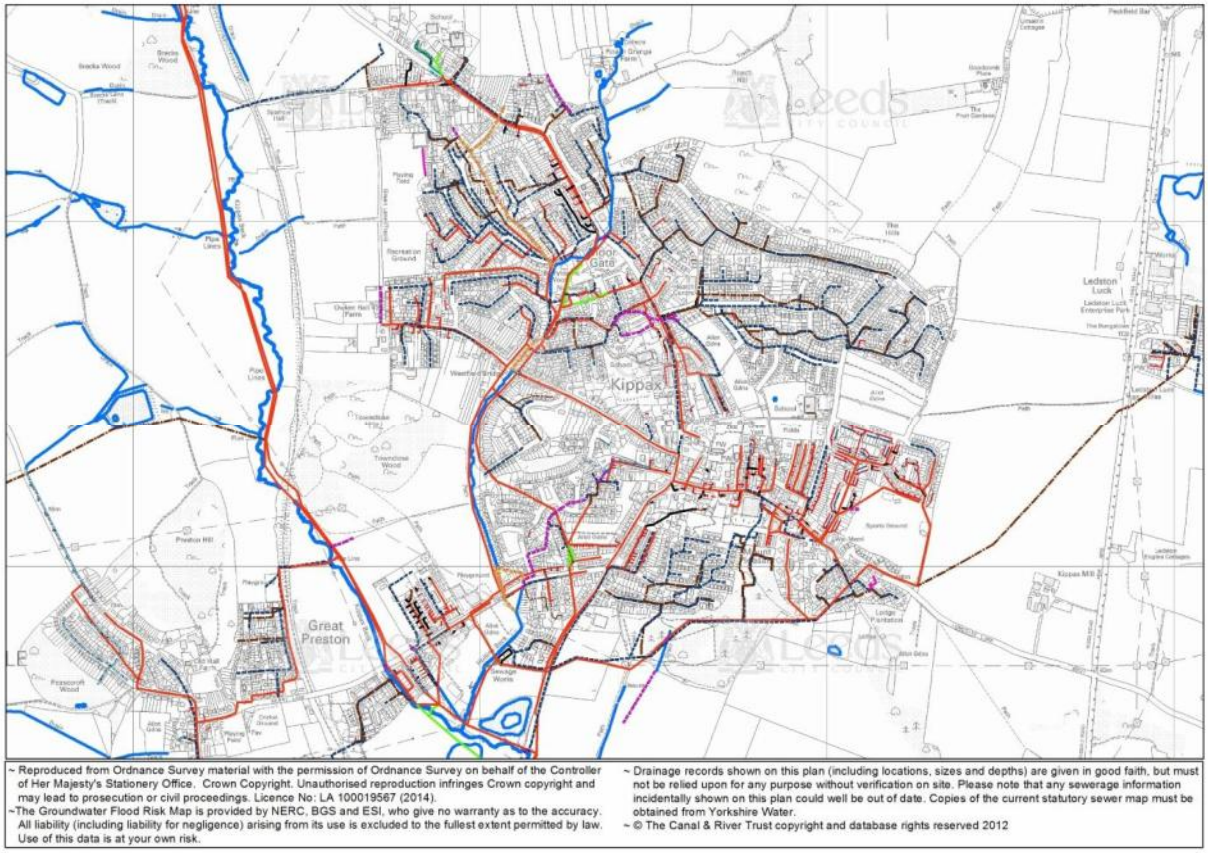



Figure 41: Extract from Leeds City Councils Geographic information system (GIS), drainage asset register showing public combined sewers (red), public surface water sewers (blue dash), becks/rivers (solid blue), culverted watercourses (pink & brown) and Highway Drainage (Turquoise), note road gullies omitted for clarity

3.4.7 Several piped and open drainage systems are present in the vicinity of the flooding that occurred on the August 8th and 10th. These are shown above in figure 41.

3.4.8 Due to the widespread nature of the flooding in Kippax, it is not appropriate or within the scope/timescale of this report to discuss the detailed layout of the existing drainage system relative to each affected street (see para 1.11 above).

Summary of findings

3.4.9 Unlike Allerton Bywater and Garforth**,** where huge swathes of the respective communities were flooded by massive overland sheet flows, flooding incidents in Kippax were more localised but just as intense and catastrophic.

**Leeds Road**

Figure 42: Leeds Road B6137, internally-flooded property and carriageway

3.4.10 Due to overwhelming water surcharge pressure of the culverted watercourse caused by agricultural surface water runoff, immense volumes of floodwater escaped and gravitated overland to lower lying residential properties. The resultant overland flows also flooded the B6137, Leeds Road as shown above in figure 42.

3.4.11 Internal CCTV inspection of the surcharged riparian owned culverted section by Leeds City Council surveyors has revealed no blockages or defects.

**Valley Road**

Figure 43: Valley Road and adjacent property internally flooded

3.4.12 Due to overwhelming water surcharge pressure on the public sewer network, immense volumes of flood water escaped and gravitated overland to flood lower lying residential properties. The resultant overland flows also flooded Valley Road as shown above in figure 43.

3.4.13 Internal CCTV inspection of the nearby riparian culverted section by Leeds City Council surveyors has revealed no blockages or defects and it is, therefore, assumed that the culverted watercourse played no part in flooding at this location.

**Gibson Lane, Pondfields Drive & Moorleigh Close**

3.4.14 Due to overwhelming water surcharge pressure on the public sewer network, immense volumes of flood water escaped and gravitated overland to flood lower lying residential properties. The resultant overland flows also flooded Gibson Lane and Leeds Road as can be seen below in figure 44.

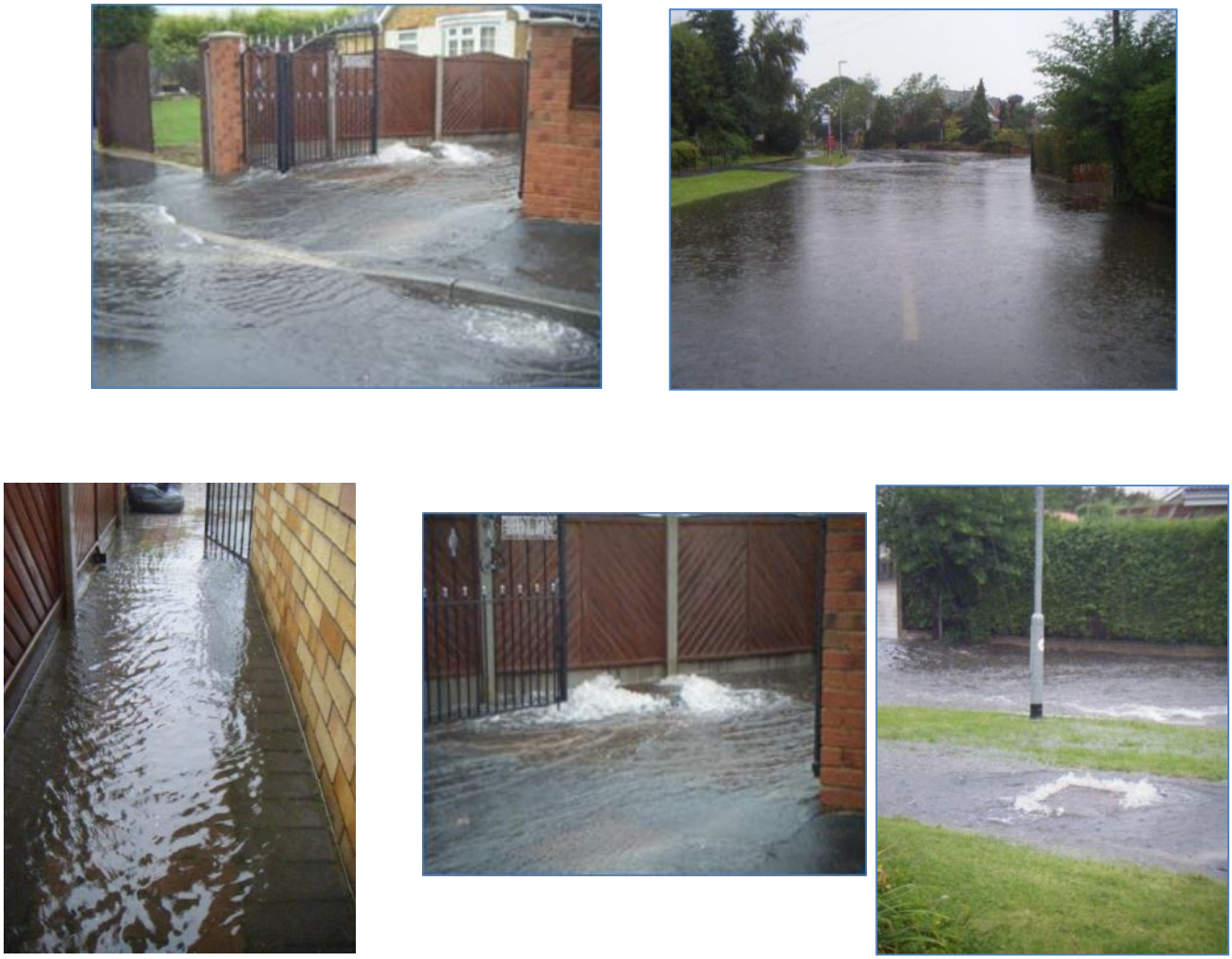


Figure 44: photographs of flooding at Gibson Lane, Pondfields Drive & Moorleigh Close

3.4.15 The highway gullies drain into the public surface water sewer system, and the inability of the highway drainage system to discharge to these surcharged systems will have contributed to the flooding.

**Kempton Road, Ebor Mount and Westfield Lane**

Figure 45: flood damage and residents desperately attempting to defend their homes with sandbags

3.4.16 Due to overwhelming water surcharge pressure on the public sewer network, immense volumes of flood water escaped and gravitated overland to flood lower lying residential properties. Eye witness reports state that manhole covers were blown off and discarded several metres away from the manhole shaft. See figure 45 above.

3.4.17 Public sewer surcharge on Ebor Mount resulted in extensive collateral damage to the carriageway. The resultant overland flows contributed to flooding property on nearby Westfield Lane.

3.4.18 YW have discovered a partial blockage in the Kempton Road public sewer which may have in a small way contributed to the sewer surcharge and resultant water escape.

3.4.19 Internal CCTV inspection of the nearby riparian-owned culverted section by Leeds City Council surveyors has, to date, revealed no significant blockages or defects and it is, therefore, assumed that the culverted watercourse played no part in flooding at this location.

**The Drive & Station Road aka "The Wimpey estate"**

3.4.20 Due to overwhelming water surcharge pressure caused by a blockage within the private sewer network, even greater volumes of flood water escaped upstream of this area and gravitated overland to flood lower lying residential properties. See figure 46 below.


Figure 46: FRM clearing blocked private sewers in The Drive, Saturday 9th August

3.4.21 Eye witness statements also report sewerage flooding from nearby surcharged / overwhelmed public sewers.

**Ramsden Street**

3.4.22 Due to overwhelming water surcharge pressure on the public sewer network, immense volumes of flood water escaped from Helena Street and gravitated overland via Station Road to flood lower lying residential properties in Ramsden Street.

3.4.23 YW have discovered a partial blockage in the Station Road public sewer which may have contributed to the sewer surcharge.

3.4.24 The highway gullies drain into the public surface water sewer system, and the inability of the highway drainage system to discharge to these surcharged systems will have contributed to the flooding.

3.4.25 Eye witness statements also report fluvial (beck/watercourse) flooding from the nearby Kippax Beck which affected properties on Ramsden Street.

3.4.26 It should be noted that most of the affected flood areas fall within valleys**,** low lying areas and the overland flows track towards natural watercourses/becks. These areas are identified as susceptible to surface water flooding as indicated by the Environment Agency's flood risk model (see figure 47 below).

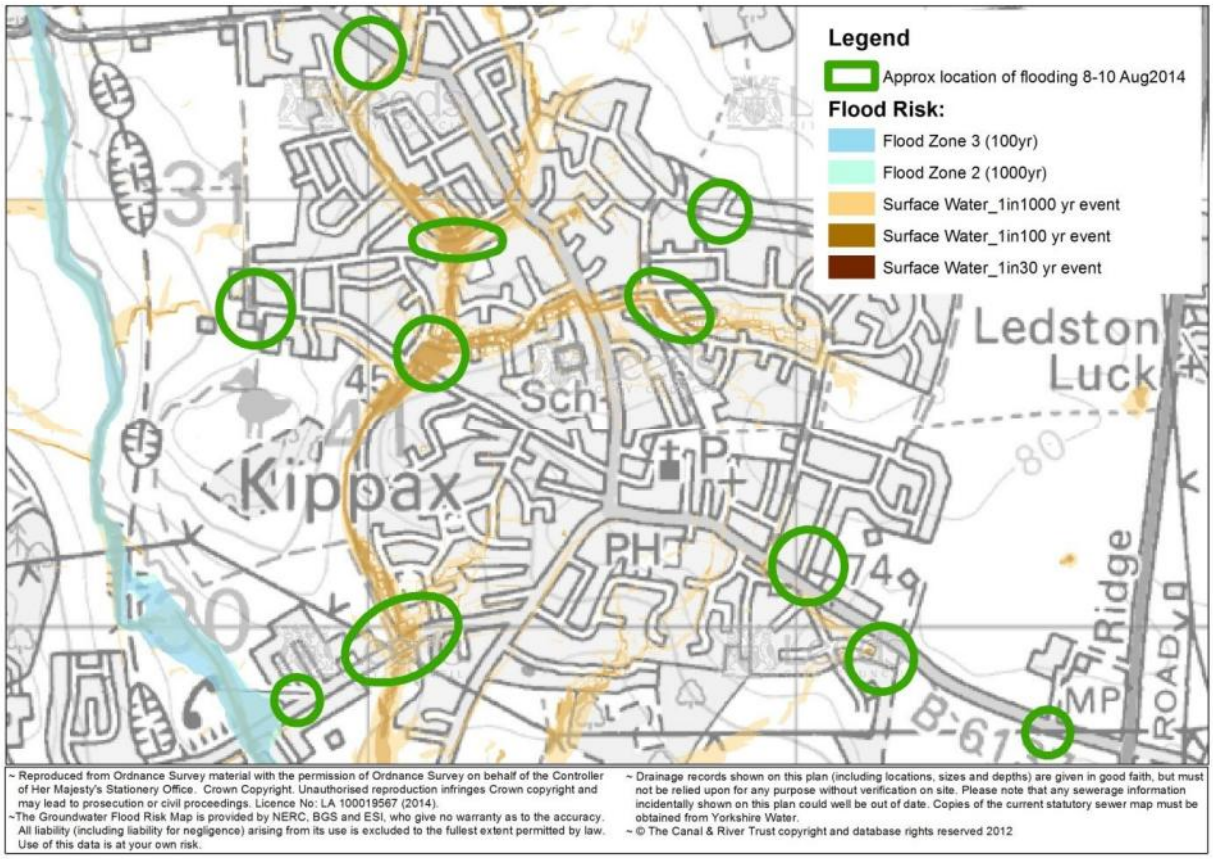



Figure 47: incidents related to topography and flood risk zones
[Whilst detailed information has been recorded, due to the restrictions imposed by the Data Protection Act flooding locations have been aggregated so as not to identify individual properties]

3.4.27 In summary, the storm that occurred in Kippax on August 8th and 10th was of exceptional intensity and exceeded current or historic design standards for all sections of drainage infrastructure and it is certain that substantial and localised flooding would have occurred irrespective of the condition or state of operation of the existing drainage network.

## 3.5 **Micklefield**

Brief description of the flooding event

3.5.1 Extensive surface water (pluvial) flooding covering sections of the district of Micklefield.

3.5.2 Streets known to have been worst affected at this time were:

Churchville, Churchville Avenue, Churchville Drive, Garden Village, Great North Road, Sunnybank and The Crescent.

3.5.3 It is reported that at least 18 properties in Micklefield as a whole were flooded internally during the rainfall event of the August 8th and 10th 2014. Flood depths internally were in the order of up to 300 mm. See figure 48 for plan of Micklefield showing incidents and low lying ground and figure 49 showing photos of damage caused by floodwater.

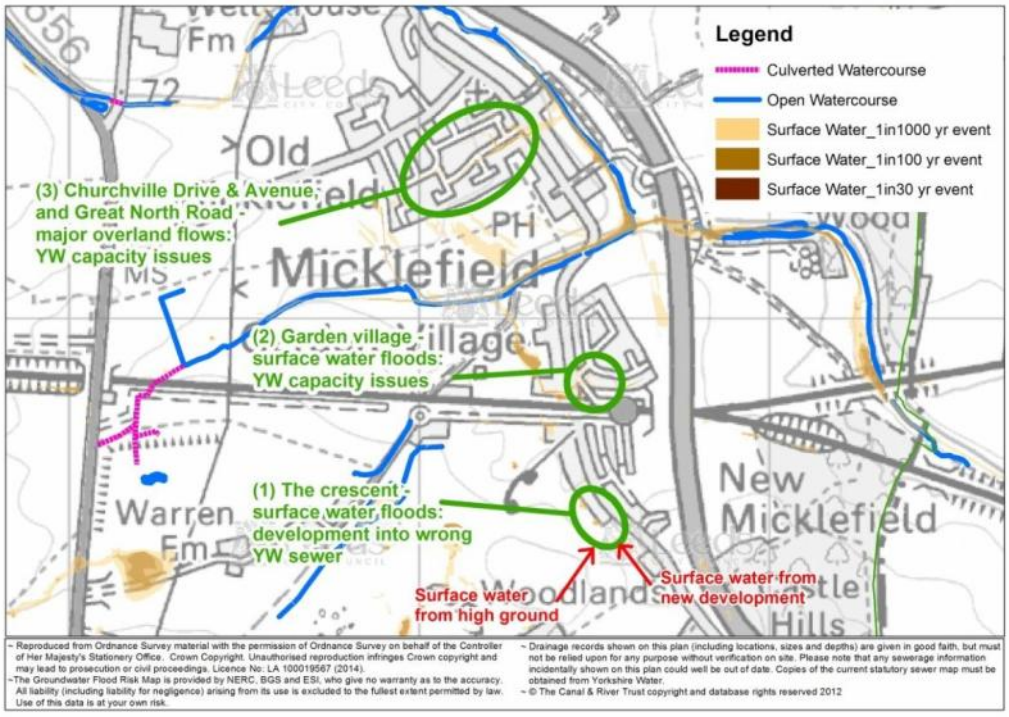



Figure 48: plan of Micklefield showing incidents and low lying ground (shown in browns). [Whilst detailed information has been recorded, due to the restrictions imposed by the Data Protection Act flooding locations have been aggregated so as not to identify individual properties]

Figure 49: clearing flood damaged properties in the aftermath flooding, Micklefield

3.5.4 Countless properties suffered flooding to gardens, as shown in figure 50.

Figure 50: gardens in flood, Micklefield

3.5.5 The floodwater came from the extreme volume of water of overland run-off, with surcharged combined sewers, surface water sewers, private drains and highway gullies. Several sizeable lakes developed to depths up to 1000mm, notably The Crescent and Great North Road. See figure 51 below.

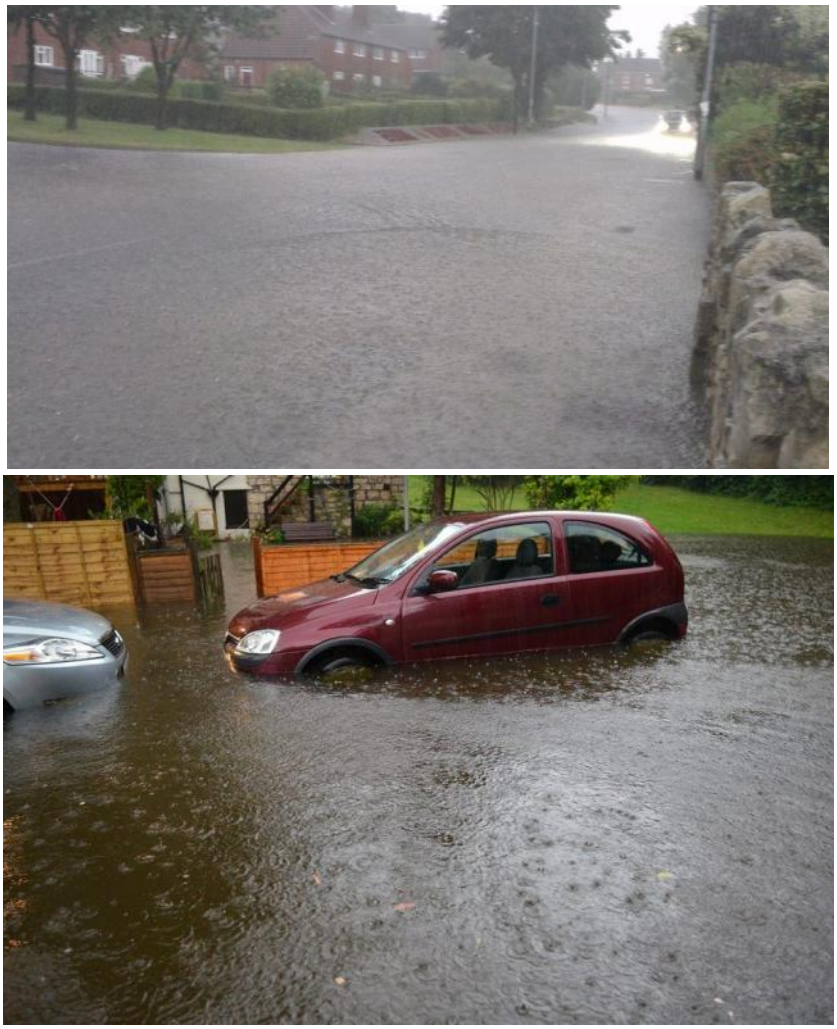


Figure 51: photographs of deep water, Great North Road & The Crescent, Micklefield

Flood History

3.5.6 Flood Risk Management have no historical records of flooding at the above locations, however, anecdotal evidence suggests properties along the Great North Road have flooded previously.

Existing Drainage System, Micklefield

3.5.7 Several piped and open drainage systems are present in the vicinity of the flooding that occurred on August 8th and 10th. These are shown below in figure 52.

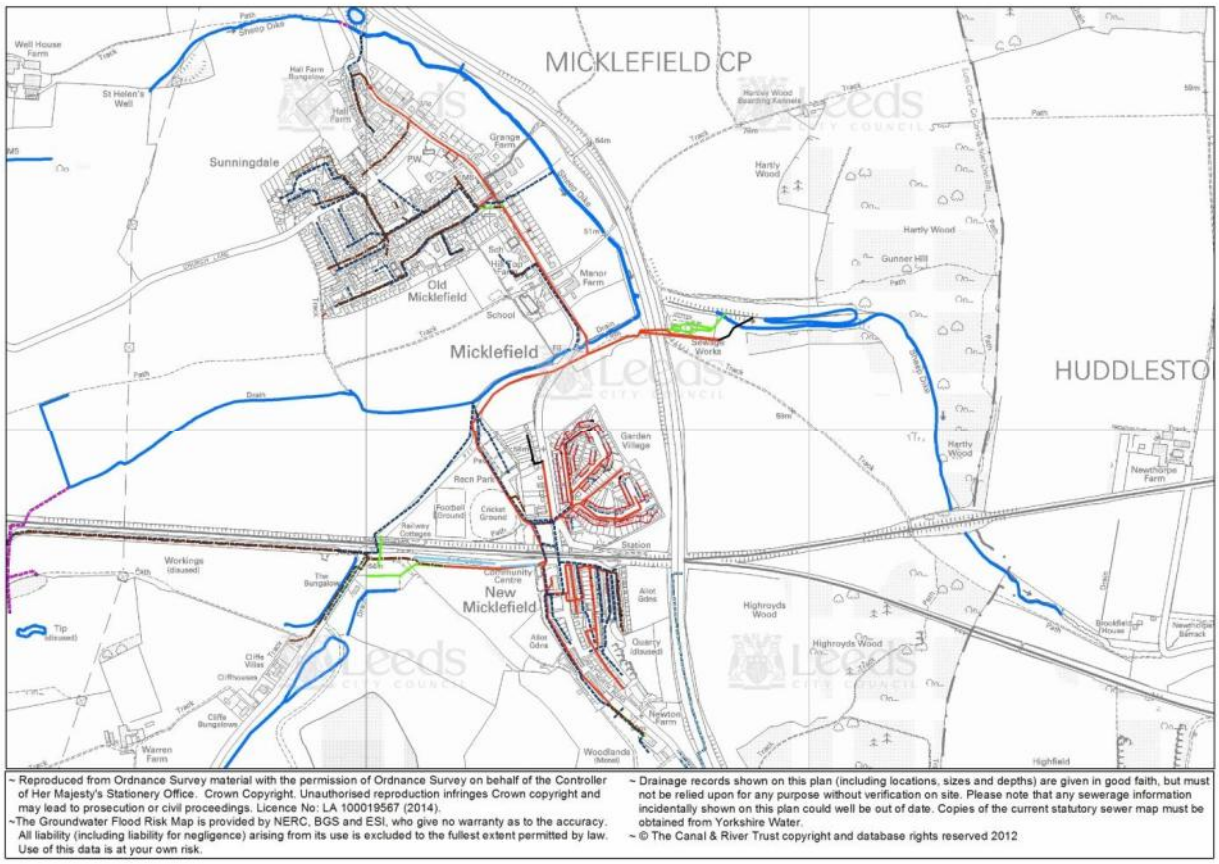



Figure 52: Extract from Leeds City Councils Geographic information system (GIS), drainage asset register showing public combined sewers (red), public surface water sewers (blue dash), becks/rivers (solid blue), culverted watercourses (pink & brown) and Highway Drainage (Turquoise), note road gullies omitted for clarity

3.5.8 Due to the widespread nature of the flooding in Micklefield, it is not appropriate or within the scope/timescale of this report to discuss the detailed layout of the existing drainage system relative to each affected street (see para 1.11 above).

**Summary of findings**

3.5.9 Unlike Allerton Bywater and Garforth where huge swathes of the respective communities were flooded by massive overland sheet flows, flooding incidents in Micklefield were more localised but just as intense and catastrophic.

3.5.10 The primary cause was the extreme volume of water, which appears to have been exacerbated by potential problems of localised flooding at The Crescent, Churchville, Churchville Avenue, Churchville Drive, Garden Village, and Great North Road as the rainfall event exceeding the design capacity of the public sewer network which drains the area.

3.5.11 The highway gullies drain into the public surface water sewer system, and the inability of the highway drainage system to discharge to these surcharged systems will have contributed to the flooding.

3.5.12 There are no culverted or open watercourses which impact on any flooding incident in Micklefield.

3.5.13 Surface water runoff from higher ground may have been a contributory factor towards flooding at Sunnybank and The Crescent.

3.5.14 Residents at The Crescent are particularly concerned about activities and land use of the adjacent landfill site and feel that this may have been a further contributory factor.

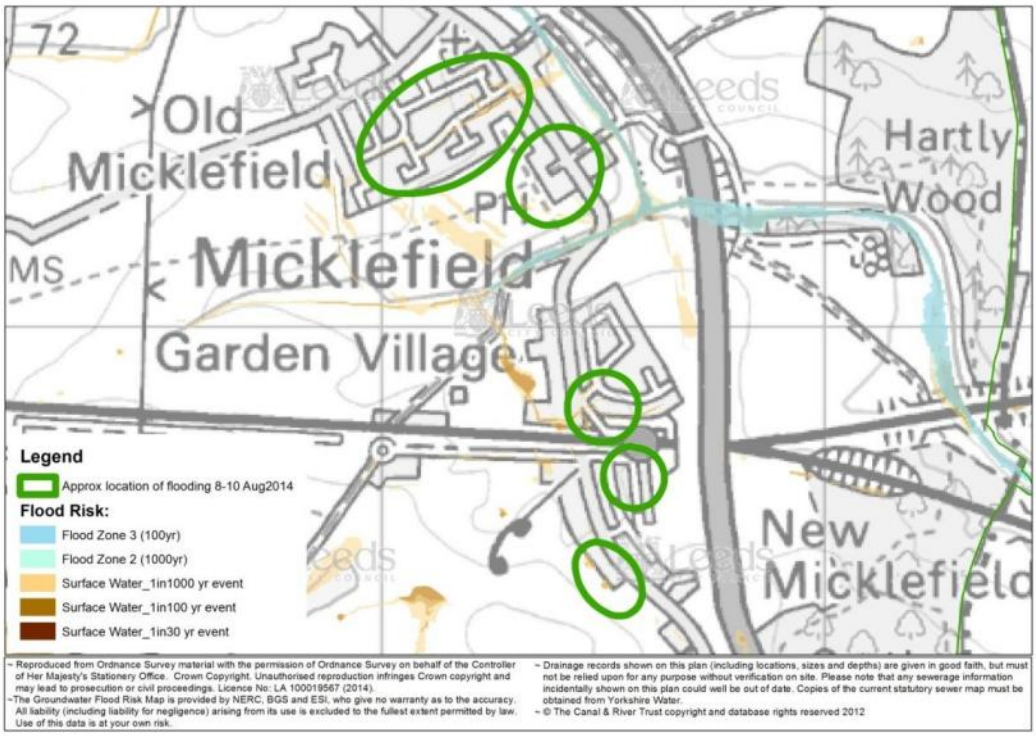



Figure 53: incidents related to topography and flood risk zones
[Whilst detailed information has been recorded, due to the restrictions imposed by the Data Protection Act flooding locations have been aggregated so as not to identify individual properties]

3.5.15 It should be noted that most of the affected flood areas fall within natural, low lying areas as the overland flows track towards distant natural watercourses/becks. These areas are identified as susceptible to surface water flooding as indicated by the Environment Agency's flood risk model (see figure 53 above).

3.5.16 In summary, the storm that occurred in Micklefield on August 8th and 10th was of exceptional intensity and exceeded current or historic design standards for all sections of drainage infrastructure and it is certain that substantial and localised flooding would have occurred irrespective of the condition or state of operation of the existing drainage network.

## 4. RIGHTS AND RESPONSIBILITIES IN RELATION TO DRAINAGE INFRASTRUCTURE

4.1 Responsibility for drainage is split between different organisations or groups of people. The principal responsibilities are summarised below:

### Yorkshire Water

4.2 Yorkshire Water (YW) is the Statutory Sewerage Undertaker, responsible for and maintaining the public sewers. The recorded position of public foul, surface water and combined sewers is shown on the Statutory Sewer Map – though this is incomplete. During normal office hours it may be inspected, free of charge, at Western House, Halifax Road, Bradford, BD6 2LZ. A printed extract from the Statutory Sewer Map may be purchased from YW mapping services. They can be contacted on 0345 1 24 24 24. Each Local Authority has a copy for their district. In Leeds this is available for the public to view free of charge at the reception of the Development Department, Leonardo Building, 2 Rossington Street, Leeds, LS2 8HD.

### Riparian Owners

4.3 Watercourses – whether in open channels or culverts – are generally owned by whoever owns the land that the watercourse runs through or alongside - i.e. the riparian owner. This means that ownership is sometimes shared by property owners on either side of the watercourse. The riparian owner is responsible for maintaining the bed and banks of the watercourse (including trees and shrubs growing on the banks), and for clearing any debris, natural or otherwise, even if it did not originate from that owner's land.

### Leeds City Council (Flood Risk Management Section)

4.4 The Council is the lead local flood authority for the District and operating authority for 'ordinary watercourses' (as opposed to 'main rivers'). It has permissive powers to carry out flood defence works, but does not have a duty in this respect. The Council has the power to require riparian owners to clear blockages and, in accordance with its Flood Defence Policy Statement, carries out routine inspections of watercourses throughout the City. It also investigates specific complaints about flooding problems.

### Leeds City Council (Landowning Departments)

4.5 The Council owns a considerable area of land, which is crossed by watercourses, and is consequently a riparian owner. In such cases, the managing Department has the overall duties of a riparian owner, but Flood Risk Management carries out the routine maintenance of these watercourses.

**Leeds City Council (Highways & Transportation/Streetscene Services)**

4.6 The Council is the highway authority and as such has a duty to maintain the highway and may provide drainage systems for the purpose of draining the highway. The Highway Services Division is responsible for providing any highway drainage systems. The Streetscene Services is responsible for highway gully cleansing. The highway authority is also responsible for any culverts carrying watercourses under highways. In the case of culverts less than 900mm in diameter, this responsibility is exercised by FRM on behalf of the Highways Services Division. For culverts greater than or equal to 900mm in diameter it is exercised by the Bridges Section of Highways & Transportation.

**Environment Agency**

4.7 The Environment Agency is the flood defence operating authority for 'main rivers' and has powers in respect of these that are similar to those of the Council for 'ordinary watercourses' (see 4.4 above)

**Private Property Owners (General Overview)**

4.8 Private sewers and drains are the responsibility of the property owner. The pipes connecting individual properties to the public sewers are generally classed as private sewers or drains. If there were a blockage or defect on such a sewer or drain, all property owners upstream of the blockage would be expected to share the cost of its removal.

4.9 Individual landowners are responsible for the drainage of their own land. This means accepting and dealing with natural flows from higher land. No liability is generally incurred by a higher landowner when flow arriving naturally on his/her land is allowed to run off onto lower adjacent land – provided that there is no wilful action involved and that the flow has not been artificially concentrated in a particular place.

4.10 Property owners are also responsible for dealing with groundwater ingress into cellars.

## 5. Conclusions

5.1 The flooding suffered by these communities was a result of an extreme rainfall event, with in excess of 80mm of rainfall in many locations.

5.2 This rainfall led to substantial overland flows, as the rainfall struggled to get into the drainage systems. This was due to the sheer volume of rainfall being unable to drain away and also, as the drains became full, lack of capacity in these drains.

5.3 Subsequently the drains themselves were overfull and they surcharged, with water escaping the drains through manholes. This happened because of the sheer volume of water in the drains. The slightest bottleneck and junction between two drains will exacerbate these problems.

5.4 As the overland flows and any surcharges built up, it created a bigger and bigger issue, leading to greater and greater flooding.

5.5 The investigations so far have shown some issues with parts of the drainage systems:

- Culverted watercourses with insufficient capacity and bottlenecks restricting flows.
- Sewers that surcharged due to capacity issues for such extreme events.
- Gullies not having sufficient capacity in such extreme events to drain water from highways.
- Areas with little or no drainage. There have been specific issues with green areas, where water is expected to drain away slowly but when there is intense rainfall, or the ground becomes saturated, this is not possible, so overland flows build up.

5.6 Where issues have been found, actions have been taken to resolve them where possible. However there are some locations where further works might reduce the risk of future flooding.

5.7 Plans of the worst affected locations, which show issues and potential measures, are included as Appendix H. A list of potential works has been drawn up which are attached as Appendix I - the cost of these works has initially been estimated at £3.6m.

5.8 This was an extreme event and, therefore, it is unlikely that sufficient measures can be taken to remove the risk of flooding, from these properties for a similar event in the future, but the measures outlined may reduce the risk they face for a number of different storm events.

5.9 This event was in the order of a 1:200 or 0.5% (source: FEH) chance of occurring in any one year and was an extreme event that occurred in only a small part of the District. It should be noted that flooding was largely due to surface water run-off only - with Rivers, in the main, not causing major issues.

5.10 The regularity of flooding events seems to be increasing. This may be a sign of long-term changing climate or just a short-term trend.

## 6. Recommendations

6.1 It is suggested that further works are carried out to ensure a full understand**ing** of all the flooding**;**

6.2 That a Capital Programme is drawn up for proposed works in this area, alongside those for other parts of the district**;**

6.3 That partnership working with the other agencies involved continues, as it is crucial that efforts are co-ordinated.

## 7. Disclaimer

This report has been prepared as part of Leeds City Council's responsibilities under the Flood and Water Management Act 2010.

The findings of the report are based on a subjective assessment of the information available by those undertaking the investigation and therefore may not include all relevant information. As such it should not be considered as a definitive assessment of all factors that may have triggered or contributed to the flooding events.

The opinions, conclusions and any recommendations in this Report are based on assumptions made by Leeds City Council when preparing this report, including, but not limited to those key assumptions noted in the Report, including reliance on information provided by others.

Leeds City Council expressly disclaims responsibility for any error in, or omission from, this report arising from or in connection with any of the assumptions being incorrect.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the time of preparation and Leeds City Council expressly disclaims responsibility for any error in, or omission from, this report arising from or in connection with those opinions, conclusions and any recommendations.

This report provides a summary of the extent and consequences of the flooding and any actions undertaken or proposed by each of the identified authorities with a responsibility for flooding at the identified site. This includes information relating to improvement works or general maintenance carried out at the site.

Whilst this report has sought to investigate the causes of flooding and may make recommendations as to how the risk and / or impact of flooding may be reduced, this does not provide Leeds City Council with the mandate or funding to implement any measures to reduce the risk of flooding at this site.

Leeds City Council does not accept any liability for the use of this report or its contents by any third party.

## 8. Glossary of terms

FEH – Flood Estimation Handbook

FRM – Leeds City Council's Flood Risk Management team

FSR – Flood Studies Report

LCC – Leeds City Council

YW – Yorkshire Water