Appleby-in-Westmorland

Flood Investigation Report

Appleby-in-Westmorland on 6th December

Flood Event 5-6th December 2015

This Flood Investigation Report has been produced by Cumbria County Council as the Lead Local Flood Authority under Section 19 of the Flood and Water Management Act 2010 in partnership with the Environment Agency as a key Risk Management Authority.

Version	Undertaken by	Reviewed by	Approved by	Date
Preliminary	Sejal Shah	Graham Fardell		20th May 2016
Draft incorporating EA feedback	Sejal Shah			
Version v2.0 Incorporates EA comments and updates	Sejal Shah	Graham Fardell	Graham Fardell	29th June 2016
Final Version	Iwan Lawton	Doug Coyle	Doug Coyle	20th Feb 2017

Contents

Executive Summary

The flooding experienced across Cumbria on 5-6th December 2015 as a result of Storm Desmond was unprecedented, although in Appleby there have been other occasions when the flooding experienced in the town is known to have been of similar magnitude. Storm Desmond caused a period of prolonged, intense rainfall across Northern England, falling on an already saturated catchment and led to high river levels and flooding throughout Cumbria and beyond. The flow in the River Eden in Appleby on the 6th of December was the highest ever recorded since recording began at the gauging station in the town in 1984, resulting in flood levels in some locations that were approximately 1.7m higher than those experienced during the previous record set in January 2005.

In response to the flood event, this *Section 19 – Flood Investigation Report* has been completed by the Environment Agency as a key Risk Management Authority (RMA) working in partnership with Cumbria County Council as the Lead Local Flood Authority, under the duties as set out in Section 19 of the Flood and Water Management Act 2010. This report provides details on the flooding that occurred in Appleby on the 5th and 6th of December and has used a range of data collected from affected residents, site visits, surveys of the area, data collected by observers and river and rainfall telemetry during the flood event. This data has been compiled by CH2M, specialist consultants in flood risk management who have provided advice in understanding the event and recommendations for future action.

The existing flood defences in Appleby were designed in 1995 to protect the town from a flooding event with an annual exceedance probability (AEP) of 1%. The river levels experienced in December 2015 exceeded the design level of the existing defences, resulting in extensive flooding of the town centre. Although defences were overtopped, no defences were breached, although the wing wall at Holme Street Foot Bridge failed as water levels receded. In some locations, defences were successful in reducing the damage and delayed flooding, which gave residents additional time to prepare and reduce the impact of the flood.

This report details the flooding that occurred from the River Eden and from surface water. It identifies the flow routes and the causes of the flooding where flood defences were overtopped or bypassed in a number of locations in Appleby which are listed below:

- The River Eden's banks upstream and downstream of St Lawrence Bridge
- Flood defence at the rear of St Lawrence Church
- Flood defence embankment at the Cricket field
- King George's Field defences
- Flood defence at Eden Community Outdoor
- Wall on left bank at Edenside Care home collapsed
- Downstream wing wall at Holme Street Bridge collapsed
- Doomgate culvert surcharged

Please note references to left and right bank are taken looking downstream in the direction of flow.

Fifteen actions have been recommended in this report to manage future flood risk, which will require the involvement of a number of organisations and local communities. One of the main actions is a review of the performance of the existing Appleby Flood Risk Management Scheme to identify what worked well and any areas that could be improved. This review will also include potential

improvements to processes such as flood warnings. This review is already underway and is expected to be complete by July.

In response to the flooding, a number of community meetings have taken place and these will continue in order to ensure that all those affected are given the opportunity to be involved in reducing the flood risk in their area of the town.

Any additional information that residents and others can provide to the Environment Agency and Cumbria County Council to help develop our understanding of the flooding is welcomed. A lot of information has already been provided, much of which has been used to inform this report. The scale of this report means that not every piece of information can be incorporated into the document. Any additional information should be provided to:

http://www.cumbria.gov.uk/planning-environment/flooding/floodriskassessment.asp

The Flood Investigation Report

Under Section 19 of the Flood and Water Management Act (2010) Cumbria County Council, as Lead Local Flood Authority (LLFA), has a statutory duty to produce Flood Investigation Reports for areas affected by flooding. Section 19 of the Flood and Water Management Act 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.

This section of the Act leaves the determination of the extent of flood investigation to the LLFA. It is not practical or realistic for Cumbria County Council to carry out a detailed investigation into every flood incident that occurs in the County, but every incident, together with basic details will be recorded by the LLFA.Only those with 5 or more properties/businesses involved will have investigations published.

An investigation will be carried out, and a report prepared and published by the LLFA when the flooding impacts meet the following criteria:

- where there is ambiguity surrounding the source or responsibility of flood incident,
- internal flooding of one property that has been experienced on more than one occasion,
- internal flooding of five properties has been experienced during one single flood incident and
- there is a risk to life as a result of flooding.

As a flood Risk Management Authority (RMA), the Environment Agency have partnered with Cumbria County Council (CCC) to produce the 53 flood investigation reports across Cumbria.

Scope of this report

This Flood Investigation Report **is**:

- an investigation on the what, when, why, and how the flooding took place resulting from the 5th-6th December 2015 flooding event and
- a means of identifying potential recommendations for actions to minimise the risk or impact of future flooding.

This Flood Investigation Report **does not**:

- interpret observations and measurements resulting from this flooding event. Interpretation will be undertaken as part of the subsequent reports,
- provide a complete description of what happens next.

The Flood Investigation Reports outline recommendations and actions that various organisations and authorities can do to minimise flood risk in affected areas. Once agreed, the reports can be used by communities and agencies as the basis for developing future plans to help make areas more resilient to flooding in the future.

For further information on the S19 process, including a timetable of Flood Forum events and associated documentation, please visit the County Council website at:

http://www.cumbria.gov.uk/floods2015/floodforums.asp

To provide feedback on the report please email **LFRM@cumbria.gov.uk**.

Introduction

Geographical Setting

The market town of Appleby-in-Westmorland is located in the Eden Valley in Cumbria, North West England with a population of approximately 3,000*. The town is situated within a meander of the River Eden which flows from south to north through the town, see Figure 1. The average annual rainfall in Appleby is 892.9mm (35.1 in).

The River Eden stretches approximately 80 miles from Helgill to the Solway and is a network of rivers, becks and lakes with the catchment area extending to approximately 2,300km^2. The River Eden rises in the Mallerstang valley on the Cumbria/North Yorkshire border, flows down through Kirkby Stephen and has many contributing becks flowing off the Pennines to the east before it reaches Appleby. The river is highly responsive and can be further fuelled in winter by snow melt, with the river rising to peak levels and back to a normal level within a period of 8-12 hours.

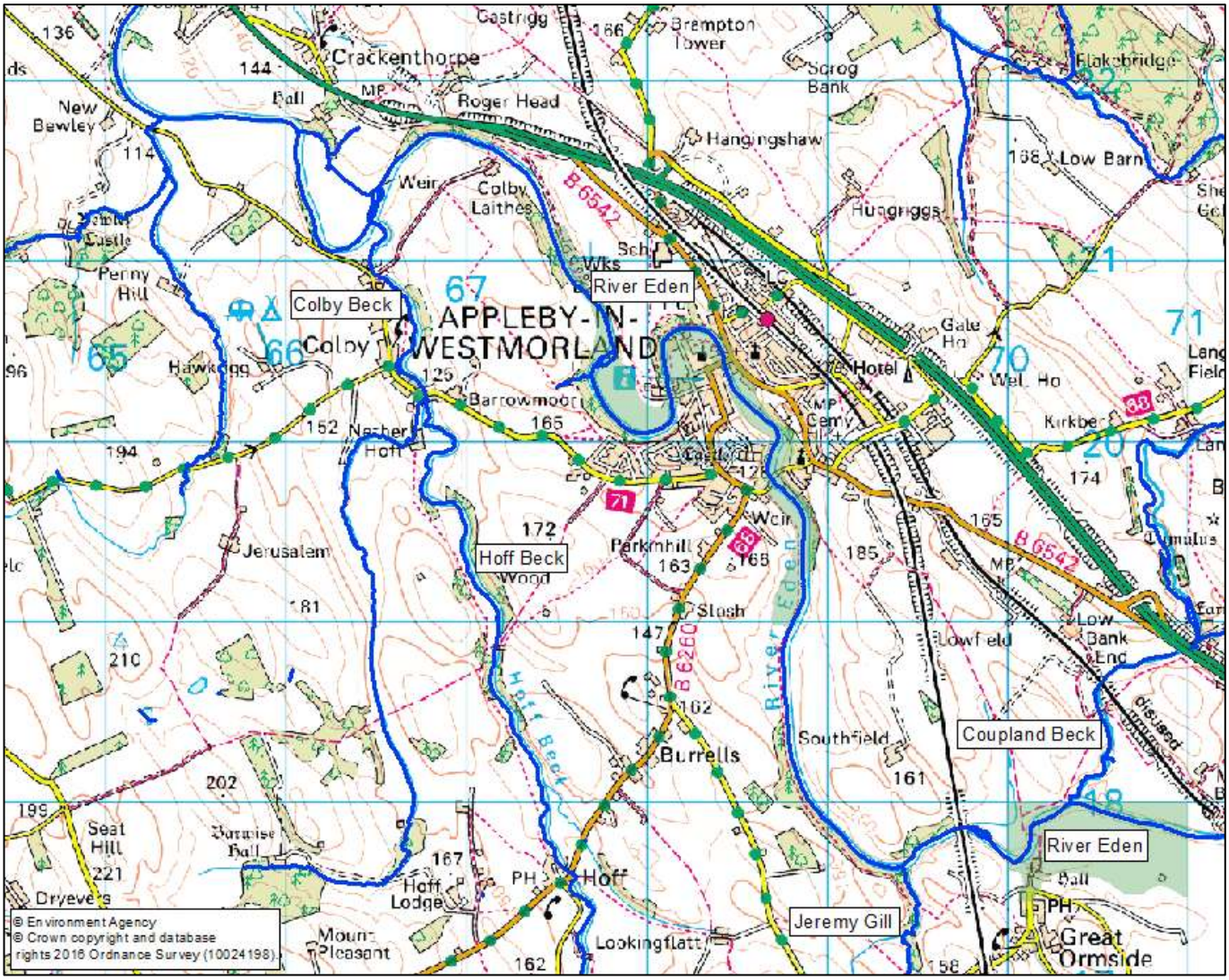


Figure 1: Location of Appleby-in-Westmorland

* Office of National Statistics, Census 2011

Flooding History

Appleby has a long history of flooding specifically The Sands area. Several areas of the town are naturally low lying and therefore most liable to flooding, these areas include St Lawrence Church and the main centre of the town including The Sands.

The first known evidence of flooding in Cumbria is from 1571 however the first known account and evidence of flooding in Appleby is from 1733. More detailed accounts of the flood events affecting the town are known from 1771. In the 200 years between 1815 and 2015 there have been 67 floods (where at least one property was flooded) recorded in 53 different years.

Apart from 2015 the other significant years when the most extensive and serious events took place were: 1817, 1822, 1856, 1925, 1968 and 2005. The majority of the floods occurred during the months of November-February, with few outside of these months. 1819, 1855, 1898, 1912 and 1928 were the only recorded flood events in summer.

No deaths have been directly attributed to flooding in the town and the deepest that the flood water is reported to have attained is 1.83 meters (6ft) – the same as reported during Storm Desmond.

The November 2009 event was estimated to be an event with a probability greater than 1% Annual Exceedence Prabability (AEP). The annual exceedence probability (AEP) describes the likelihood of a specified flow rate (or volume of water with specified duration) being exceeded in a given year. There are several ways to express AEP as shown in Table 1. Throughout this report AEP is expressed as a percentage. As such, an event having a 1 in 100 chance of occurring in any single year will be a 1% AEP event.

AEP (as percent)	AEP (as probability)	Annual recurrance interval (ARI)
50%	0.5	2-year
20%	0.2	5-year
10%	0.1	10-year
4%	0.04	25-year
2%	0.02	50-year
1%	0.01	100-year
0.1%	0.001	1000-year

Table 1: Probabilities of Exceedance

In December 2005, approximately 53 properties flooded in Appleby when the defences were overtopped. In The Sands area of the town, 35 properties flooded on three separate occasions. This area is more vulnerable to flooding as it is not protected by the flood defence scheme completed in 1995.

After the December 2005 flooding, around 45 properties received funding from one of the first national pilots for property level protection. The local Environment Agency Flood Resilience Team also worked with the local community to develop a flood action plan, so local people know what to do when there is a risk of flooding.

In the November 2009 flood event, the River Eden overtopped its banks and flooded four properties on The Sands.

The December 2015 event was of significantly greater magnitude than past events and the flow in the River Eden was the highest level ever recorded. Table 2 shows the river flow recorded upstream of Appleby for the historical events and for the 2015 flooding.

Flooding Event	Number of Properties Flooded	Peak Flow in River Eden @ Great Musgrave Bridge (m^3/s)*
January 2005	53	276.751
November 2009	4	240.7
December 2015	**176**	**372**

Table 2: Recent flood events affecting Appleby

* Flows for past events taken from CEH National River Flow Archive **http://nrfa.ceh.ac.uk/data/search**

Flood Event 5th-6th December 2015

Background

On 5th and 6th December 2015, approximately 166 properties were affected by flooding, with a number of properties along The Sands flooded on three separate occasions throughout December. The flooding can be attributed to a record-breaking rainfall event from Storm Desmond which led to widespread flooding from the River Eden as well as the surface water and drainage systems exceeding their capacities. Figure 2 shows the approximate extent of the flooding.

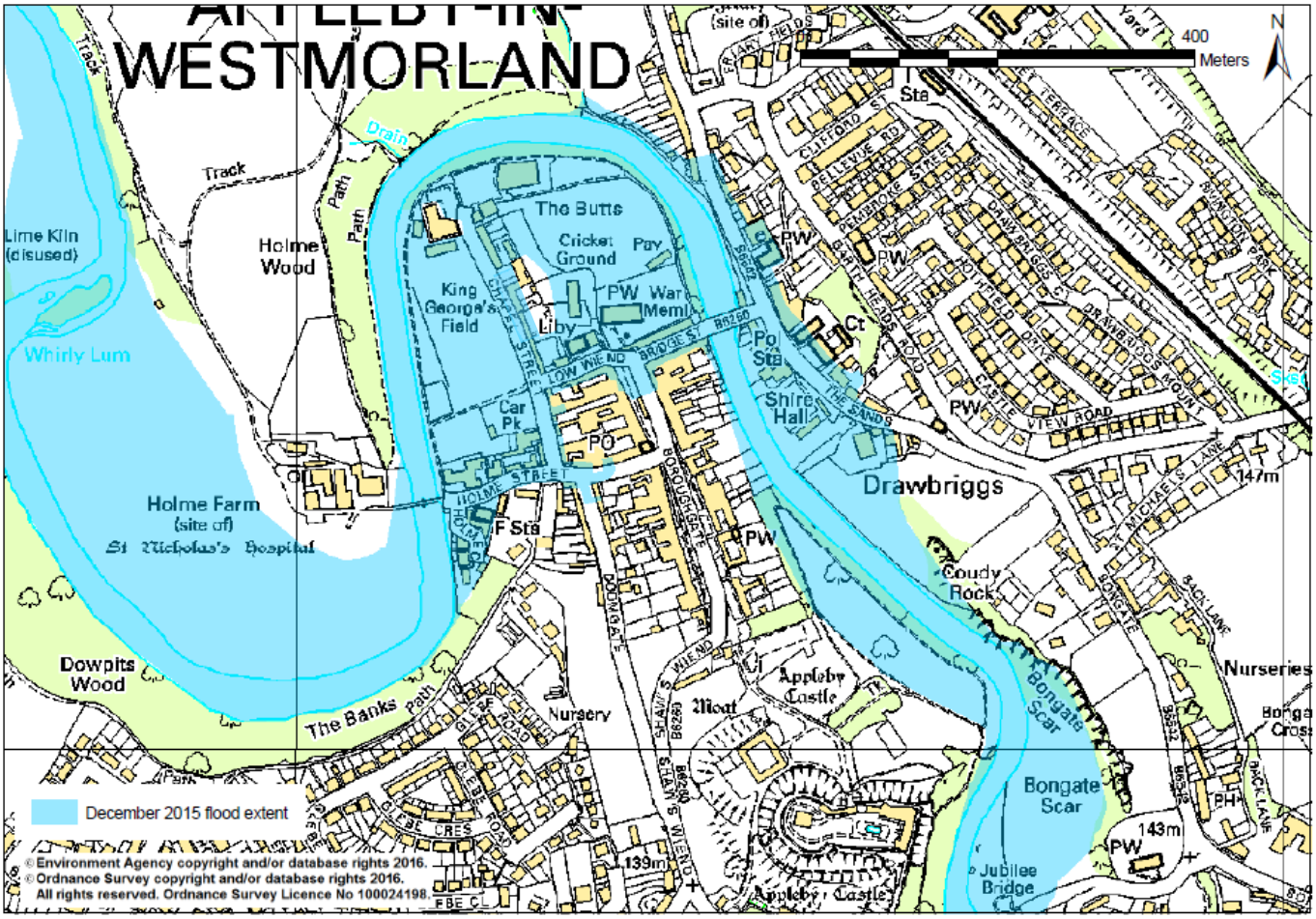


Figure 2: Extent of River (Fluvial) Flooding in Appleby on 5-6th December 2015

Flooding was primarily associated with fluvial (river) sources and the flooded properties are located in low lying areas adjacent to the River Eden.

The extent of the flood is similar to the Environment Agency's Flood Zone 3, however flood depths were higher than previously recorded.

Rainfall Event

December 2015 was the wettest calendar month on record with much of the northern UK receiving double the average December rainfall. This followed a particularly wet November and therefore much of the soil within the Cumbria catchments was already saturated.

From the 4th to the 7th of December 2015 there was a period of prolonged, intense rainfall caused by Storm Desmond. Over this period, new 24-hour and 48-hour rainfall records were set for the UK. Both of these were within Cumbria and these broke the previous records, also within Cumbria, set during the 2009 floods.

Table 3 shows the previous 24 and 48 hour rainfall records prior to the 2015 flooding event and the new records set in December 2015 during Storm Desmond.

	Previous record November 2009		Current Record December 2015	
	Location	**mm**	**Location**	**Mm**
24 hour rainfall	Seathwaite	316.4	Honister Pass	341.4
48 hour rainfall	Seathwaite	395.6	Thirlmere	405

Table 3: UK Rainfall Record*

Table 4 shows the rainfall more widely recorded over the catchment on the 4th and 5th December 2015. The location of these rain gauges around Appleby can be found in **Figure 3**.

Monitoring Station	Rainfall (mm)		
	4th December (09:00-08:59)	**5th December (09:00-08:59)**	**Max. rainfall in 24 hours**
Appleby Mill Hill†	50.3	61.6	111.9
Brackenber	42.2	63.2	82.6
Aisgill	43.7	94.9	104.75

Table 4: Rainfall recorded at gauges around Appleby

* Taken from met office – **www.metoffice.gov.uk/public/weather/climate-extremes** **http://www.metoffice.gov.uk/climate/uk/interesting/nov2009**

† Rainfall figures assuming standard rainfall days (09:00-08:59). Source: D.Rogers

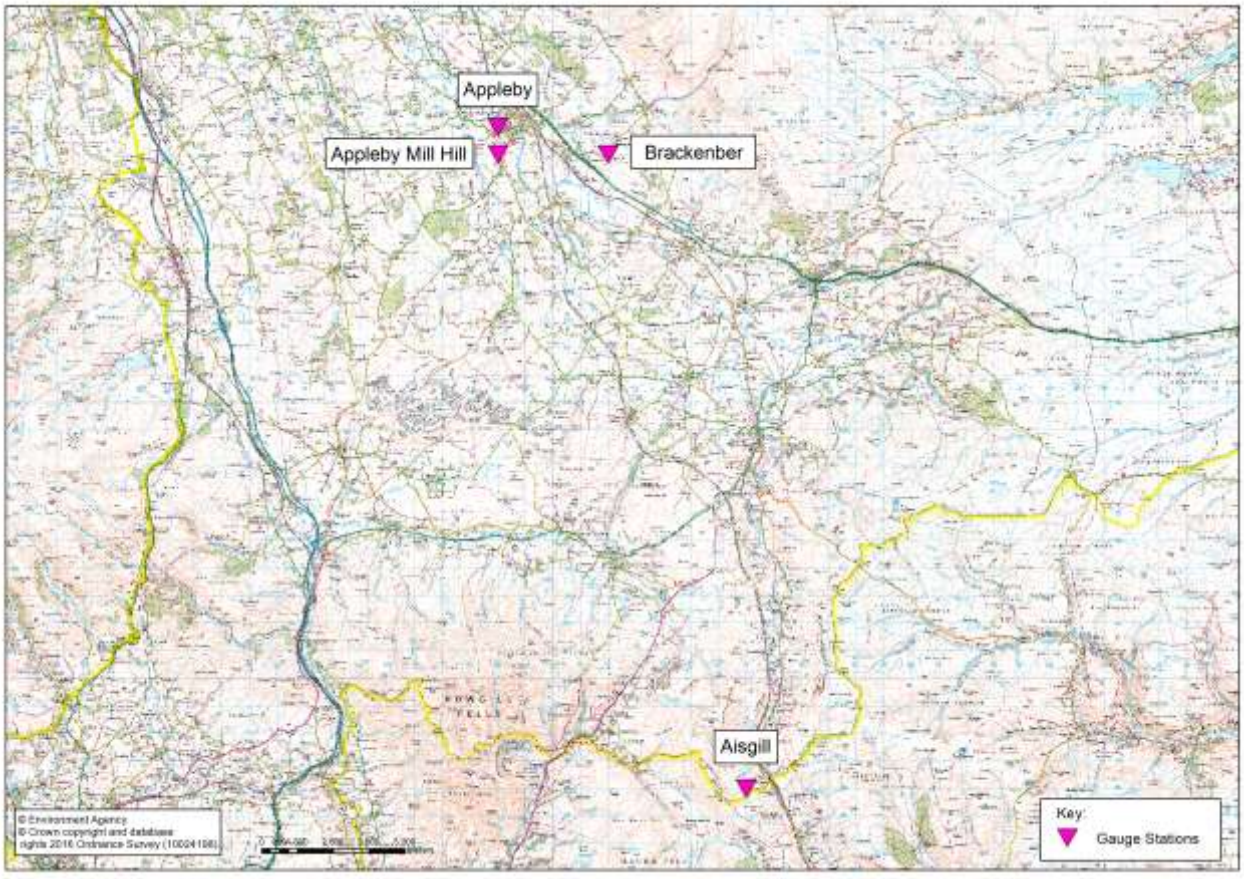


Figure 3: River Eden catchment and locations of rain gauges

River Levels

There are two river monitoring gauges upstream of Appleby and these are shown in Figure 4. The peak flows recorded on the River Eden are shown in Table 5, along with the flows from past flooding events.

Gauging Station	River	Peak flow (m3/s)		
		Dec 2015	Past Events*	
			Dec 2011	Jan 2005
Kirkby Stephen	Eden	**136**	123.5	129.12
Great Musgrave	Eden	**372**	280.88	276.75
Temple Sowerby	Eden	**1150**	353.1	925

Table 5: Peak Flow in River Gauges around Appleby

Figure 5 shows the flow recorded by these river monitoring gauges from the 4th to 9th of December 2015. This shows the time and duration of the flood event on the 5th and 6th of December and illustrates the magnitude of the flood event.

This is a greater magnitude event than the scheme was designed to protect against (1% AEP - 1 in 100). As such, river levels would be expected to be higher than the flood defence level and some overtopping of the defences would be expected to occur.

* Flows for past events taken from CEH National River Flow Archive **http://nrfa.ceh.ac.uk/data/search**

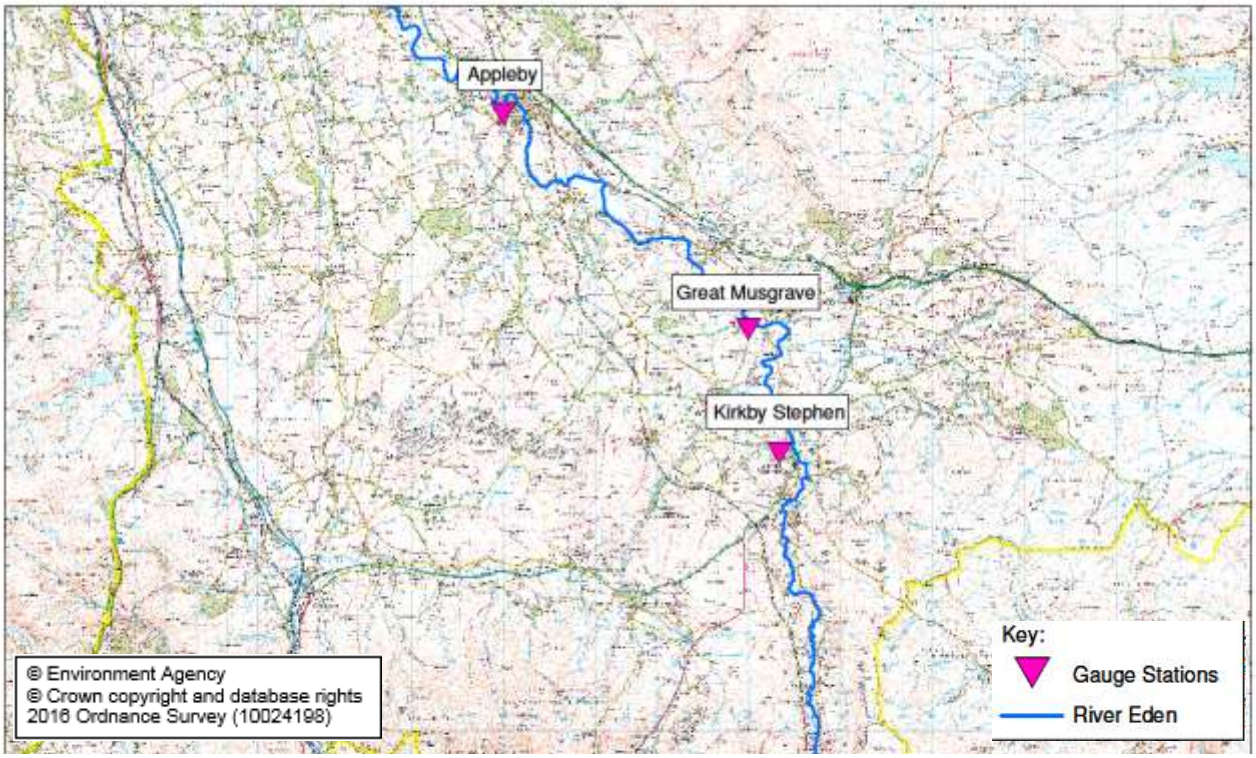


Figure 4: Location of river gauges upstream of Appleby

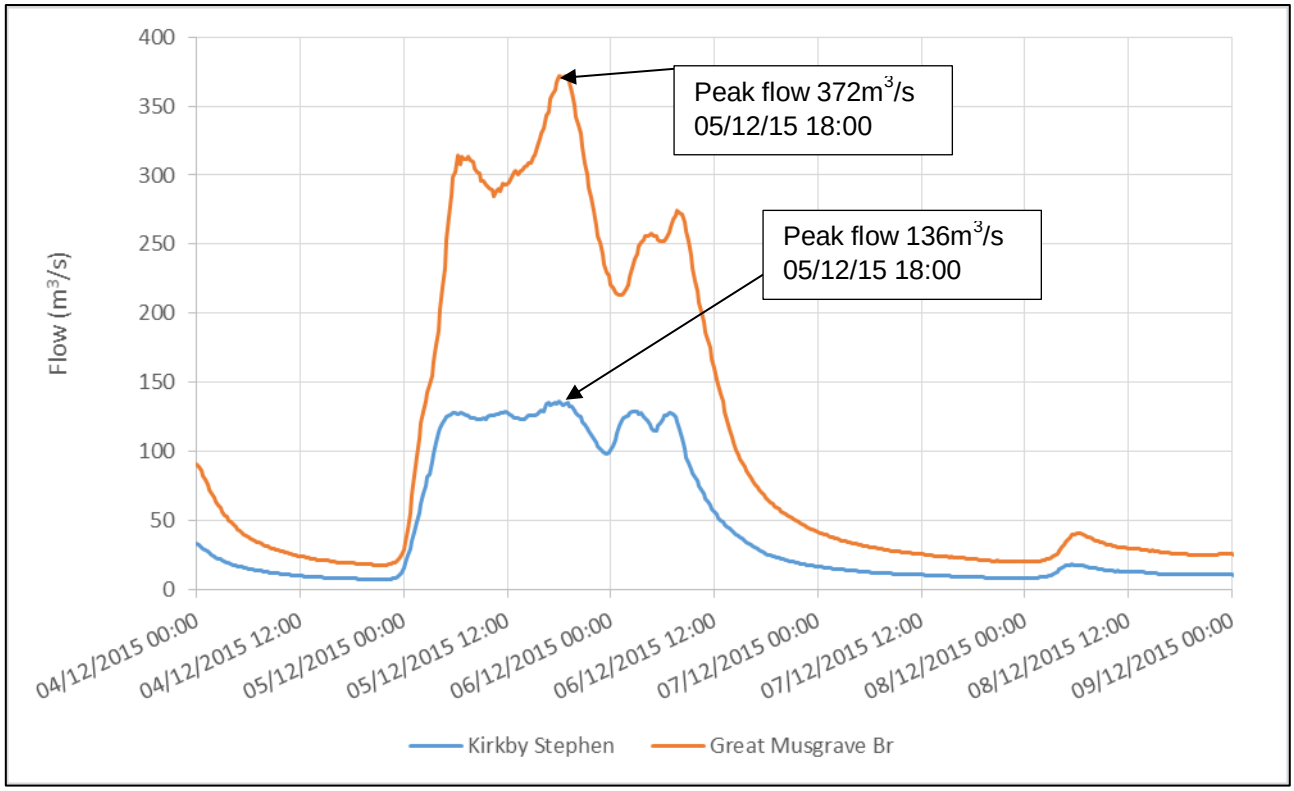


Figure 5: Recorded river flows for the December 2015 event upstream of Appleby

Existing Flood Defences

The Appleby flood defences have been constructed in several phases. In 1995, the Appleby Flood Risk Management scheme was constructed in the centre of Appleby, designed to provide 1% AEP protection to properties on Chapel Street, Bridge Street, Low Wiend & Holme Street from the River Eden, Figure 6.

The Appleby Flood Risk Management Scheme includes:

- Upstream of St Lawrence's Bridge – Raised flood defence wall including two stop logs
- Rear of St Lawrence Church/Bridge Street – Flood defence wall including pedestrian flood gate and raised earth embankment
- The Cloisters – demountable stop logs
- Cricket Ground – Raised embankment with central masonry wall core with wood and stone revetment on F/I. Pedestrian access flood gate to Allotment Gardens
- Appleby Leisure Centre – Vehicular and pedestrian access flood gates. Earth embankment to wall and flood wall now forming part of swimming pool building. Demountable flood wall (now replaced with reinforced concrete wall along river side of car park, including flood gates)
- Appleby Health Centre – Sandstone faced raised flood wall
- King George's Field/Chapel Street – Sandstone faced raised flood wall and raised earth embankment – remote from the river bank. Pedestrian and vehicular flood gates
- Rear of Holme Street – Raised earth embankment – remote from the river bank. Flood wall around Edenside Residential Home
- Rear of Holme Court – Rock armour then grass berm to base of masonry wall acting as raised defence

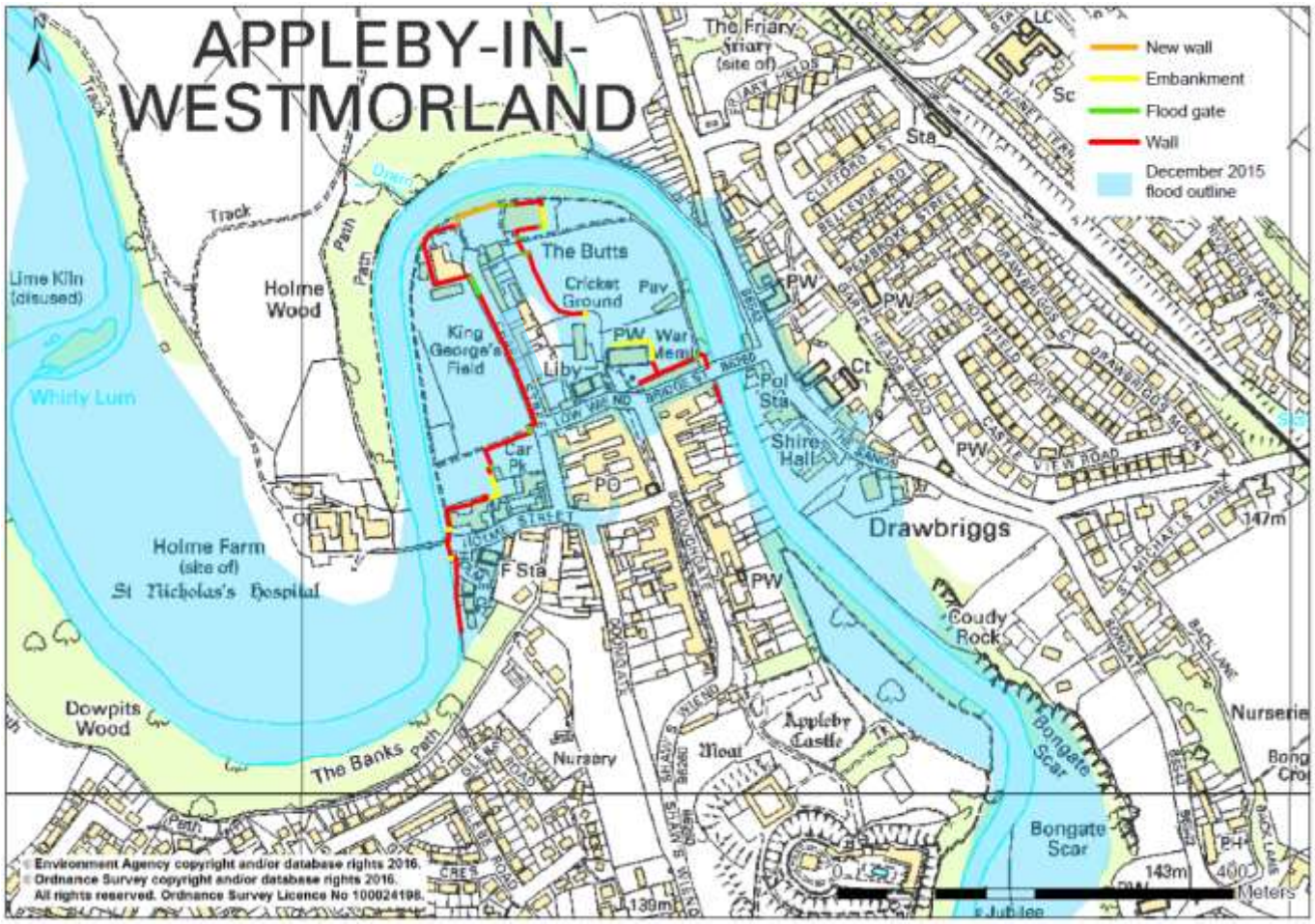


Figure 6: Flood defences in Appleby

Appleby was flooded in the 2005 flood event. The defences protected the town, however the surcharging of the Doomgate Culvert flooded 28 properties in the Holme Street area.

In 2007, Defra launched a pilot grant scheme in Appleby that provided property level flood protection. This included demountable flood barriers, pumps, new drains, water resistance external render and floodwalls, Photographs 1 & 2.

Photographs 1 & 2: Property level flood defence measures introduced. Wall in photo on right is a CCC highways wall not part of DEFRA pilot

In November 2009, another flood event on the River Eden occurred with banks being overtopped. The property level protection measures successfully reduced disruption and damage and hence reinstatement costs were less. The flood event was however within the design tolerance of the measures.

After the November 2009 event, the demountable flood wall at Appleby Leisure Centre, which was built as part of the 1995 scheme, was replaced with a new flood wall. These works had started before the flooding in December 2015. The £400,000 floodwall has since been completed to the same standard as the 1995 scheme (protecting the same number of properties). The objective of the scheme was to achieve significant operational resource savings, enabling these resources to be re-deployed elsewhere in Cumbria.

The flood event on 5th-6th December 2015 was of a greater magnitude than the Appleby Flood Risk Management Scheme defences were designed to defend against, resulting in the defences being overtopped. In some locations however, defences were successful in reducing the damage and delayed flooding, which gave residents additional time to prepare and reduced the impact of the flood.

The Flood Warnings Direct (FWD) is the primary dissemination system of issuing warnings for flooding in Appleby however, the use of the former air raid siren in the town has been known locally as a ‘back up warning’ for many years. During Storm Desmond, the procedure for the operation of the siren was for it to be activated by Cumbria Police on advice from the Environment Agency that the Flood Warning Area NC1A (The Sands) was forecast to flood.

On the evening of the 4th December, unfortunately it was not possible to co-ordinate the issue of the flood warning with the activation of the siren as Appleby Police Station is no longer manned 24/7 and officers in the Upper Eden Police Team were already deployed to other incidents due to the severe weather conditions. This caused some confusion amongst the residents and as a result it was reported that they felt they lacked a head start and had less time to prepare for the flooding.

The Sands area of Appleby flooded again on two separate occasions during December 2015 (22nd and 26th). On both of these occasions the siren was successfully activated by Cumbria Police.

Following a review of what happened during the floods of December 2015 and following discussions with the Appleby Community Group, steps are being made to create a more robust procedure in co-operation between the police, Environment Agency, Cumbria Fire and Rescue Service and Appleby Community Group leads who will be provided with a key. This revised procedure will be embedded in the Appleby Community Flood Response Plan and procedures of the Environment Agency, Cumbria Police and Cumbria Fire and Rescue Service.

Investigation

This investigation was carried out by the Environment Agency through surveys of the area and data collected from the communities affected with help from Cumbria County Council.

This report has been compiled by CH2M from the data collected by the Environment Agency. CH2M are a global civil engineering consultancy providing a full range of flood management consultancy services in the UK and overseas. CH2M's range of experienced specialists have provided input into understanding this event and producing recommendations for future flood management in Appleby. More details of CH2M's work in the UK is included in Appendix 5.

For the purposes of this report, the flooded areas within Appleby-in-Westmorland have been divided into four sub-areas for investigation, Table 6. These are shown in Figure 7 and are examined in detail in the following sections of this report.

Sub-area	Sub-area Name	Description**
A	The Sands	An area on the right bank of the River Eden
B	Doomgate	An area on the left bank of the River Eden including Colby Lane, Holme Street & Holme Court
C	Defended Town	An area of the town including the Leisure Centre, Holme Street, Chapel Street, St Lawrence Church & Bridge Street
D	Undefended Town	Areas on the left bank of the River Eden including the Cricket Pitch & King George's Field

Table 6: Identified sub-areas for investigation

**Please note references to left and right bank are taken looking downstream in the direction of flow.

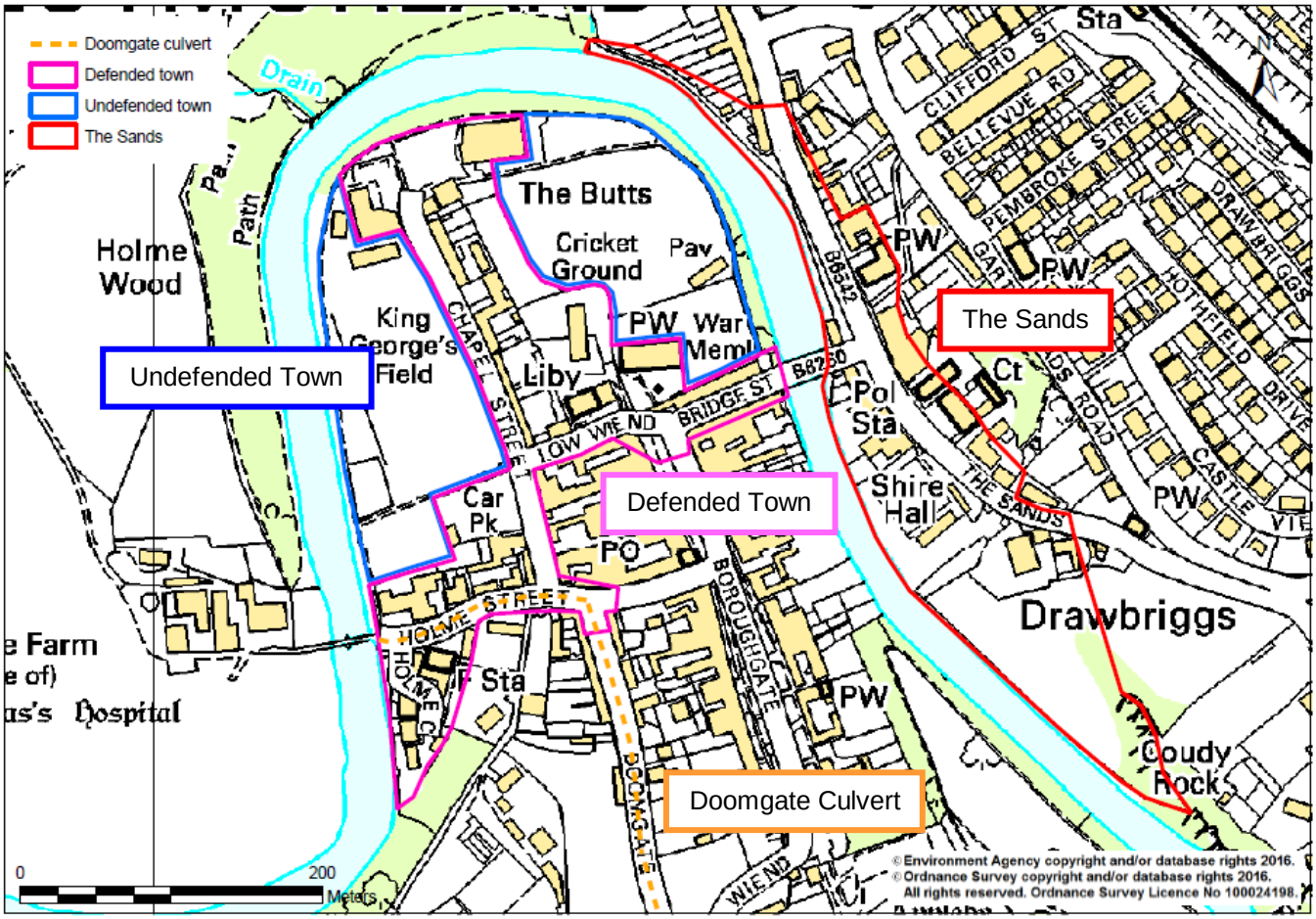


Figure 7: Identification of Areas Flooded

Impacts and Likely Causes of Flooding

Timeline

Table 7 below shows the times of key events during the Appleby flooding in December 2015.

4th December	Event
15:15	Flood Alert Issued – Upper River Eden
20:49	Flood Warning issued at The Sands, Cricket ground, King George's Field
5th December	**Event**
07:30	Doomgate culvert manhole starts to surcharge
07:40	Flood Warnings Issued at Chapel Street, Bridge Street, Holme Street & Court and Low Wiend Area
07:41	Flood Warnings Issued at Market Square, Boroughgate, Doomgate
08:00	Appleby Bridge closed for public use
08:30	Approximate time that The Sands becomes impassable due to flood water and flooded The Sands
09:30	Pump at Appleby Leisure Centre operated
10:30	Power failure
11:00	River Eden started seeping through the left bank wall upstream of the Bridge
11:30	Holme Street / Broad Close car park observed sitting in 500mm deep flood water caused by the surcharging of Doomgate Culvert.
11:48-11:49	**Severe Flood Warning Issued**
12:00	River Eden observed seeping through the left bank wall on upstream of the Bridge. Manhole observed surcharging on downstream side of bridge
14:00	Surcharging of Doomgate culvert manhole contributing to a lot of the flood water
14:30	Doomgate, Holme Street, Chapel Street area significantly affected by flooding purely from Doomgate Culvert and trapped local surface water.
16:00	All defences observed as holding, however seepage from wall and surcharging manhole has meant that Bridge Street is sitting in flood water about 100-200mm deep.
18:00	River Eden overtops defences upstream and downstream of the bridge (precise sequence unknown, but will be very close). Torrent of water observed coming down Bridge Street
18:00	River Eden overtopped the left bank wall
18:00	Flood defences at St Lawrence Church and King George's Field overtopped
20:30	**Peak River Level on the River Eden at Appleby – 4.68m**
21:45	Internal flooding reported at St Lawrence Church
6th December	
Approx. 02:00	Left bank retaining wall at Holme street footbridge collapsed

Table 7: Appleby 4-6th December flood incident timeline

The timeline highlights that flood warnings were issued well in advance of the peak of the flood event.

The flooding mechanisms observed in Appleby were a combination of the river banks and flood defences being overtopped or outflanked, surface water flooding caused by drainage being unable to discharge into the river and manhole/culvert surcharging.

Flood defences and river banks were overtopped at:

- The River Eden's banks upstream and downstream of St Lawrence Bridge
- Flood defence at the rear of St Lawrence Church
- Flood defence embankment at the Cricket field
- King George's Field defences

Surface water flooding also occurred at Doomgate, and a river wall on the left bank at Edenside Care Home and downstream wing wall at Holme Street Bridge collapsed.

The following sections detail the sources of flooding within the sub-areas identified on Figure 7 and indicates the flood flow routes and recorded impacts.

Overview of Flow Routes

There were three main flooding mechanisms in Appleby during the 2015 event:

1. Flooding of The Sands through out-of-bank flow
2. Flooding of Holme Street and Low Wiend areas from Doomgate Culvert
3. Flooding of Chapel Street, Bridge Street, Holme Street and Low Wiend from overtopping of the defences.

There were a number of flood flow routes observed during the flood event as shown by Figure 8**.** The details of these flow routes and the flooding within each of the identified sub-areas are discussed in greater detail in the following sections of this report. There may also have been other flooding mechanisms that were not identified during this investigation.

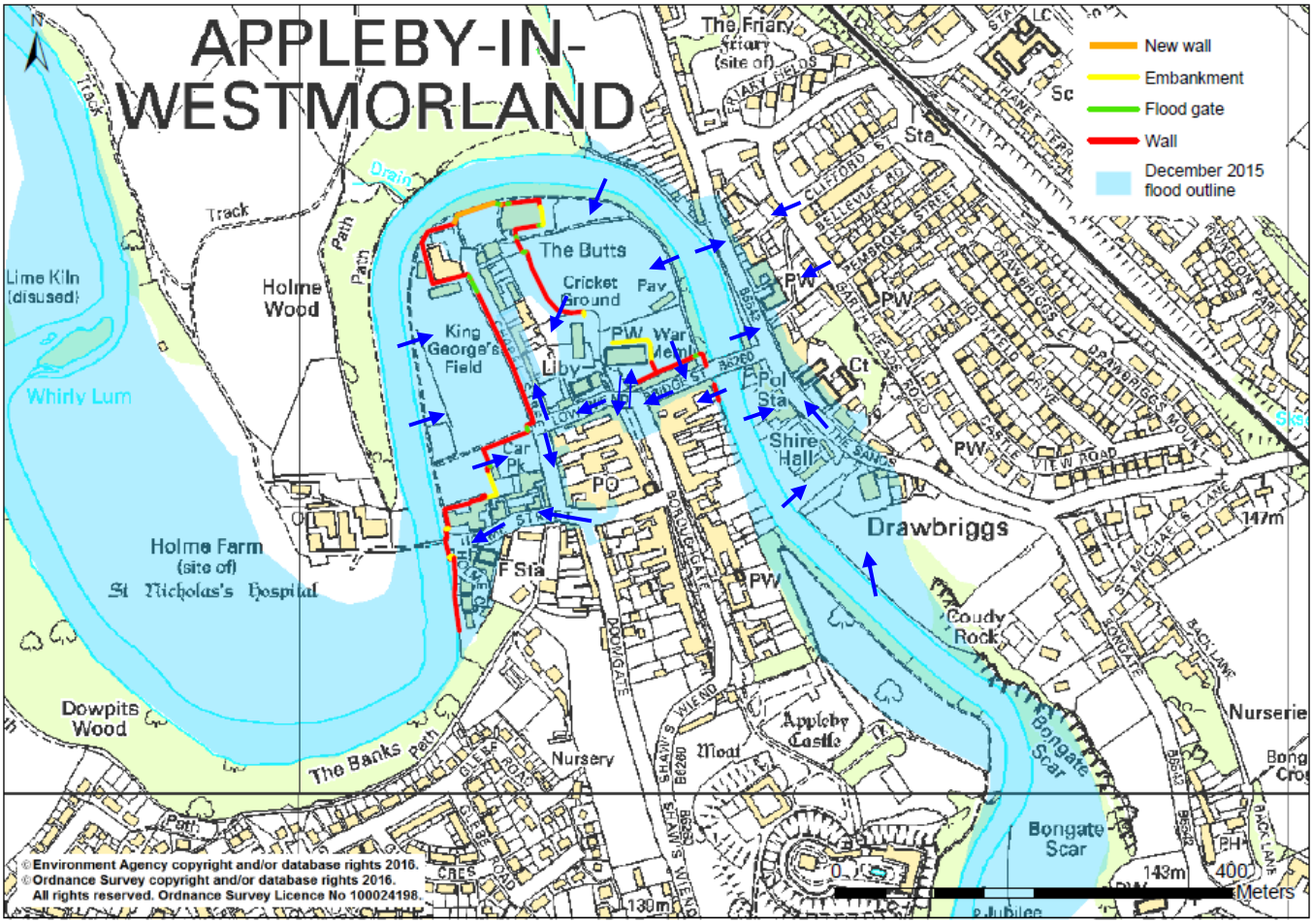


Figure 8: Flood flow route

Sub-area A: The Sands

4th December	Event
2049	Flood Warning Issued
5th December	**Event**
0830	Approximate time that The Sands becomes impassable due to flood water
1148	**Severe Flood Warning Issued**

Table 8: Timeline of events - The Sands

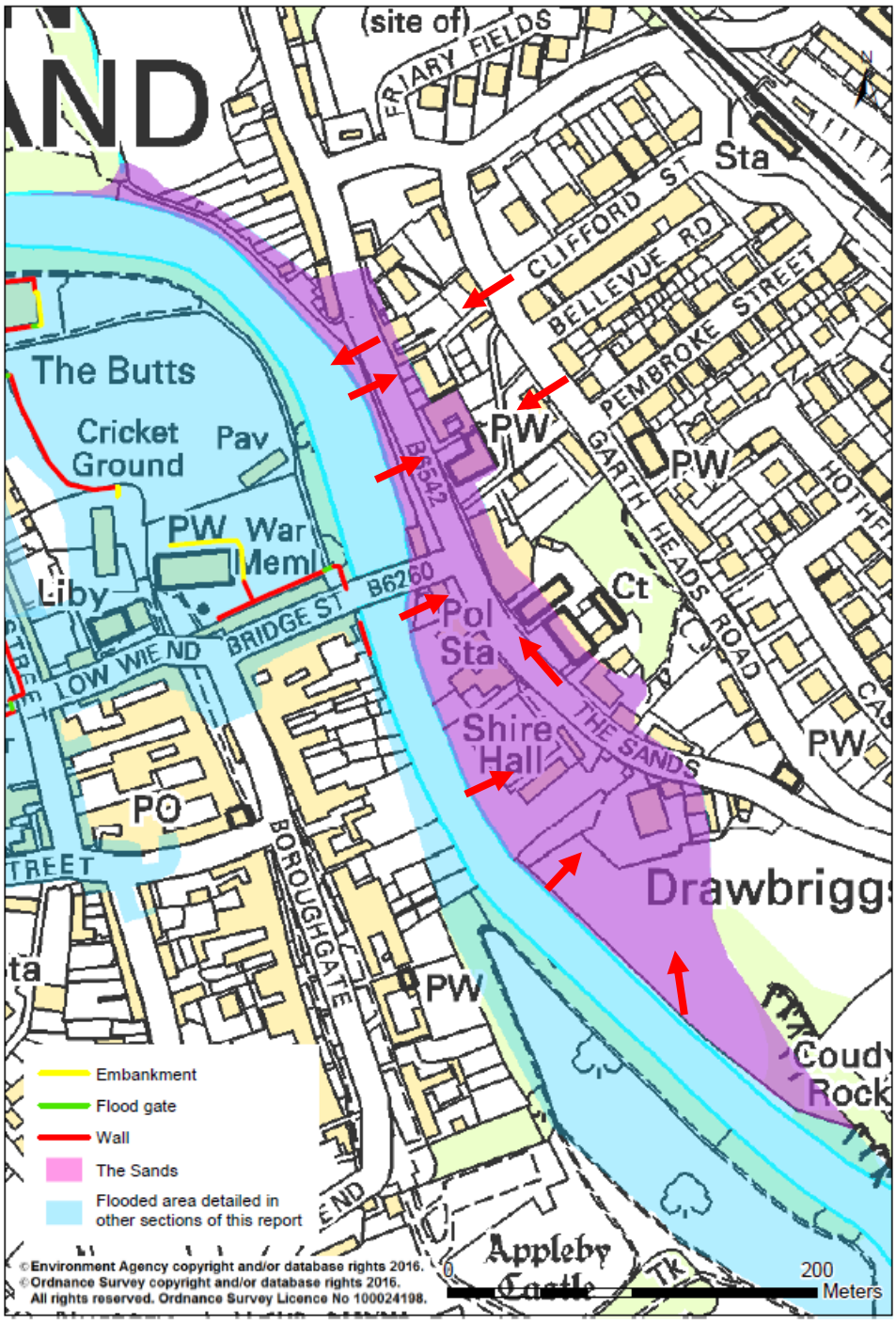


Figure 9: Flood flow routes at The Sands, Appleby

The Sands is an area of residential and commercial properties, located on the right bank of the River Eden, which also acts as a key access route into the town, Figure 9. The area includes several independently owned businesses, as well as the Co-operative supermarket and the police station. St Lawrence's Bridge and the narrowed channel immediately upstream forms a constriction to river flows in this area and can cause elevated river levels upstream of the bridge.

The properties along The Sands have a recurrent history of flooding with the commonly observed flooding mechanism being the River Eden overtopping its bank upstream of St Lawrence's Bridge, flowing parallel to the river around the bridge and on to affect The Sands area, before re-entering the river further downstream. It is likely that this flood mechanism assists in reducing pressure on the bridge during flood events and therefore helps to minimise damage to the structure.

In the December 2015 flood event, a flow route was observed from the River Eden overtopping its right bank upstream of the bridge to the rear of the bowling green, flooding the bowling green and then continuing towards The Sands - flooding properties located at the low point, Photograph 3. Another flooding mechanism in this area was the river overtopping its banks downstream of the bridge directly on to The Sands.

Photograph 3: Flooding at The Sands, Appleby

In 2007, as part of the Pilot Property Level Protection Grant Scheme, a short section of wall was constructed in front of the terrace of properties along The Sands adjoining The Grapes Inn, to provide additional protection from out of bank flows. Flood gates were installed in the access gaps. Residents reported that given the magnitude of the event, all installed property level protection measures were overwhelmed, Photograph 3. At its peak the flood water level on The Sands was recorded up to 1.8m above ground level and several of the lowest lying properties were flooded up to mid window height.

The properties affected in this area included a combination of both residential and commercial. Flood levels measured inside the Co-operative supermarket were in excess of 1.5m (5ft). A vast quantity of stock was written off and the store remained closed until March 2016. Due to the temporary closure of the bridge, the east side of the town was temporarily without a supermarket until a small mobile kiosk was opened stocking basic essentials - the nearest larger supermarkets being Kirkby Stephen (12 miles) or Penrith (14 miles).

It was reported that surface water runoff from Clifford Road, to the rear of The Sands properties also contributed to flooding of properties in this location. See Photograph 4.

Photograph 4: Flood at the Sands, Appleby

The Environment Agency has investigated the feasibility of constructing a flood defence scheme to protect The Sands area on several occasions over recent years, however this has proven to be technically difficult due to the constraints of the Bridge and would also result in unfavourable aesthetic impacts to this area of the town which have previously been deemed unacceptable to the local community.

Sub-area B: Doomgate

5th December	Event
07:30	Surcharging of culvert manhole observed by EA site controller
07:41	Flood Warning Issued
11:30	Holme Street / Broad Close car park observed sitting in 500mm deep flood water cause by the surcharging of Doomgate Culvert.
11:48	**Severe Flood Warning Issued**
14:30	Doomgate, Holme Street, Chapel Street area significantly affected by flooding purely from Doomgate Culvert and trapped local surface water.

Table 9: Timeline of events in the Doomgate area

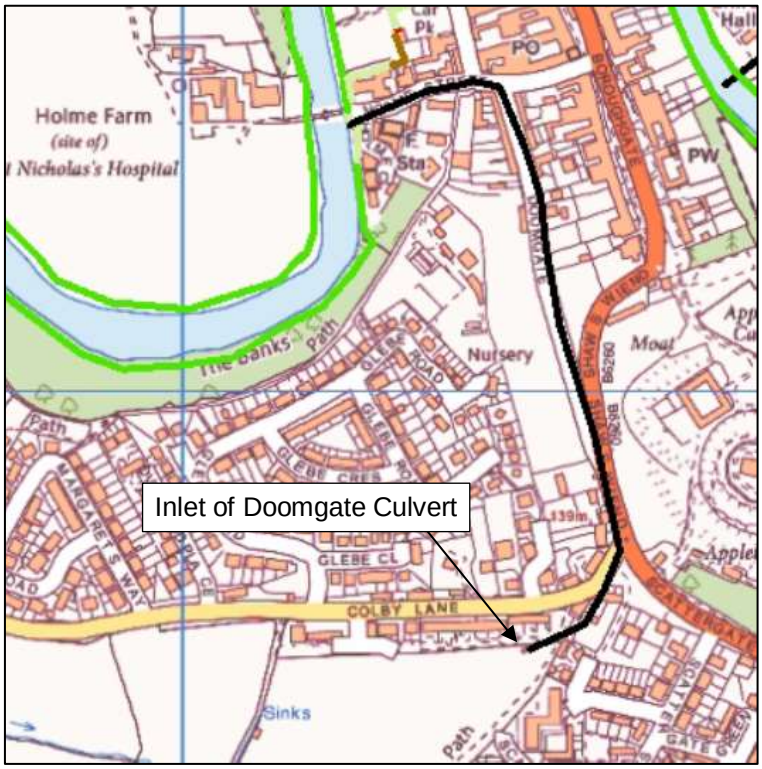


Figure 10: Doomgate Culvert

The drainage system arrangement at Doomgate is shown in Figures 10 and 11. There are two drainage systems - a 525mm diameter surface water culvert and a combined sewer with a Combined Sewer Overflow (CSO) which discharges into a surface water culvert.

The field to the south of Colby lane acts as a flood plain, which contributes runoff to Doomgate culvert. The 525mm diameter culvert discharges into the River Eden via a flap valve outfall.

During the flood event, due to the high river level, the flap valve on the outfall closed to prevent the River Eden backing up into the town. This resulted in the Doomgate Fluvial Flows and local surface water runoff backing up the drainage system and surcharging the pipes and manhole covers on the culvert at Doomgate. Initial flooding was observed from manholes at the Doomgate and Holme Street junction and the continued surcharging flooded properties on both Holme Street and Chapel Street. See Photographs 5 and 6.

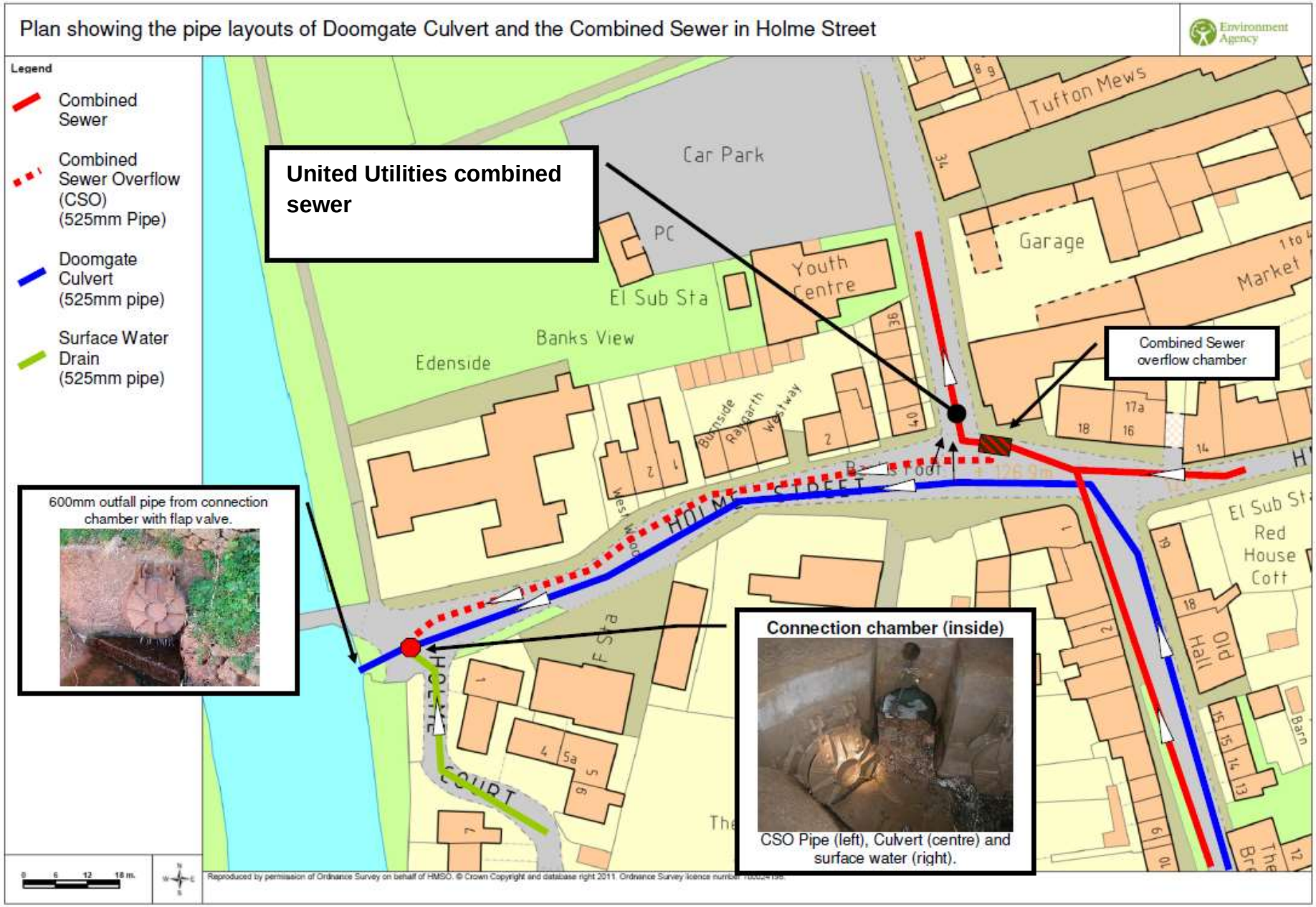
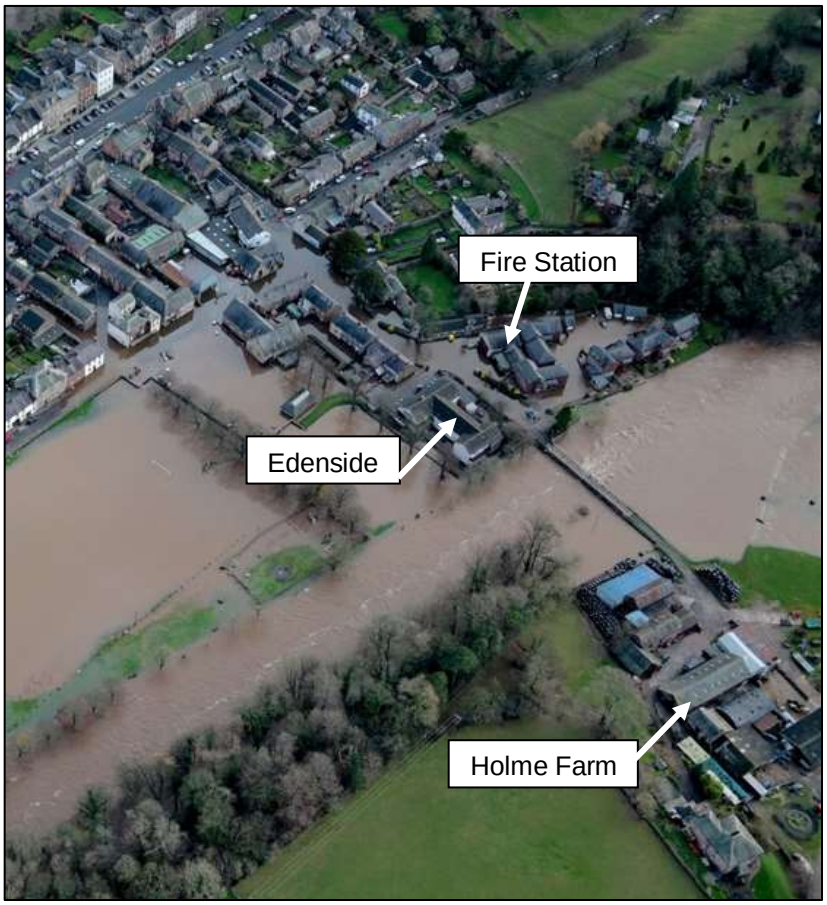


Figure 11: Combined Sewer Overflow Arrangement


Photographs 5 and 6: Doomgate Culvert Manhole Surcharged, 11:00hrs (left) and 13:30 (right) on 5th December

An Environment Agency pumping station is located at Appleby Leisure Centre and pumps surcharged water from the United Utilities combined sewer into the River Eden. An Environment Agency site controller observed that although Doomgate Culvert manholes were surcharging, flood water was still draining away into gully pots connected to the combined sewer. A power failure occurred on Saturday 5th December at 10:30 am, the pumping station was however running on a diesel generator and so was unaffected.

Holme Street connects Holme Farm to the main town via a metal bridge over the River Eden. Holme Street is predominantly residential but also includes Edenside residential care home and Appleby Fire Station, Photograph 7.



Photograph 7: Flood Extent on Holme Street

Holme Street was flooded due to a combination of surcharged surface water drainage systems, as described above from Doomgate, runoff from Chapel Street and surface water ponding at the low point

on Holme Street. At the peak of the event flood water also overtopped the flood defences at the Broad Close car park - an additional flooding mechanism which will be discussed in the following section of the report. It was reported that runoff from Holme Street collected in Holme Court.

Photograph 8: Aerial view at Doomgate

A local resident confirmed that the river wall, on the left bank, immediately downstream of Holme Farm Bridge did not overtop. A section of this retaining wall however collapsed outwards into the river, after the peak of the flood event, in the early hours of 6th December 2015. See Photograph 9.

Photograph 9: Left bank retaining wall collapsed

Following the flood event, the collapsed section of the retaining wall was protected by sand bags and barriers were erected for public safety. The necessary repair works to the wall are now complete.

On the right bank, the River Eden overtopped its banks and flooded the floodplain in front of Holme Farm.

At the upstream end of the Doomgate culvert inlet on Colby Lane, a field acts as a flood plain and contributes runoff to the culvert. Photograph 10 below is from a previous flood event however demonstrates the likely ponding effect experienced in this location during the December 2015 event.

Photograph 10: Doomgate culvert inlet at Colby Lane (2005)

Three properties at the upstream end of the Doomgate culvert have fitted property level flood protection measures including flood gates and pumps, see Photograph 11. These three properties did not flood during the 2015 event.

Photograph 11: Properties on Colby Lane - Property level measures

Sub-area C: Defended Town

4th December	Event
20:49	Flood Warning Issued at Cricket Ground and King George's Field
5th December	**Event**
08:30	Appleby Bridge/Bridge Street closed for public use
11:48	**Severe Flood Warning Issued**
12:00	River Eden observed seeping through the left bank wall upstream of the Bridge. Manhole observed surcharging on downstream side of bridge
14:00	Surcharging of Doomgate culvert manhole contributing to a lot of the flood water.
16:00	All defences observed as holding, however seepage from wall and surcharging manhole has resulted in flooding to a depth of 100-200mm in Bridge Street.
18:00	River Eden overtops defences upstream and downstream of the bridge (precise sequence unknown, but will be very close). Torrent of water observed coming down Bridge Street
21:15	Flooding of St Lawrence Church

Table 10: Timeline of events in the defended area of the town

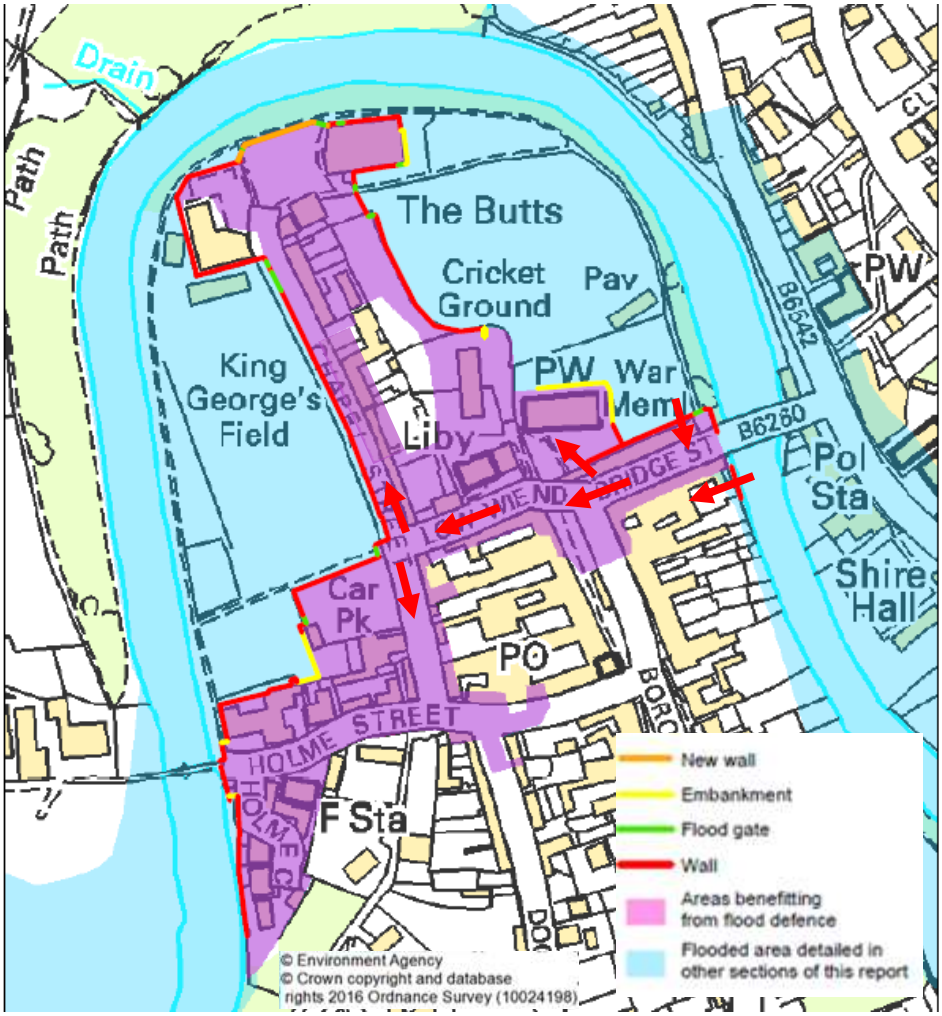


Figure 12: Town Centre Flow Route

The defended town includes the area on the left bank of the River Eden within and adjacent to the meander of the river, Figure 12. This area comprises the main town centre and contains numerous businesses as well as St Lawrence Church and Appleby Leisure Centre. The defended town also includes the properties along Chapel Street, Low Wiend, Holme Street and Bridge Street. This area is defended by the Appleby Flood Risk Management Scheme described previously.

Rebuilt in 1889, St Lawrence's Bridge is a Grade II listed road bridge over the River Eden linking the east and west sides of the town and consists of two wide stone arches. The bridge along with the narrowed channel upstream of the bridge form a constriction to river flows and often cause elevated river levels immediately upstream. The December 2015 event was so severe that river levels reached the bridge soffit level, Photograph 12.

Photograph 12: River level just below the bridge soffit level before the event peak

Bridge Street was closed prior to the peak of the flood event due to concerns over the structural safety of the bridge. These concerns were as a result of the increased pressure applied on the upstream face due to the high river water level.

Initially, on 5th December 2015, the river water started seeping through the left bank stone wall immediately upstream of the bridge, Photograph 13. Flood water also surcharged in large quantities from the surface water drainage manhole behind the defences on the downstream side.

Photograph 13: Stone wall on the left bank - water seeping through 13:22 hrs 5th Dec. '16

The surface water manhole, located behind the floodwall, surcharged at Factory 33 on Bridge Street. This was due to the surcharging of the surface water drainage system caused by the failure of a flap valve on the outfall to the River Eden. See Photographs 14 and 15.

Photographs 14 and 15: Surcharged manhole behind the flood defence 13:40 5th Dec. '15

At its peak, the river over topped the walls upstream and downstream of the bridge (precise sequence unknown, but believed to be in close succession) and water flowed down Bridge Street and flooded into the town centre, through the lower market place, along Low Wiend and Cherry Row and collected on Chapel Street, Figure 12.

Located within the defended area is St Lawrence Church. The church is an active Anglican parish church in the deanery of Appleby and is recorded in the National Heritage List for England as a designated Grade I listed building. In 2014, the church built a flood defence wall and embankment to protect it to the same standard as the rest of the Flood Risk Management Scheme.

During the December 2015 flood event, the river water rose and overtopped the embankment which resulted in water ponding in the crypt of St Lawrence church, see Photograph 17. The church's flood defences are dependent upon two sump pumps installed on top of the flood embankment, which are triggered when water enters the crypt up to a depth of 50mm. Due to a wider power failure in the town, these pumps failed to operate and thus the impact of the flood was heightened.

The church was reported to have flooded to approximately 700mm deep (Photograph 16) within 15 minutes via the doors and the crypt. The flood level recorded at the entrance of the church was 2.0m above existing ground level. Flood waters were reported to have receeded by 04:00 on 6th December although water was still present in the churchyard.


Photographs 16 & 17: Flood data collection inside St Lawrence Church & Flood Extent

The flood embankment at the end of the flood wall surrounding the cricket ground was reported to have settled and had created a low point along the flood defence. Sand bags were placed at the low point in an attempt to bolster the defences as a temporary measure during the event (shown in Photograph 18).

Photograph 18: Embankment Settled at Cricket Ground – 15:44hrs on 5th December 2015

The rear gardens of properties on Chapel Street were reported to have flooded after the flood defence wall on the landward side of the cricket ground was outflanked.

Also located within the defended area is Appleby Leisure Centre, situated adjacent to the cricket ground, on the inside bend of the river meander. The flood defence around the landward edge of the cricket ground ties in to the Leisure Centre and the building now forms part of the defended line. On the western side, the building tied in to the then demountable defences.

During December 2015, construction works to replace the existing flood defence barrier with a new floodwall were in progress, see Photographs 19 and 20. During the flood event, the flood barrier was operated/installed by the contractor Breheny who reported that the barrier was not overtopped. The area was however subsequently flooded due to the overtopping of the defences at Bridge Street resulting in water flowing towards Appleby Leisure Centre. Appleby Health Centre although located adjacent to the Leisure Centre is situated on slightly higher ground and as a result did not flood.

Photographs 19 and 20: After flood peak - Flood Barrier in Operation at Appleby Leisure Centre

Photograph 21: River Eden at Appleby Leisure Centre

Photograph 22: Appleby Leisure Centre

A landward flood protection wall with a flood gate is located around Kings George's Field, which protects properties on Chapel Street, Eden Community Outdoors Centre, Edenside Residential Care Home and the rear of properties on Holme Street.

Following the River Eden overtopping its bank into King George's field, overtopping of the flood defence wall was reported at Eden Community Outdoors' car park at approximately 19:00 on 5th December 2015. The flood water flowed along Chapel Street to Holme Street and Appleby Leisure Centre. These areas were however already submerged due to flooding from Doomgate Culvert (Photographs 5 and 6). The north end of the flood defence wall on Chapel Street was also overtopped at the peak of the event.

The wall on the left bank that protects the care home collapsed outwards towards the river (Photograph 23), evidence shows that it failed after the peak of the event when water levels were higher inside the defences than outside. The care home's entrances were protected by sand bags however it was reported that the home was flooded internally with flood water entering the property initially via the drains, water outlets and through the walls.

Photograph 23: Collapsed flood wall at Edenside Care Home

Sub-area D: Undefended Town

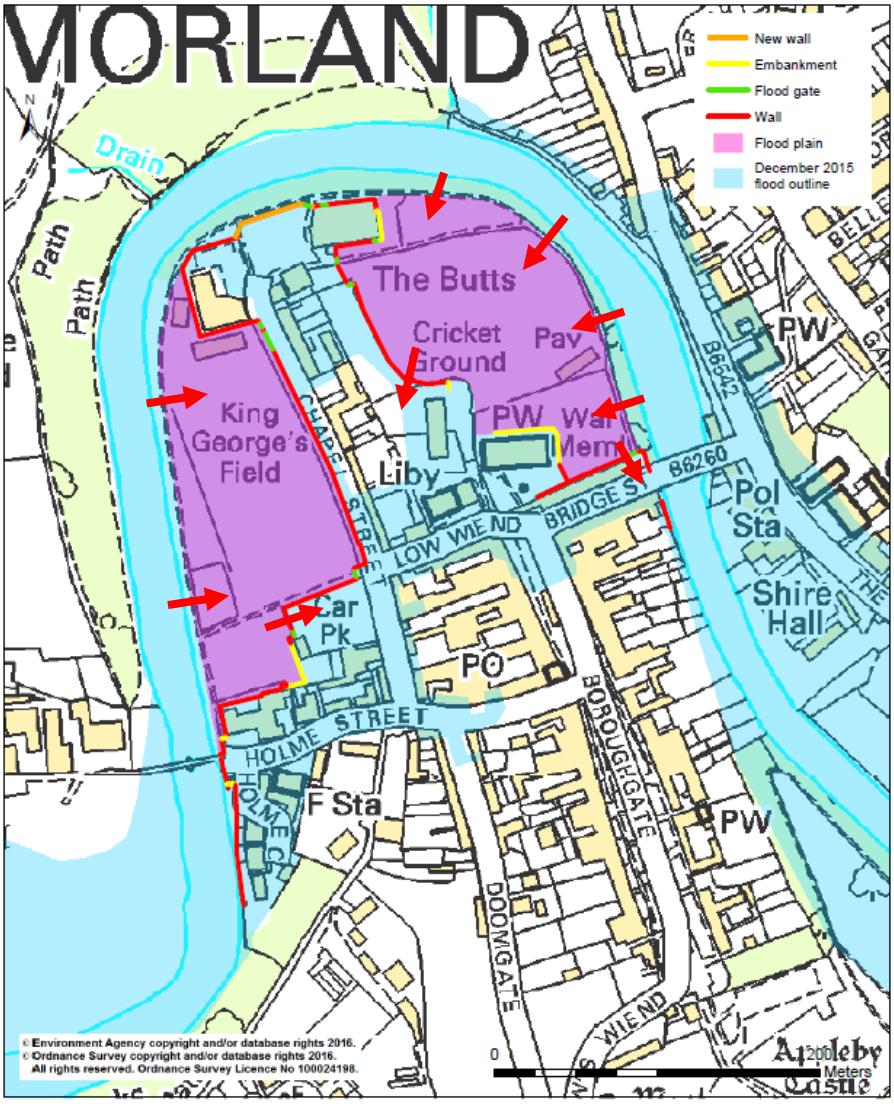


Figure 13: Flood Plain Area

The Cricket Ground and King George's field on the left bank of the River Eden are not defended and are intended to be used as flood plain storage during a flood event, Figure 13 and Photographs 24 and 25. The floodwater deposited silt and debris across both the cricket and football pitch and caused significant damage to the park facilities, including the cricket clubhouse, Scout Hut and children's playarea. Both the cricket pitch and football pitch had to be relaid.

Photographs 24 and 25: Flood water Cricket Ground (left) and King George's Field (right)

A land slip was observed upstream of the stone revetment on the right bank opposite King George's field, see Photograph 26. Also, scouring of the riverbank was observed on the right bank, opposite the Cricket Ground, see Photograph 27.

Photographs 26 (left) and 27 (right): Land Slip and Scour on Right Bank

Photograph 28: Flood Extent at Cricket Field

Photograph 29: Water ponding behind floodwall on Chapel Street

Photograph 30: Flood water from the Eden being held back by the defences. Water ponding behind floodwall on Chapel Street is from Doomgate culvert.

Environment Agency Flood Incident Response

The Environment Agency's response to the flood event on the 5th and 6th December 2015 started well in advance of the event. This response included the closure of flood gates and clearing of grids in the town. Additional resources including manpower and machinery such as pumps were also brought to the town. The Environment Agency contractors working on construction of the new wall at the Leisure Centre were deployed to carry out activities in the town as required (orange jackets).

The Environment Agency and Cumbria County Council are members of the Cumbria Local Resilience Forum. The Cumbria Local Resilience Forum (LRF) is a partnership, made up of all the organisations needed to prepare for and respond to any major emergency in the LRF area. All services and organisations worked together prior to and during the flooding to ensure that the best possible preparations and plans were in place.

A flood alert for the lower River Eden was issued on the 4th of December at 15:08. Flood warnings were issued to the flood warning areas within Appleby at 20:49 on the 4th December.

A severe flood warning was issued at 11:48 on 5th December. The majority of properties reported that they had received these warnings within good time.

A number of properties affected by the flooding event did not receive flood warnings as the residents were not registered with the Environment Agency's flood warning system. It was also recognised that the details stored for many residents were not up to date.

Recommended Actions

The following table details recommended actions for various organisations and members of the public to consider using the Cumbria Floods Partnerships 5 Themes: Community Resilience, Upstream Management, Strengthening Defences, Maintenance and Internal Drainage Boards (IDB's). Some of these recommendations may have already been carried out and or are ongoing.

Some of the actions referred to below are identified on the location map following this table.

Cumbria Flood Partnership Theme	Action by	Recommended Action	Timescale
Community Resilience	Cumbria Local Resilience Forum *	Review and update plans to enable homes & business to be better prepared for flooding & reduce the impacts of flooding	On going
	Environment Agency and Cumbria County Council Highways and Electricity North West.	To review the flood risk and resilience of critical transport and power supply infrastructure.	On going
	Environment Agency and Cumbria County Council Highways	Investigate potential to increase the flood flow capacity of Appleby Bridge.	2017
	Cumbria Planning Group, Appleby Town Council, Cumbria County Council and Environment Agency	Review Local Development Plans and Strategic Flood Risk Assessment to reflect current understanding of flooding	2016
	Environment Agency	Ensure all properties at risk can register to receive flood warnings and details are up-to-date.	On going
Upstream Management	Cumbria Floods Partnership (CFP)	The CFP action plan will consider natural flood management options to reduce flood risk across the catchment. This may also include land use changes and or flood storage.	On-going
Maintenance	County Council, United Utilities and Appleby Town Council	Review and investigate drainage and sewage systems to better understand where improvements are required.	On-going
	Environment Agency, United Utilities and Cumbria County Council	Complete on-going inspections and repairs to assets which may have been damaged during the flood event	Completed

Strengthening Defences	Environment Agency	Review modelling data to ensure that models for Appleby reflect real conditions as accurately as possible and use this information to make any improvements to the flood warnings service. This will be used to inform future investment plans.	On-going
	Environment Agency	Review scheme performance and consider what worked well, and where improvements to defences are required	On-going
	Environment Agency	Investigate potential to improve defences upstream of Appleby Bridge to prevent overtopping and outflanking of defences in St Lawrence Church	On-going
	Environment Agency	Develop business case to support construction of additional upstream storage on Doomgate culvert and pumped discharge to River Eden from Holme St.	On-going
	Environment Agency	Develop business case to support construction of flood defence scheme at The San ds.	On-going
	Environment Agency	Review the need and practicalities of deploying temporary defences in certain locations as an interim or longer term measure to help reduce flood risk	2016
	Environment Agency	Improve resilience of pumping stations at Appleby Leisure Centre so that these assets remain in operation longer during severe flood events.	Completed

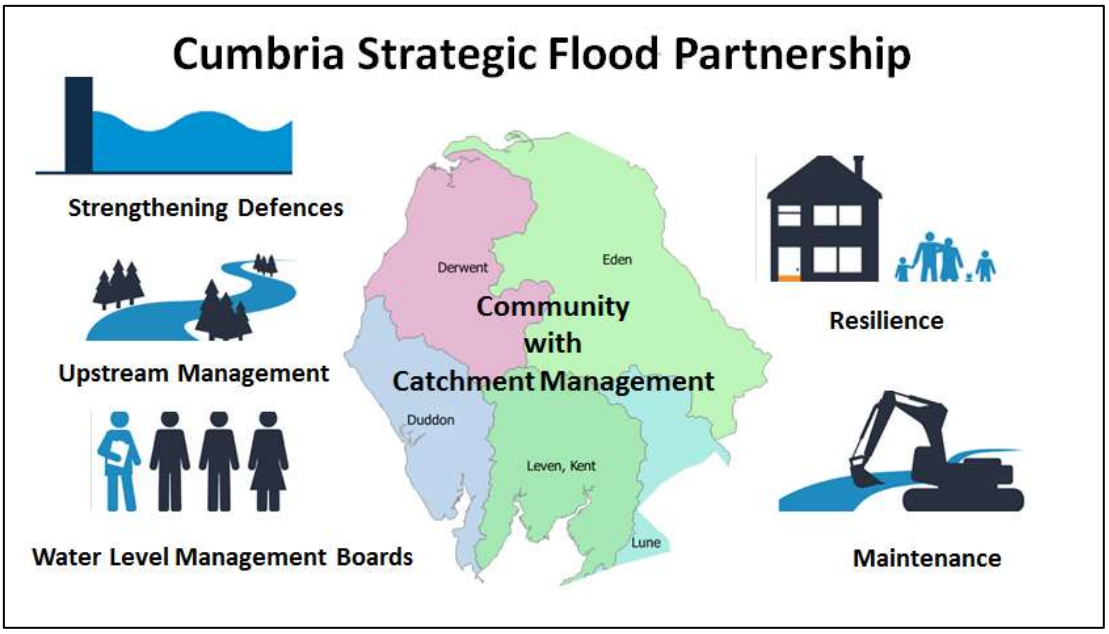
* The Cumbria Local Resilience Forum includes emergency services, local authorities, Cumbria County Council, Environment Agency, Maritime Coastguard Agency and health agencies along with voluntary and private agencies.

Under the Civil Contingencies Act (2004) every part of the United Kingdom is required to establish a resilience forum.

Next Steps – Community & Catchment Action Plan

The Cumbria Floods Partnership has brought together a wide range of community representatives and stakeholders from a variety of sectors to plan and take action to reduce flood risk. The Cumbria Floods Partnership, led by the Environment Agency, is producing a 25 year flood action plan for the Cumbrian catchments worst affected by the December 2015 flooding, including Carlisle. The plan will consider options to reduce flood risk across the whole length of a river catchment including upstream land management, strengthening flood defences, reviewing maintenance of banks and channels, considering water level management boards and increasing property resilience. The Cumbria Floods Partnership structure below details how these 5 themes are being delivered in the Flood Action plans which will be completed in July.

The diagrams below helps demonstrate how the two partnerships have now come together:



Cumbria Strategic Flood Partnership

RFCC

Cumbria Strategic Partnership Board

Catchment Management Group

Eden

Catchment Management Group

Derwent

Catchment Management Group

Kent and Leven

Steering Groups

(Various per Catchment)

MSFWG

Community

'Farmers, environmental charities, landowners, private companies, councils and government agencies have joined together with a common goal.
To look at the evidence and potential funding sources to find flood solutions for defences, resilience, maintenance, upstream management and water level management boards, so they can work together to help communities at risk of flooding.'

In a dynamic move the Cumbria Strategic Flood Partnership have created three groups whose aim is to look at all options for how flood risk can be reduced in Cumbria.

This group the first of its kind in the country brings together the expertise of all those whose water and land management experience to look at what can be done to protect communities both residential and farming.

They will then discuss their findings to the communities at risk and plan a way forward.

This landmark move will ensure that fully integrated solutions for land and water management are utilised to protect people and the environment in which they live and rely on.

Appendices

Appendix 1: Glossary

AEP	Annual Exceedance Probability
ARI	Annual Recurrence Interval
AOD	Above Ordnance Datum
CCC	Cumbria County Council
EA	Environment Agency
FAG	Flood Action Group
FWD	Flood Warnings Direct
LLFA	Local Lead Flood Authority
LRF	Local Resilience Forum
MsfWG	Making space for Water Group
RMA	Risk Management Authority

Term	Definition
Aquifer	A source of groundwater comprising water-bearing rock, sand or gravel capable of yielding significant quantities of water.
Attenuation	In the context of this report - the storing of water to reduce peak discharge of water.
Catchment Flood Management Plan	A high-level planning strategy through which the EA works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.
Culvert	A channel or pipe that carries water below the level of the ground.
De Facto Flood Defence	A feature or structure that may provide an informal flood defence benefit but is not otherwise designed or maintained by the Environment Agency
Flood Defence	Infrastructure used to protect an area against floods as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Floodplain	Area adjacent to river, coast or estuary that is naturally susceptible to flooding.
Flood Resilience	Measures that minimise water ingress and promotes fast drying and easy cleaning, to prevent any permanent damage.
Flood Risk	The level of flood risk is the product of the frequency or likelihood of the flood events and their consequences (such as loss, damage, harm, distress and disruption)

Term	Definition
Flood Risk Regulations	Transposition of the EU Floods Directive into UK law. The EU Floods Directive is a piece of European Community (EC) legislation to specifically address flood risk by prescribing a common framework for its measurement and management.
Flood and Water Management Act	Part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to clarify the legislative framework for managing surface water flood risk in England.
Flood Storage	A temporary area that stores excess runoff or river flow often ponds or reservoirs.
Flood Zone	Flood Zones are defined in the NPPF Technical Guidance based on the probability of river and sea flooding, ignoring the presence of existing defences.
Flood Zone 1	Low probability of fluvial flooding. Probability of fluvial flooding is < 0.1%
Flood Zone 2	Medium probability of fluvial flooding. Probability of fluvial flooding is 0.1 – 1%. Probability of tidal flooding is 0.1 – 0.5 %
Flood Zone 3a	High probability of fluvial flooding. Probability of fluvial flooding is 1% (1 in 100 years) or greater. Probability of tidal flooding is 0.5%(1 in 200 years)
Flood Zone 3b	Functional floodplain. High probability of fluvial flooding. Probability of fluvial flooding is >5%
Fluvial	Relating to the actions, processes and behaviour of a water course (river or stream)
Fluvial flooding	Flooding by a river or a watercourse.
Freeboard	Height of flood defence crest level (or building level) above designed water level
Functional Floodplain	Land where water has to flow or be stored in times of flood.
Groundwater	Water that is in the ground, this is usually referring to water in the saturated zone below the water table.
Inundation	Flooding.
Lead Local Flood Authority	As defined by the FWMA, in relation to an area in England, this means the unitary authority or where there is no unitary authority, the county council for the area, in this case Lancashire County Council.
Main River	Watercourse defined on a ‘Main River Map’ designated by DEFRA. The EA has permissive powers to carry out flood defence works, maintenance and operational activities for Main Rivers only.
Mitigation measure	An element of development design which may be used to manage flood risk or avoid an increase in flood risk elsewhere.
Overland Flow	Flooding caused when intense rainfall exceeds the capacity of the drainage systems or when, during prolonged periods of wet weather, the soil is so saturated such that it cannot accept any more water.
Residual Flood Risk	The remaining flood risk after risk reduction measures have been taken into account.

Term	Definition
Return Period	The average time period between rainfall or flood events with the same intensity and effect.
River Catchment	The areas drained by a river.
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
Sustainability	To preserve /maintain a state or process for future generations
Sustainable drainage system	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.
Sustainable development	Development that meets the needs of the present without compromising the ability of future generations meeting their own needs.
Sustainable Flood Risk Management	Sustainable Flood Risk Management promotes a catchment wide approach to flooding that uses natural processes and systems (such as floodplains and wetlands) to slow down and store water.
Topographic survey	A survey of ground levels.
Tributary	A body of water, flowing into a larger body of water, such as a smaller stream joining a larger stream.
Watercourse	All rivers, streams, drainage ditches (i.e. ditches with outfalls and capacity to convey flow), drains, cuts, culverts and dykes that carry water.
Wrack Marks	An accumulation of debris usually marking the high water line.
1 in 100 year event	Event that on average will occur once every 100 years. Also expressed as an event, which has a 1% probability of occurring in any one year.
1 in 100 year design standard	Flood defence that is designed for an event, which has an annual probability of 1%. In events more severe than this the defence would be expected to fail or to allow flooding.

Appendix 2: Summary of Relevant Legislation and Flood Risk Management Authorities

The table below summarises the relevant Risk Management Authority and details the various local source of flooding that they will take a lead on.

Flood Source	Environment Agency	Lead Local Flood Authority	District Council	Water Company	Highway Authority
RIVERS					
Main river					
Ordinary watercourse					
SURFACE RUNOFF					
Surface water					
Surface water on the highway					
OTHER					
Sewer flooding					
The sea					
Groundwater					
Reservoirs					

The following information provides a summary of each Risk Management Authority's roles and responsibilities in relation to flood reporting and investigation.

Government – DEFRA develop national policies to form the basis of the Environment Agency's and the LLFA's work relating to flood risk.

Environment Agency has a strategic overview of all sources of flooding and coastal erosion as defined in the Act. As part of its role concerning flood investigations this requires providing evidence and advice to support other Risk Management Authorities (RMA's). The EA also collates and reviews assessments, maps, and plans for local flood risk management (normally undertaken by LLFA).

Lead Local Flood Authorities (LLFAs) – Cumbria County Council is the LLFA for Cumbria under the Flood & Water Management Act 2010. Part of their role requires them to investigate significant local flooding incidents and publish the results of such investigations. LLFAs have a duty to determine which RMA has relevant powers to investigate flood incidents to help understand how they happened, and whether those authorities have, or intend to, exercise their powers. LLFAs work in partnership with communities and flood RMA's to maximise knowledge of flood risk to all involved. This function is carried out at CCC by the Development Management Team.

District and Borough Councils – These organisations perform a significant amount of work relating to flood risk management including providing advice to communities and gathering information on flooding. These organisations are classed as RMA's.

Water and Sewerage Companies manage the risk of flooding to water supply and sewerage facilities and the risk to others from the failure of their infrastructure. They make sure their systems have the appropriate level of resilience to flooding and where frequent and severe flooding occurs they are required to address this through their capital investment plans. It should also be noted that following the Transfer of Private Sewers Regulations 2011 water and sewerage companies are responsible for a larger number of sewers than prior to the regulation. These organisations are classed as RMA's

Highway Authorities have the lead responsibility for providing and managing highway drainage and certain roadside ditches that they have created under the Highways Act 1980. The owners of land adjoining a highway also have a common-law duty to maintain ditches to prevent them causing a nuisance to road users. These organisations are classed as RMA's

Flood risk in Cumbria is managed through the Making Space for Water process, which involves the cooperation and regular meeting of the Environment Agency, United Utilities, District/Borough Councils and CCC's Highway and LFRM Teams to develop processes and schemes to minimise flood risk. The MSfWGs meet approximately 4 times per year to cooperate and work together to improve the flood risk in the vulnerable areas identified in this report by completing the recommended actions. CCC as LLFA has a responsibility to oversee the delivery of these actions.

Where minor works or quick win schemes can be identified, these will be prioritised and subject to available funding and resources will be carried out as soon as possible. Any major works requiring capital investment will be considered through the Environment Agency's Medium Term Plan process or a partners own capital investment process.

Flood Action Groups are usually formed by local residents who wish to work together to resolve flooding in their area. The FAGs are often supported by either CCC or the EA and provide a useful mechanism for residents to forward information to the MSfWG.

Appendix 3: Links to Other Information on Flooding

Sign up for Flood Warnings
https://www.gov.uk/sign-up-for-flood-warnings

Environment Agency – Prepare your property for flooding; a guide for householders and small businesses to prepare for floods
https://www.gov.uk/government/publications/prepare-your-property-for-flooding

Environment Agency – What to do before, during and after a flood: Practical advice on what to do to protect you and your property
https://www.gov.uk/government/publications/flooding-what-to-do-before-during-and-after-a-flood

Environment Agency – Living on the Edge: A guide to the rights and responsibilities of riverside occupiers
https://www.gov.uk/government/publications/riverside-ownership-rights-and-responsibilities

Flood and Water Management Act 2010:
http://www.legislation.gov.uk/ukpga/2010/29/contents

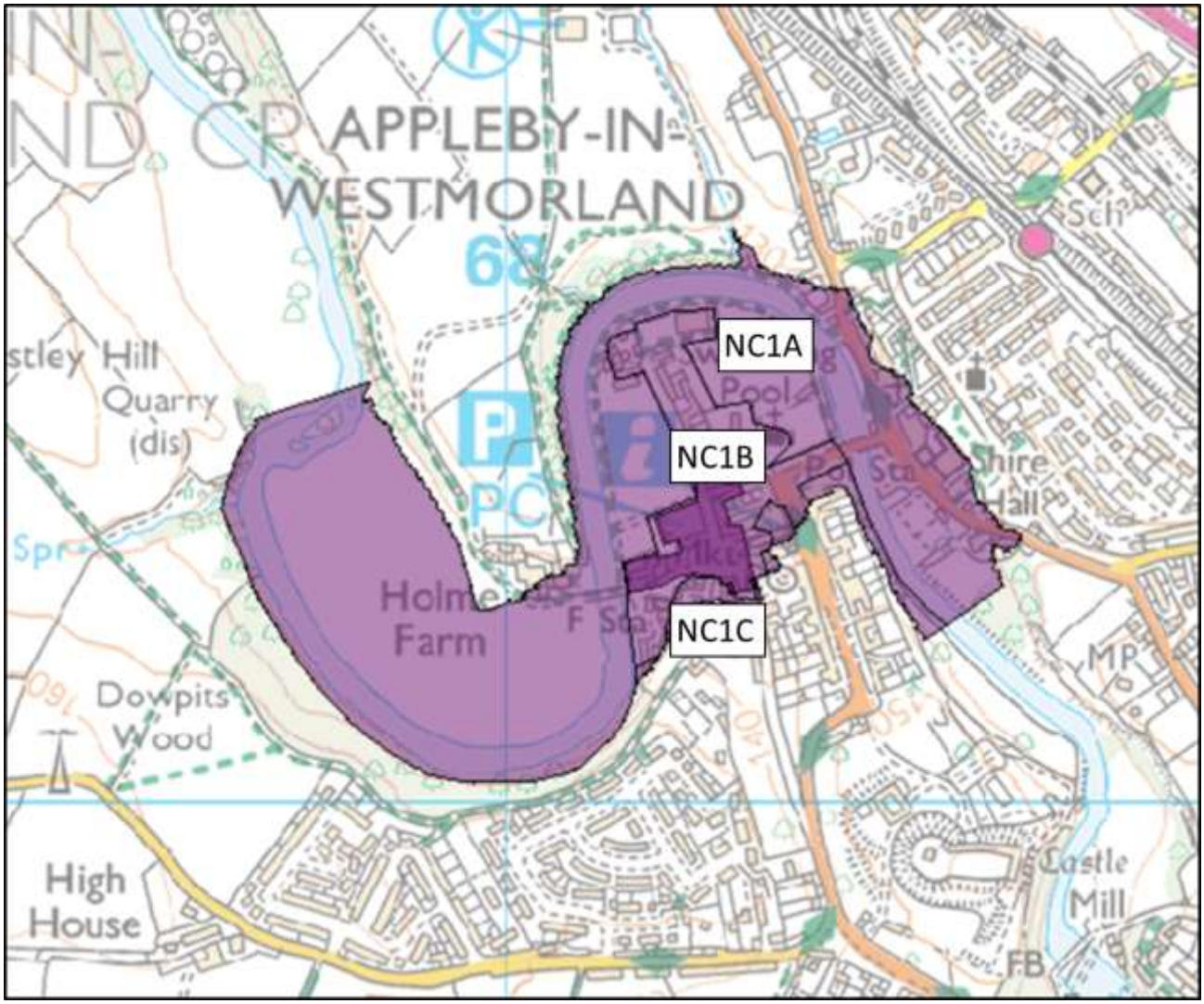
Water Resources Act 1991:
http://www.legislation.gov.uk/all?title=water%20resources%20act

Land Drainage Act:
http://www.legislation.gov.uk/all?title=land%20drainage%20act

Appendix 4: Flood Warnings and Alerts

Appleby is covered by a Flood Alert, and certain areas are additionally served by Flood Warnings including the 3 shown in the map above. Flood Warning Areas are well defined following the major flood event in 2005. Flood Warning Levels will be reviewed in terms of revised modelling for the Rivers Eden, some amendments to these areas are anticipated.

The table below summarises the times of the flood warnings issued during this flood event:



Flood Warning Areas within Appleby-in-Westmorland

Flood Alerts:

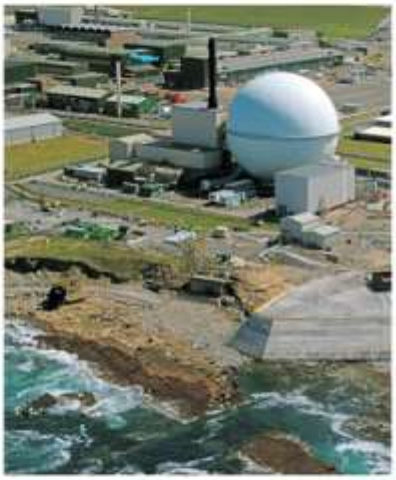
Upper River Eden 03/12/16 14:46 hrs & 04/12/15 15:15 hrs

Flood Warning Area	Flood Warning Issued	Severe Flood Warning Issued (05/12/15)	Properties	Contacts	%Success
NC1A River Eden at Appleby, The Sands, Cricket ground, St Georges Field	**(04/12/15)** 20.49	11:48	53	104	68%
NC1B River Eden at Appleby, Chapel Street, Bridge Street, Holme Street and Court, Low Wiend Area	**(05/12/15)** 7:40	11:48	72	145	72%
NC1C River Eden, Appleby, Market Square, Boroughgate, Doomgate	**(05/12/15)** 7:41	11:48	29	70	69%

Appendix 5: CH2M Hill UK Projects and Flood Risk Management brochure

CH2MHILL.

Key Projects in the UK



We partner with your industry

- Municipal Water, Wastewater, and Water Supply
- Aviation, Ports, Transit, and Rail
- Nuclear Decontamination and Decommissioning
- Chemical Manufacturing
- Environmental Remediation and Compliance Management
- Environmental Industrial Systems
- Commercial Nuclear
- Oil and Gas
- Electronics and Advanced Technologies
- Manufacturing
- Life Sciences
- Communications Infrastructure
- Security Systems

Employee-owned CH2M HILL is one of the world's leading consulting, design, design-build, operations, and programme management companies serving government, civil, industrial and energy clients, employing over 28,000 people worldwide. Our work is concentrated in the areas of water, transportation, environmental, energy, facilities and resources.

Having operated in the UK for over 20 years, we acquired Halcrow in 2011 and continue to base our European headquarters in London, now employing over 3,300 people in the UK. CH2M HILL is working on some of the most iconic infrastructure programmes including High Speed 2, Thames Tideway Tunnels, the decommissioning of Dounreay and was one of the leading partners in CLM, Delivery Partner to the ODA for the London 2012 Olympic & Paralympic Games.

We serve as a single point of contact and responsibility, managing your project through planning, financing, permitting, design, construction, and operations. We use technology transfer and leverage established relationships with local firms to deliver industrial and enterprise management solutions throughout the United Kingdom.

CH2M HILL is an active member of Business in the Community and the Employee Ownership Association.

Urban Programmes

Key endorsements:

"From the outset of the project, the Olympic Park has set new standards in sustainability, including delivery of lightweight venues, recycling or reuse of waste materials, using concrete with a high recycled content and delivering materials by rail or water. We have achieved new standards for a project of this size and scale and have raised the bar for the industry."
– John Armitt, ODA Chairman

"The ODA did a fantastic job in delivering the Olympic venues and infrastructure on time and within budget. They did our nation proud."
– Margaret Hodge MP, Chair of the Public Accounts Select Committee

London 2012 Olympic and Paralympic Games

CH2M HILL was one of the three first constituting the international consortium CLM, the Delivery Partner to the Olympic Delivery Authority (ODA). CLM oversaw the design and construction of the nine venues across the 500-acre Olympic Park for the London 2012 Olympic and Paralympic Games. CH2M HILL provided the consortium and ODA with global engineering, construction and programme management expertise.

Completed one year ahead of the games, the programme was delivered at an impressive £1Bn under the baseline budget of £7.2Bn with notably zero construction fatalities, the first of such records of any modern Olympics.

Water

Thames Tideway Tunnel and Lee Tunnel

CH2M HILL is the programme manager for the London Tideway Tunnels Programme, one of the biggest and most historic public works initiatives in London's history. With the Rivers Lee and Thames currently overflowing approximately 50-60 times annually, the London Tideway Tunnels Programme looks to reduce overflows to three or less per year.

The programme will see the construction of the Lee Tunnel and the Thames Tideway Tunnel and aims to greatly improve the river quality and reduce the environmental impact of sewerage overflows. Both tunnels will be more than seven metres wide, running beneath a vast network of existing tunnels, including six Underground lines and utilities. The programme includes constructing numerous collection and diversion facilities, a large high-head underground pumping station, and a major upgrade at Beckton sewage treatment works. Ultimately, CH2M HILL will manage over 300 work packages. So far, CH2M HILL have delivered £700M of savings on a £4.1Bn budget and carried out exemplary stakeholder relations across 14 London Boroughs.

Transport

Crossrail

As Europe's largest engineering project, Crossrail will connect 37 stations, including Heathrow airport and Maidenhead in the west with Canary Wharf, Abbey Wood and Shenfield in the east—reducing journey times across London while delivering extensive economic benefits.

The Transcend team, which includes CH2M HILL, AECOM and The Nichols Group, was appointed as the programme partner to work alongside Crossrail to oversee the construction of a 21 kilometre-long tunnel beneath central London, build eight new stations and integrate Crossrail with London's existing transport systems. Additionally, the team is responsible for programme controls, encompassing the functions of scope, cost and schedule control, as well as risk and value management.

When Crossrail opens in 2018, the £14.8Bn rail link will boost London's rail-based network capacity by ten percent—transporting 200 million passengers annually, bolster the capital's position as a world-leading financial center, and significantly reduce journey times across the city.

High Speed 2 (HS2)

HS2 will be the UK's new high speed rail network and is being designed and built to resolve impending capacity issues for both passengers and freight on existing routes, particularly the West Coast Main Line.

The network will provide enhanced infrastructure links between London and the West Midlands (Phase One), as well as the Channel Tunnel, expanding in future to connect Manchester, Leeds and the North with Birmingham, the south of England and Heathrow Airport (Phase Two).

CH2M HILL is development partner with HS2 Ltd and is leading the development of the next phase of engineering, design and environmental work on the London to the West Midlands line. The 80 strong team, working alongside HS2 Ltd, largely consists of project management and engineering specialists from the UK. The team project manage the professional services companies who are carrying out the design, environmental and land referencing work for the London to West Midlands line. CH2M HILL's expertise ensures that the work is fully integrated and delivered to the required quality.

On appointing CH2M HILL, HS2 Ltd's Chief Executive Alison Munro said: "The appointment means that we will have world class project managers and technical experts working alongside us to deliver the design, engineering and environmental work necessary for the hybrid bill. They will bring, in particular, their highly regarded experience of working on HS1 and Crossrail, two major UK infrastructure projects that have direct relevance to our work."

We provide services for your success

- Programme and Project Management
- Site Selection
- Infrastructure Planning
- Economic Development
- Energy Management and Planning
- Information Systems
- Master Planning
- Licensing and Permitting
- Management Consulting
- Project Financing
- Project Development
- Architecture and Programming
- LEED and BREEAM Facility Certification
- Civil, Structural, Mechanical, and Electrical Engineering

Water Resources-Ecosystem Management Services

Flood Risk Management

CH2M is a world leader in flood risk management, providing integrated and sustainable solutions for both the built and natural environment. Our large team of specialists and scientists, who are primarily based in the UK and USA, deliver projects around the world. They are supported by environmental scientists, surveyors, geotechnical engineers, and business planning, finance and contract, and other specialists. Our work includes the full cycle of flood risk mapping and strategic planning; capital works delivery; and operation, maintenance and asset management.

The solutions we develop recognize the effect climate change is increasingly having on the built and natural environment within river catchments and estuaries, and thus our focus is on developing long-term solutions that work with nature and continue to leave a sustainable legacy to protect future generations from the effects of climate change.

A core focus is delivering fully integrated solutions that maximize both direct and indirect benefits for the clients that we serve in WBG, TBG and Strategic Consulting. This means we are linked with several technologies including IWRM, Dams and Levees (Conveyance), Water Resilience, H&H modeling (Software Applications and Integration), Urban Watershed Management; and Coastal Planning and Engineering.

Sub-technologies

The FRM technology group has three key sub-technology areas that we steward, offering several capabilities in each:

Flood mapping and appraisal

- Watershed-scale flood risk management planning
- Flood hazard modeling/mapping and hydraulic analysis
- Flood risk management alternatives development and testing
- Risk vulnerability and damage analysis
- Flood forecasting/warning
- Flood incident management and exercise

Capital works delivery

- Program/project management
- Conceptual, preliminary and final design
- Contract preparation and administration
- Construction supervision
- Due diligence and other pre-bid assistance

O&M and asset management (AM)

- Asset management
- Strategic and tactical investment advice
- Disaster recovery

Challenges, Trends, Opportunities

Floods are increasing in frequency around the world and it is forecast that these will only get worse as a result of climate change. As the frequency of floods increases, the tolerance of the public, governments, the private sector, and insurance companies is reducing, prompting action.

A key market differentiator is being able to deliver multiple outcomes to clients through a river basin management approach which links together flood risk management needs with regeneration, recreational, and environmental enhancement opportunities and combines the associated available funding to generate both efficiencies and the financial support necessary for scheme delivery.

To achieve this we need to combine our flood risk management capabilities and technology with our knowledge of what the issues are within the river basins.

Did You Know?

- A review by the Organization for Economic Cooperation and Development on 136 coastal cities found that the estimated damage from sea level rise, storm surge and subsidence for 1 in 100 year flood event in 2070 was estimated at $35,000 billion.
- In 2070 it is estimated that over 150 million people will live in these 136 coastal cities at risk.
- River flooding is the most common type of flood event.
- Floods are the number one natural disaster in the US, and just a few inches of water from a flood can cause tens of thousands of dollars in damage.
- The flooding in Alberta, Canada in 2013 flooding displaced 100,000 people and is estimated to cost $6 billion.
- According to the House of Commons library, £2.34 billion has been spent on new flood defenses in England alone since 2011.