Cumbria County Council

Cockermouth

S.19 Flood Investigation Report

Confluence of the Rivers Derwent and Cocker, Cockermouth 06/12/2015
Photograph provided by Peter Smith Photography. Taken 06/12/2015 12:33

Flood Event 5-6th December 2015

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

Version	Prepared by	Reviewed by	Date
Working Draft for discussion with EA	Ian McCall	Michael Lilley	17th March 2016
Draft incorporating EA feedback	Ian McCall	Michael Lilley	19th May 2016
Final	Chris Evans	Doug Coyle	

Contents

Executive Summary

Cockermouth experienced severe flooding on the 5th and 6th of December following Storm Desmond. This storm 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 Derwent on the 6th December was the highest flow ever recorded, with the previous record set in the November 2009 floods. Record levels were also observed in Derwentwater and Bassenthwaite Lake.

In response to the flood event, this 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 Cockermouth on the 5th and 6th of December, and has used a range of data collected from affected residents, site visits, surveys of the area, and data collected by observers, along with 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. Further information can be found in Appendix 5.

594 properties in Cockermouth were flooded from both the River Cocker and River Derwent, when the flood defences in the town were overtopped and outflanked. Overtopping of the defences occurred when the water level exceeded the height of the defence and flowed over the structures. Outflanking occurred when the river levels were high enough for water to flow around the furthest extent of the defended line. The flood event exceeded the design level of the existing flood defences within Cockermouth, however, no defences failed or collapsed. The defences reduced the damage caused to property and infrastructure, and delayed the onset of flooding, allowing residents additional time to prepare for the flood.

This report details the flooding that occurred from the Rivers Derwent and Cocker. The flow routes and causes of flooding are identified. River banks and flood defences were overwhelmed in a number of locations throughout Cockermouth:

- Victoria Road Bridge, on the left bank of the River Cocker, upstream of Rubbybanks Road and the raised hump north of this bridge.
- Flooding to properties at Hatters Croft on the left bank of the River Cocker downstream of South Street Footbridge that are part of the defended line
- The defences on the left and right banks of the River Cocker downstream of Main Street Bridge
- The defences at Jennings Brewery
- The left bank of the River Derwent at Waterloo Street
- The car park at the Trout Hotel on the left bank of the River Derwent
- The embankment on the right bank of the River Derwent at Derwentside Gardens
- The embankment on the right bank of the River Derwent immediately upstream of Gote Bridge
- Outflanking of defences protecting the Gote Road area to the north of Spital Ing Lane

Surface water flooding also occurred at:

- Junction at Rubbybanks Road and South Street

Both these locations were also flooded from rivers when defences were overtopped.

Please note that references to left and right bank are taken looking downstream with the flow of water.

Seventeen actions have been recommended in this report to manage future flood risk. These 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 Cockermouth 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 and gravel management. This review is being undertaken separately to this report and is already underway, with an expected completion date in July 2016.

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 to the town.

Any additional information that can be provided 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. 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

Cockermouth is located at the confluence of the Rivers Cocker and Derwent. Both rivers have a large catchment area incorporating the high fells of the Lake District National Park. Buttermere and Crummock Water are located along the course of the River Cocker, and Bassenthwaite Lake and Derwent Water lie within the Derwent catchment. Cockermouth is a historic town with a castle and a thriving market with medieval and Georgian streets beneath the castle walls. It is located in the Borough of Allerdale in Cumbria and has a population of approximately 7,900.

Cockermouth is a town that has historically grown up around the river system with much of the industry using its water. Jennings Brewery is sited on the right bank of the River Cocker immediately upstream of the confluence. The centre of Cockermouth retains much of its historic character. It is known for its range of small specialist shops and is a popular destination for tourists. **Figure 1** provides an overview of the location of Cockermouth and the surrounding catchment.

Figure 1: Location of Cockermouth and the Wider Catchment

Flooding History

Cockermouth is highly prone to flooding with 15 flood events recorded since detailed records began in 1761. The town, at the confluence of the Rivers Cocker and Derwent, is prone to flooding due to the natural topography of the area. Flooding occurred most recently in 2005, 2008 and 2009.

The November 2009 event was estimated to be an event with a rarity greater than 0.2% Annual Exceedence Probability (AEP)[*]. The 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 described as a 1% AEP event.

AEP (as percent)	AEP (as probability)
50%	0.5
20%	0.2
10%	0.1
4%	0.04
2%	0.02
1%	0.01
0.1%	0.001

Table 1: Probabilities of Exceedance

At the time, the November 2009 event produced the highest recorded flow in both the River Cocker and the River Derwent. It occurred following torrential rainfall with one month's average rainfall falling on the 19th November 2009. The impacts of the 2009 storm were worsened by flows peaking on both rivers at almost the same time.

The water level recorded in the River Cocker in December 2015 did not reach the level experienced in 2009. In the 2009 event, the peak level in the River Cocker reached 4.970m, roughly 0.5m higher than in 2015 level of 4.476m both recorded at South Street footbridge in Cockermouth. As such, the area of Cockermouth at risk from the Cocker only, experienced less severe flooding in 2015 compared to the 2009 event. The impacts of the 2015 flooding were also lessened by the improvements to defences in the south of the town following the 2009 event. **Table 2** shows the flow recorded in the two rivers upstream of Cockermouth for the historical events and for the 2015 flooding.

Flooding Event	Number of Properties Flooded	Peak Flow in River Cocker at Southwaite (m^3/s)[†]	Peak Flow in River Derwent at Ouse Bridge (m^3/s)
January 2005	261	107.3	196.0
October 2008	45	117.6	187.1
November 2009	537	**201.4**	377.9
December 2015	594	170.0	**395.0**

Table 2: Recent flood events affecting Cockermouth

[*] Estimate taken from CEH briefing note **http://nora.nerc.ac.uk/s510223/1/Nov09Floods-CEH-briefing-note.pdf**
[†] 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, 594 properties suffered flooding. The area affected by the flooding is shown in **Figure 2**. The main impact of this flooding can be attributed to the River Derwent, rather than both rivers, following Storm Desmond. This storm caused 36 hours of intense rainfall leading to high river levels that overtopped and outflanked flood defences at a number of locations within the town.

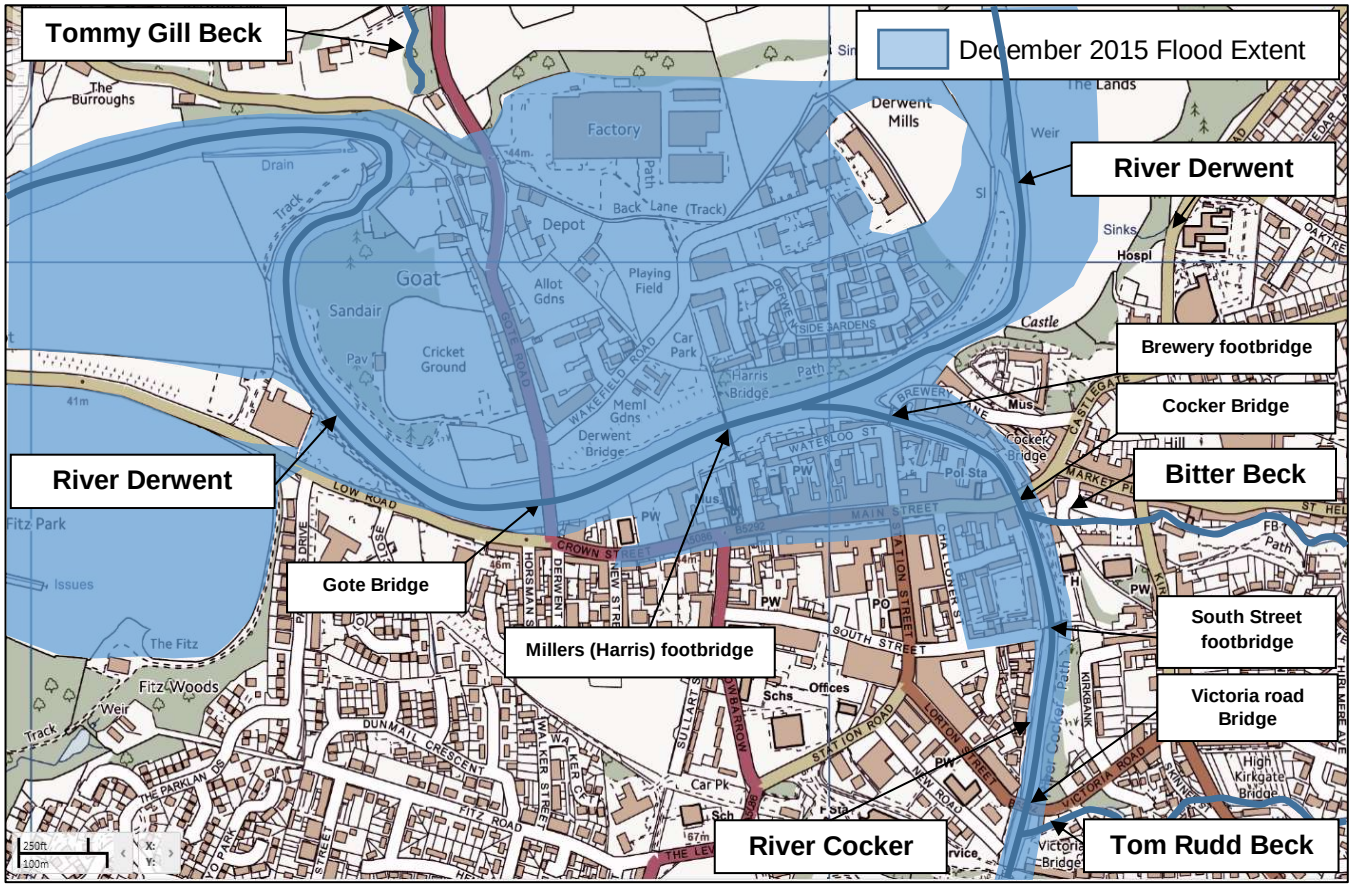

Figure 2: Extent of River (Fluvial) Flooding* in Cockermouth on 5-6th December 2015

*The flood outline identifies the maximum extent of flooding. Not all properties within the extent area were flooded.

The extent of the flood is similar to that of the 2009 event, however, flood depths tended to be lower since raised defences on both the Rivers Derwent and Cocker were able to hold back flows for longer, and increased the capacity of the channel.

Rainfall Event

December 2015 was the wettest calendar month on record for the UK, with much of northern England receiving double the average December rainfall. This also followed a particularly wet November and as such, much of the ground within the Cumbria catchments was already saturated.

From the 4th to the 7th of December 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 broke the previous records, also within Cumbria, set during the November 2009 floods.

Table 3 shows the record levels of rainfall that fell prior to the flooding event. **Table 4** shows the rainfall more widely recorded over the catchment on the 4th and 5th December 2015. **Figure 3** shows the location of these rain gauges around Cockermouth.

	Pre 2015 UK records		New UK records as of December 2015	
	Location	**mm**	**Location**	**mm**
24 hour rainfall record	Seathwaite	316.4	Honister Pass	341.4
48 hour rainfall record	Seathwaite	395.6	Thirlmere	405

Table 3: UK Rainfall Records*

Return periods (calculated using historical rainfall event data) have been calculated for this event. Two of these locations have recorded rainfall that is estimated to be rarer than 0.1% AEP.

Monitoring Station	Rainfall (mm)			Estimated Return Period (AEP) of max. rainfall in 24 hours†
	4th December (09:00 – 08:59)	5th December (09:00-08:59)	Max. rainfall in 24 hours	
Cornhow	12.8	81.8	94.4	7.1%
High Snab Farm	39.6	159.2	193.0	0.7%
Honister Pass	58.6	294.4	341.4	**<0.1%**
Seathwaite	36.6	185.2	214	1.33%-1.67%
Sunderland Waste Water Treatment Works (WWTW)	7.8	42.8	50.6	25%
Thirlmere	35.0	317.6	324.8	**<0.1%**
Portinscale	Data not within validation tolerances			
Dale Head Hall	Data not within validation tolerances			
Mosedale	Monthly storage – no telemetry			

Table 4: Rainfall recorded at gauges around Cockermouth

* Taken from met office – **www.metoffice.gov.uk/public/weather/climate-extremes**
http://www.metoffice.gov.uk/climate/uk/interesting/nov2009
† Calculated using FEH DDF methodology, this estimation is not calibrated for values with an AEP less than 0.1%

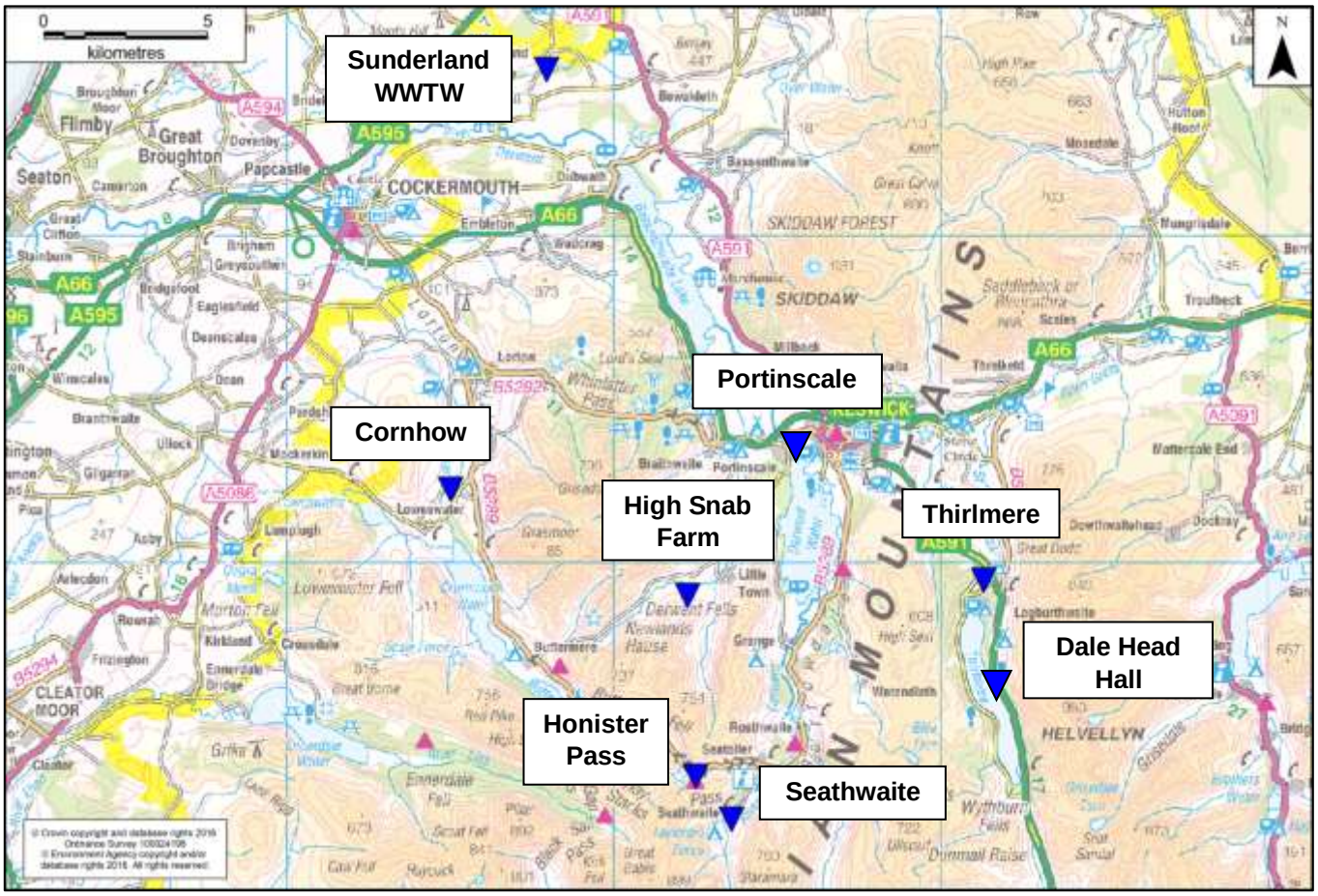

Figure 3: River Derwent catchment and locations of rain gauges

This rainfall event led to exceptionally high river flows across the country and widespread flooding. There are a number of river monitoring gauges upstream and within Cockermouth measuring flow and level on the Rivers Cocker and Derwent. The locations of these are shown in **Figure 4**.

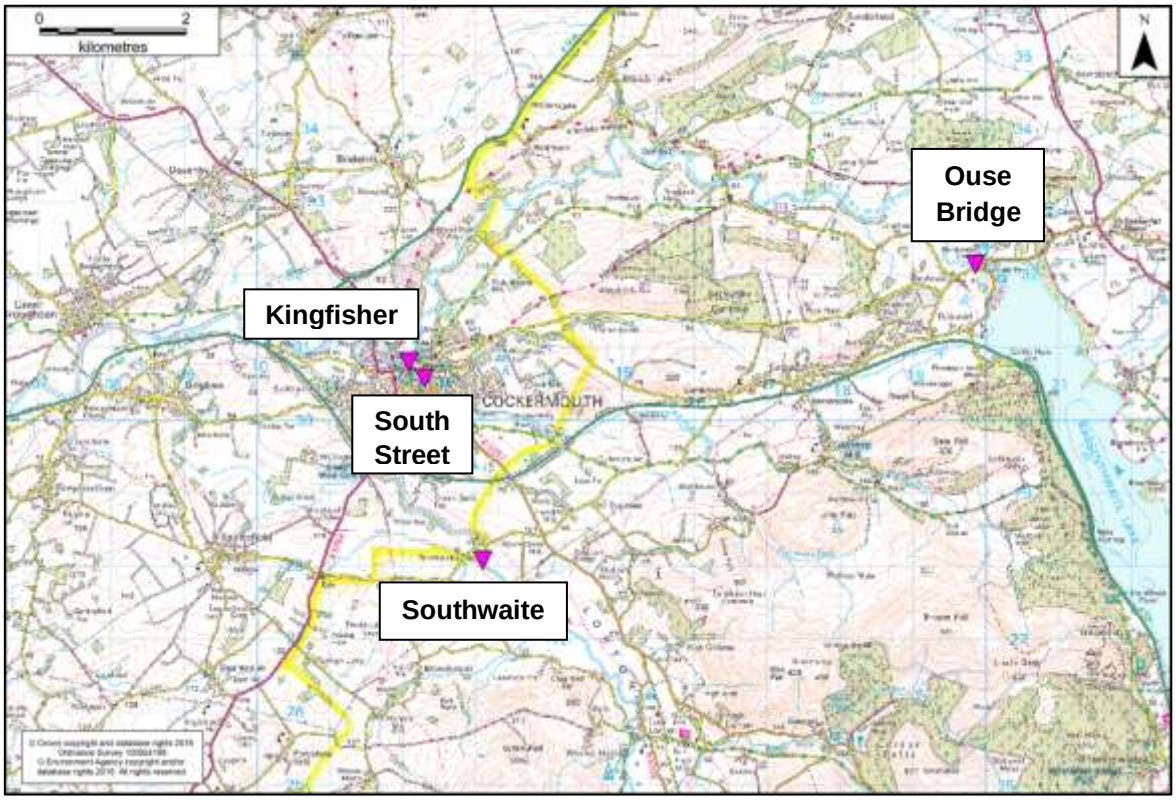

Figure 4: Location of river gauges upstream of Cockermouth

Table 5 shows the peak flows recorded at these gauging stations. For the Ouse Bridge gauging station on the River Derwent, the flows on 5th December were higher than those for any previous event. Flows calculated at Southwaite Bridge on the River Cocker were less than the November 2009 event and this is reflected in the flooding extent and mechanisms.

Figure 5 shows the recorded river levels at the two monitoring gauges from the 4th to the 8th of December. This illustrates the relative size of the two rivers and the times of peak flow during the December flood event.

Gauging Station	River	Peak flow (m3/s)					Estimated AEP of Dec 2015 event
		Dec 2015	Past events				
			June 2012	Nov 2009	October 2008	Jan 2005	
Ouse Bridge	Derwent	**395**	154	378	187	196	0.1%-0.3%
Southwaite	Cocker	170	110	**201**	117	107	1%

Table 5: Flows recorded at the gauging stations

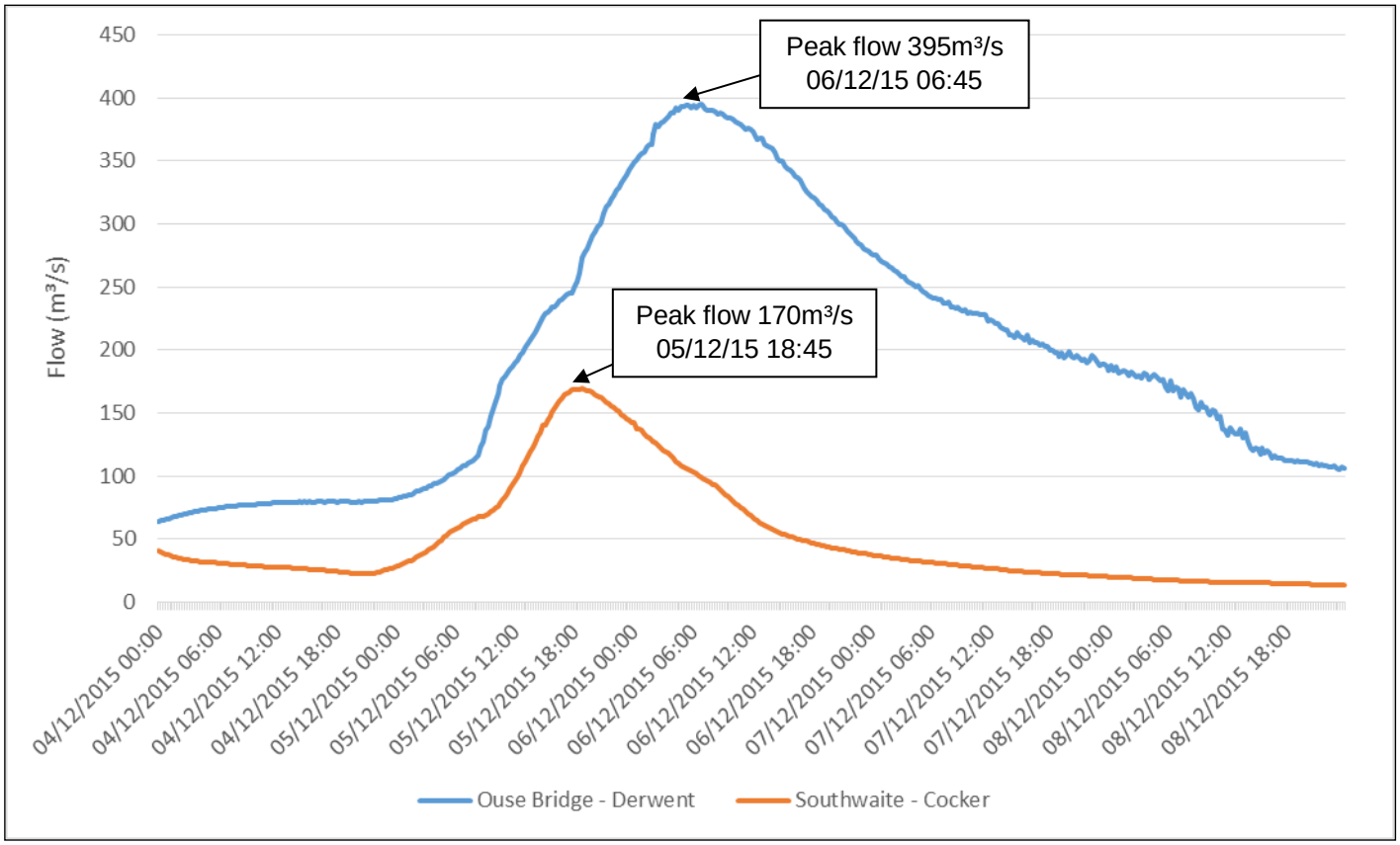

Figure 5: Flow measured at river gauges upstream of Cockermouth

This flood event was of a greater magnitude than the Cockermouth scheme was designed to protect against (1% AEP). As such, river levels would be expected to be higher than the level of the flood defences.

Existing Flood Defences

There are currently raised flood defences within Cockermouth, which are shown in **Figure 6**. In locations between or adjacent to defences, flood protection is provided by existing features such as higher ground. For example, the flood wall east of the Derwentside Gardens estate ends at an area of ground higher than the flood defence level of the wall.

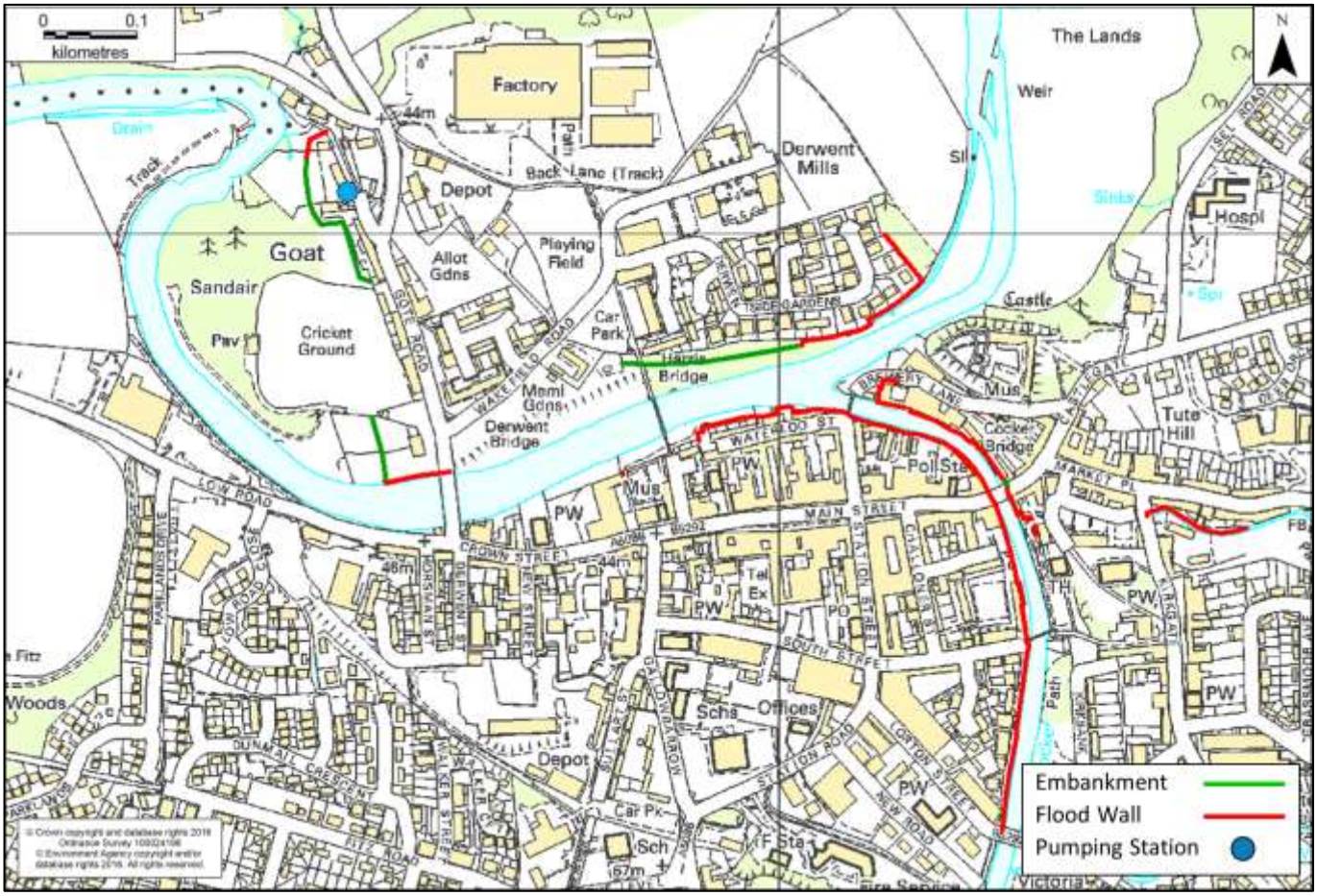

Figure 6: Flood Defences within Cockermouth

The defences are designed to protect the town against a 1% AEP flood event. Flood defences in Cockermouth have been constructed and improved in several phases following previous flooding events.

The first improvements to flood defences were constructed in 1999 on the Rivers Cocker and Derwent. Further improvement work was also carried out in 2008.

During the November 2009 flood event many of the existing third party privately owned river walls that acted as flood defences were damaged as the flood waters overtopped them. As part of the recovery from this incident, a programme of Emergency Works to rebuild these walls was completed in October 2010.

New flood defences along Gote Road were completed in November 2010, reducing the risk of flooding to 42 homes. In 2012 the Environment Agency started the construction of the Cockermouth Flood Risk Management Scheme to reduce the risk of flooding to 361 residential and 55 commercial properties to 1% AEP in any year. The scheme cost £4.4 million and was completed in spring 2013. The scheme was funded by the Environment Agency, professional partners, and the local community.

The Cockermouth Flood Risk Management Scheme consists of:

- Rubbybanks Road – Stone-clad reinforced concrete defence wall incorporating a self-closing barrier to raise the height of the wall during a flood event. The road level is raised at the downstream end of this wall near Victoria Bridge.
- Hatters Croft – Stone-clad reinforced concrete defence wall with glass panel at top of wall. Croft Cottage numbers 1-4 fitted with flood-resilient windows.
- Market Street – Reinforced concrete wall and flood gate at Riverside Car Park
- Brewery Lane – Reinforced concrete wall along riverside. Flood Gate across Brewery Lane
- Police Station – Stone-clad reinforced concrete wall
- Waterloo Street – Stone-clad reinforced concrete wall
- Derwentside Gardens – Embankment and brick-clad reinforced concrete wall joining into area of high ground
- Gote Road – Embankment and flood wall with pumping station

In 2015 Cumbria County Council installed a new surface water storage system under Main Street. The scheme is designed to reduce flood risk to a 1% AEP event and consists of enlarged man holes and pipe work.

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

Investigation

This investigation was carried out by the Environment Agency through surveys of the area and data collected from the community affected. This report has compiled this data to provide details of flooding from the Rivers Derwent and Cocker both of which are Main Rivers.

For this report, the flooded area has been divided into five sub-areas for investigation as shown in **Table 6**. These are based on flood flow routes, and broadly correspond to the flood warning areas within Cockermouth. These sub-areas are shown in **Figure 7**:

Sub-area	Sub-area Name	Description
A	**Rubbybanks road**	The area on the left bank of the River Cocker upstream of Main Street Bridge
B	**Jennings Brewery**	The area on the right bank of the River Cocker including Jennings Brewery itself
C	**Main Street**	The area on the left bank of the River Derwent
D	**Derwentside Gardens**	The eastern area on the right bank of the River Derwent including Derwentside Gardens, Derwent Mills industrial estate and the James Walker factory
E	**Gote Road**	The remainder of the right bank of the River Derwent within Cockermouth

Table 6: Identified sub-areas for investigation

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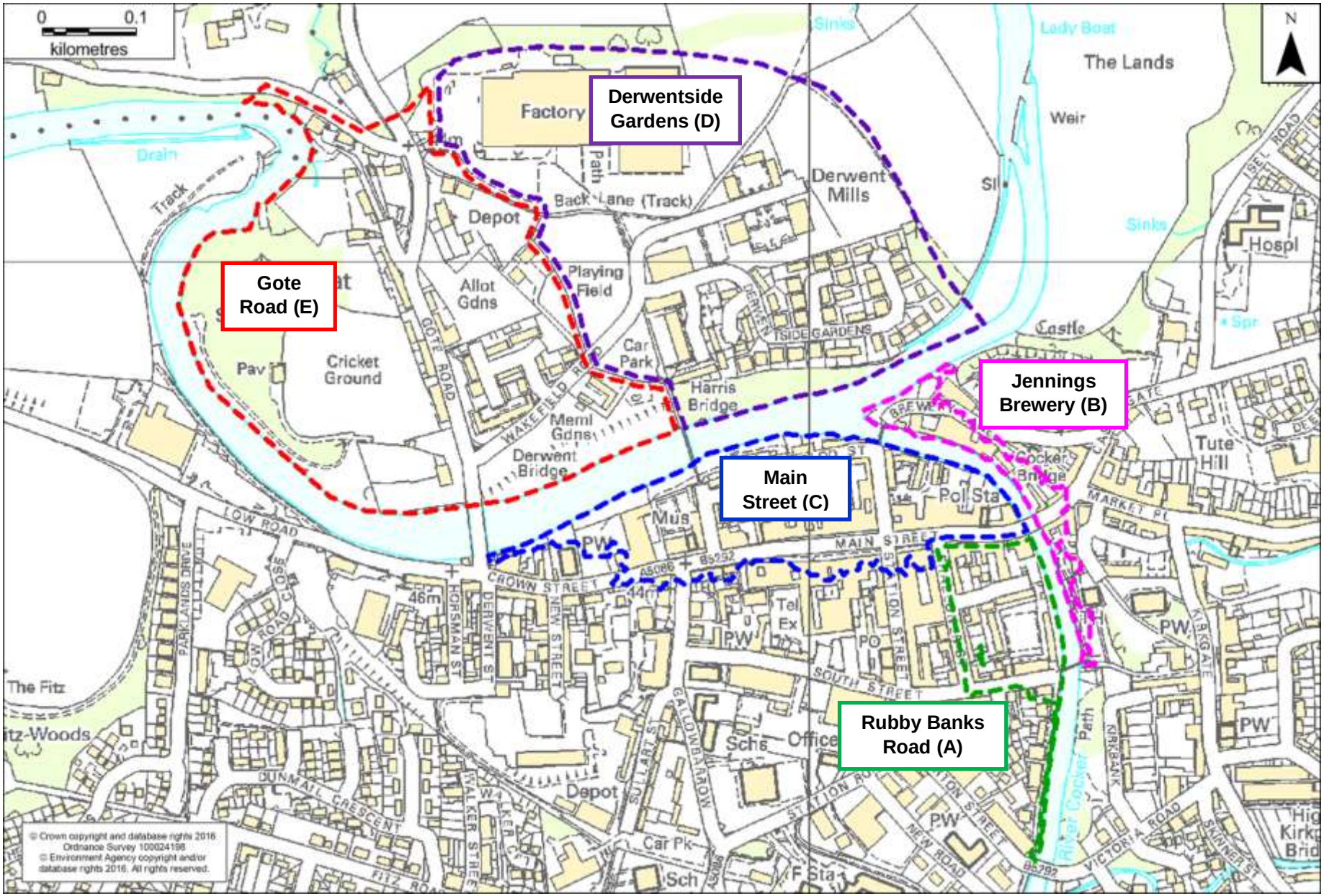


Figure 7: Identification of areas flooded

Impacts and Likely Causes of Flooding

Timeline

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

4th December	**Event**
	Flood gates closed
1530	Flood alert issued
5th December	**Event**
1440-1530	Flood warnings issued
1500	The self-closing barrier on Rubbybanks Road fully lifted.
1500	Flood flow is reported via a route upstream of Derwent Mills outflanking the defences along the river at Derwent Gardens
1530	Reports of the embankment being outflanked at the north area of Gote Road and Spital Ing Lane
1630	Initial flooding reported at Hatters Croft flats. Ingress from the balcony side over door barriers.
1630	The embankment upstream of Gote Bridge is reported to be overtopped leading to flow onto Gote Road from the south
1649	Reports of the River Cocker overtopping the defences at Waterloo footbridge and flowing up High Sand Land towards Main Street
1649	**Severe Flood Warning issued**
	Gote Road Pumping Station fails
1655	Continued overtopping from the River Derwent observed behind Waterloo Street
1700	Properties on Main Street reported to have been flooded
	Jennings Brewery defences overtopped
1710	Reports of the floodwall being overtopped at Derwentside Gardens.
1720	Overtopping of the floodgate on Low Sand Lane reported
1740	Flow through Trout Hotel Car Park
1800-1900	Flood flow is reported flowing down Rubbybanks Road outflanking the defences having overtopped the road hump at Victoria Road Bridge
1845	**Peak flow at South Street footbridge gauging station (Cocker) – 4.476m**
2000	The river level had risen above the base of the South Street footbridge and debris started to collect at the structure. A clear rise in river level upstream was observed.
2100	The floodgate at the Town Hall Riverside public car park is overtopped
2100	Self-closing barriers were being regularly overtopped by flow surges approximately every 25 seconds.
6th December	**Event**

0330	**Peak flow at Kingfisher gauging station (River Derwent) – 4.543m**
0800	Floodwater flowing back into the Derwent from James Walker factory.

Table 7: Timeline of Key events

The timeline highlights that flood warnings did not give sufficient time. This is currently under review. The flooding mechanisms included both rivers overtopping or bypassing existing flood defences, and flooding from surface water drainage that was unable to discharge into the rivers. Flood defences and river banks were overtopped at:

- Victoria Road Bridge, on the left bank of the River Cocker, upstream of Rubbybanks Road and the raised hump north of this bridge
- Flooding to properties at Hatters Croft on the left bank of the River Cocker downstream of South Street Footbridge that are part of the defended line
- The defences on the left and right banks of the River Cocker downstream of Main Street Bridge
- The defences at Jennings Brewery
- The left bank of the River Derwent at Waterloo Street
- The car park at the Trout Hotel on the left bank of the River Derwent
- The embankment on the right bank of the River Derwent at Derwentside Gardens
- The embankment on the right bank of the River Derwent immediately upstream of Gote Bridge
- Outflanking of defences protecting the Gote Road area to the north of Spital Ing Lane

Surface water flooding also occurred at:

- Junction at Rubbybanks Road and South Street

A number of areas in Cockermouth were identified to have experienced significant erosion during this flood event. In particular, the riverbank at Cockermouth Castle was severely eroded, and the castle has been identified as being at risk of damage. Damage to this bank, and fallen trees on the upstream island led to blockages at Gote Bridge. **Photograph 1** shows the riverward side of the castle and the erosion to the bank at this location. There was also significant erosion around Bitter Beck and to the playing fields and footpaths east of Gote Road.

Photograph 1: Cockermouth Castle showing erosion to riverbank. Taken 21/12/2015

The following sections details overland flow routes and the sources of flooding within the sub-areas identified on **Figure 7.**.

Overview of Flow Routes

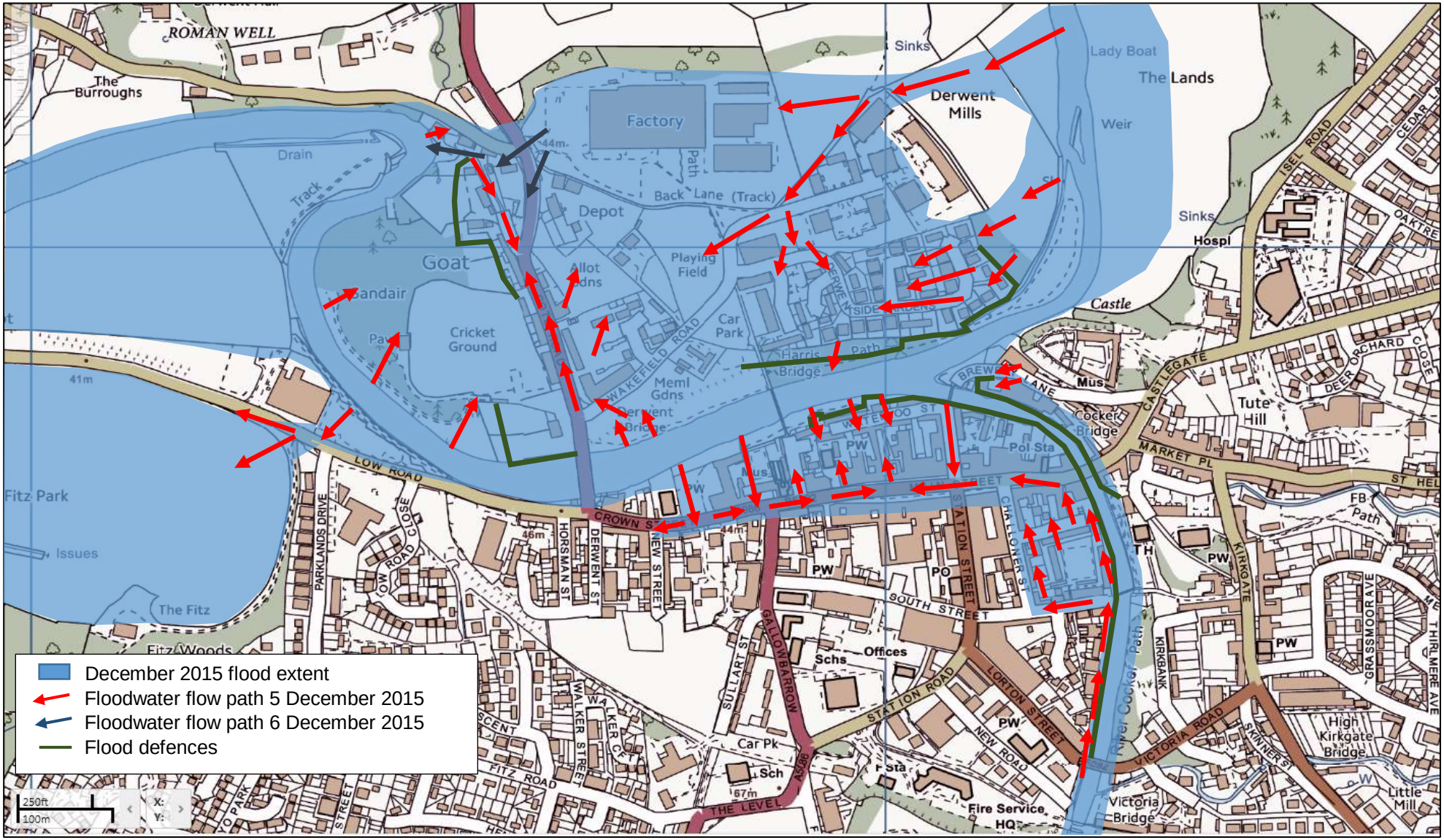


Figure 8: Map of flood flow routes **Note: The flood outline identifies the maximum extent of flooding. Not all properties within the extent area were flooded.**

Sub-area A: Rubbybanks Road Area

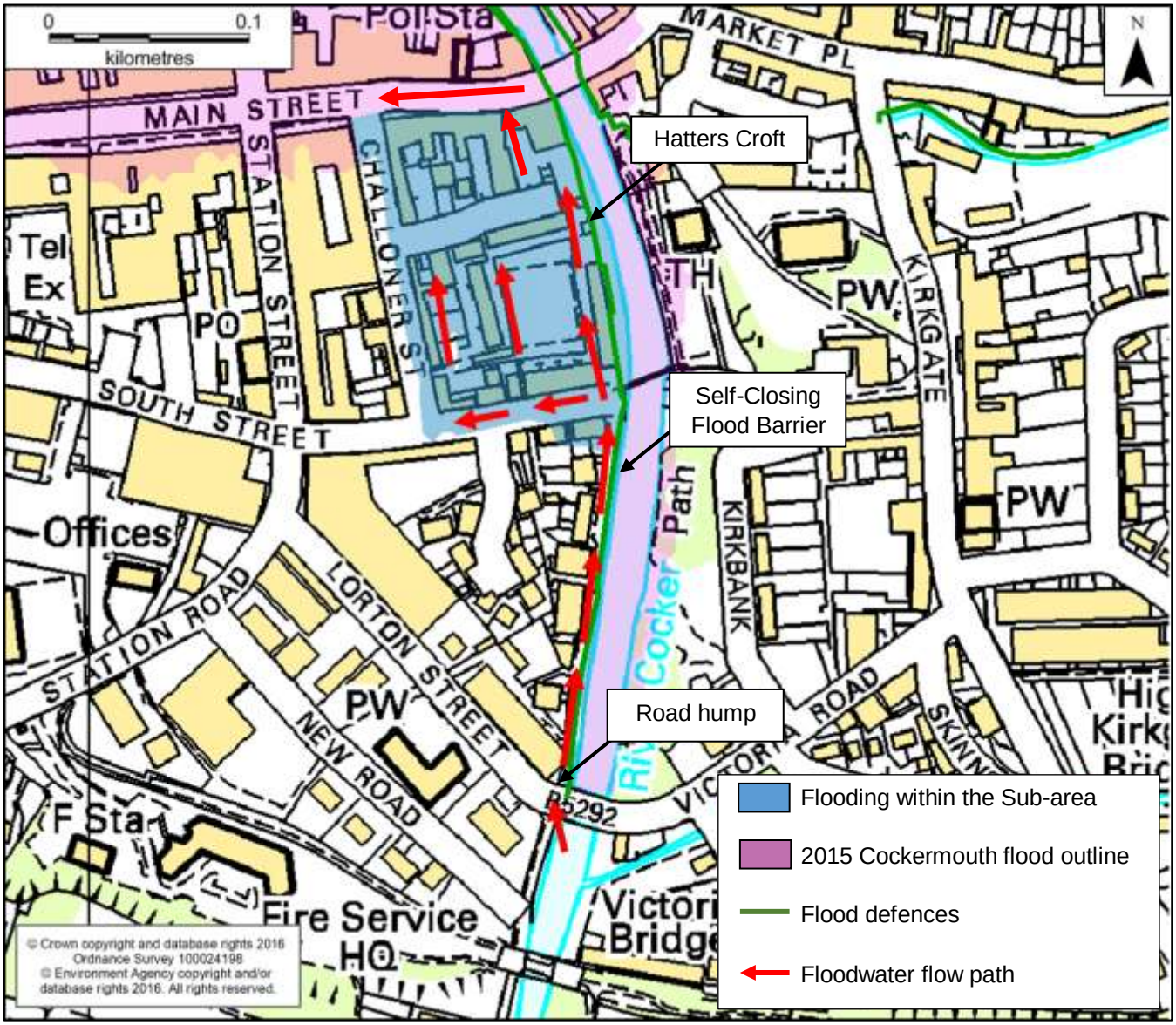


Figure 1: Flow routes from the River Cocker along Rubby Banks Road

Note: The flood outline identifies the maximum extent of flooding. Not all properties within the extent area were flooded.

This is an area of residential properties on the left bank of the River Cocker including Rubby Banks Road which runs in parallel to the river. The flood extent and the flood flow routes into this area are shown in **Figure 9**.

The Rubbybanks Road area is situated to the north of Victoria Road (B5292) Bridge. The flood defences in this area run alongside Rubbybanks Road. Along part of this wall's length, the defences include self-closing barriers housed within the lower part of the defence wall. These are not visible outside of flood conditions. At the southern extent of this wall, the road level of Rubbybanks Road was raised to form a hump, acting as a flood defence. There are also a number of properties downstream of South Street, including Hatters Croft Cottages, forming part of the defence line. At these locations, property-level protection, such as flood resilient windows, have been installed in some of the properties.

The self-closing flood barriers along Rubbybanks Road worked correctly and did not overtop. There was some overtopping immediately upstream of the self-closing barrier as a wave was created by river flow hitting the upstream corner of the barrier wall. This water then continued to flow down the inside of the

defence wall causing ponding of floodwater at the junction of Rubbybanks Road and South Street. The surface water drainage system was also surcharging in this location.

The flood resilient property windows fitted to 1-4 Hatters Croft Cottages forming part of the defence line were also seen to have worked successfully, however these properties were still flooded. No resilience measures are installed on the Hatters Close Flats. This occurred early in the flood event prior to the peak river level. The bunded balcony at Hatters Croft was overwhelmed at about 1600, resulting from over-topping of the upstream wall. Initial ingress of water came from the balcony, over the door barrier at approximately 1630, three hours before water entered the front door from flows down Rubbybanks Road. The source of this flooding was seen to be water rising through the floor of the buildings, followed later by flood water entering through the front of the properties. All contents and fittings were damaged or destroyed to a height of approximately 1 metre.

Water from the River Cocker overflowed the riverbank between the Victoria Road Bridge and Victoria Jubilee Railway Bridge**. Photograph 2** shows the riverbank which does not have any raised defences at this location. After overtopping the riverbank, the floodwater passed through the pedestrian archway. The water level was high enough to pass over the raised road hump, located at the upstream end of Rubbybanks Road. This road hump is higher than the level of the flood defence wall but was thought to be overtopped due to the Victoria Road Bridge restricting flow and raising the river level upstream of the bridge.

Flood water continued to flow down Rubbybanks Road, although the properties on this road have relatively high thresholds with only a single property flooded through a doorway. However, a number of properties sustained sub-floor damage caused by water ingress through air bricks. Water then continued down Rubbybanks Road and onto South Street, flooding the properties on this street and in the surrounding area. Flood water also flowed through the alley on Croftside onto Main Street. The flooding continued to the junction between South Street and Challoner Street. This was reported to have occurred close to the time of the peak flow in the River Cocker.

Photograph 2: Riverbank between Victoria Jubilee Rail Bridge and Victoria Road Bridge (facing downstream). Taken 9/12/2015 at 11:40

There was also the reporting of significant surcharge from surface water drains along Rubbybanks Road before any overtopping occurred from the river. In addition to this, there was seepage through the pedestrian floodgate on South Street footbridge leading to a pool of water on the dry side of this gate. These sources combined with the river water on the road contributed to the flooding in the area.

The depth of flooding within specific houses varied from 0.23m to 0.97m. This was often higher than the water level outside of the properties. This was reported by some of the affected residents.

Sub-area B: Jennings Brewery Area

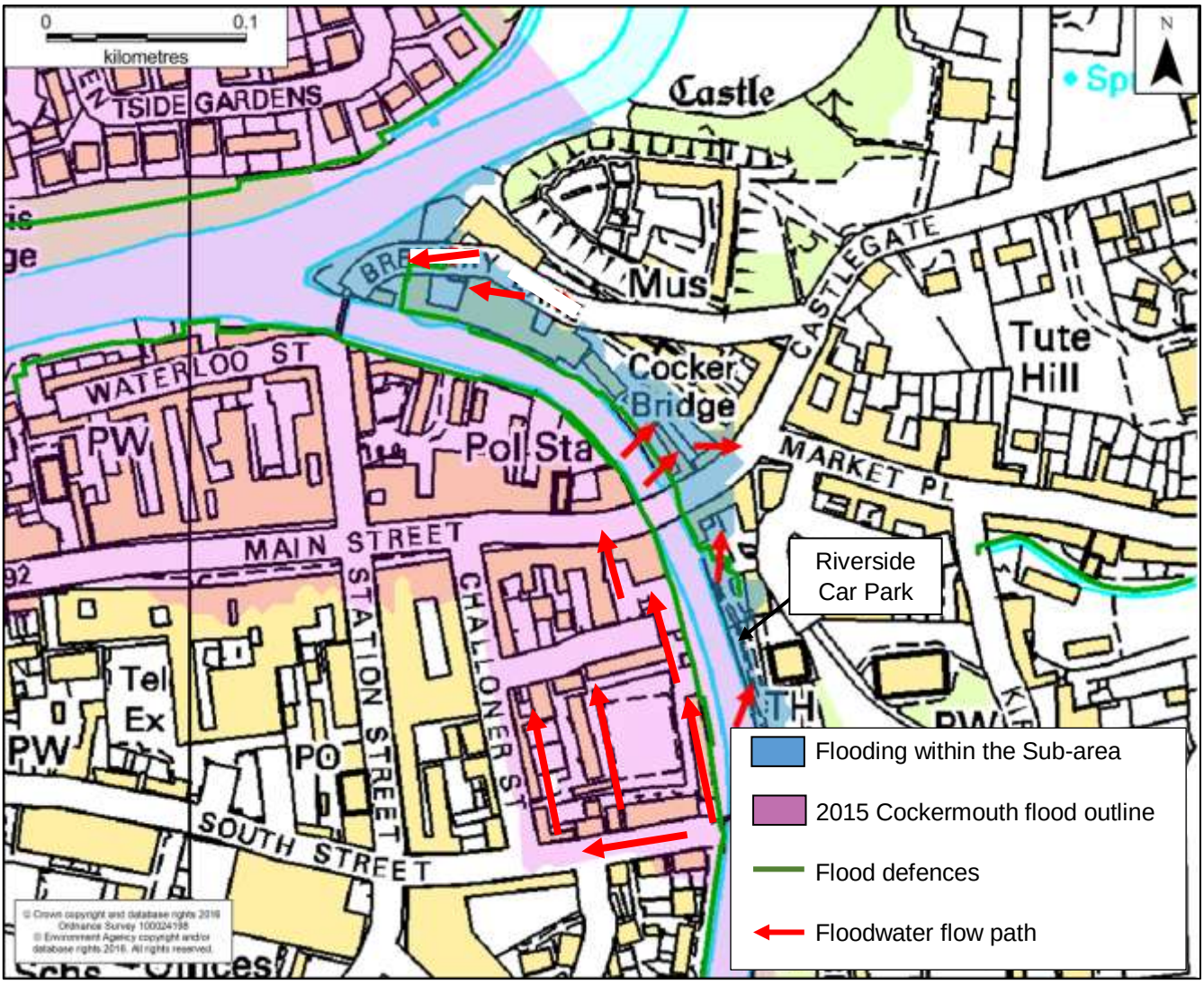


Figure 20: Flow routes on the right bank of the River Cocker

Note: The flood outline identifies the maximum extent of flooding. Not all properties within the extent area were flooded.

This is an area of properties on the right bank of the River Cocker. It is a mix of retail and residential properties and also includes Jennings Brewery and Cockermouth Town Hall. The area is adjacent to Cocker Bridge carrying Main Street across the river. The area and the flood flow routes into this area are shown in **Figure 10**.

There are flood defence walls at the river bank and at Jennings Brewery. The public car park at the town hall is designed to flood as part of the defence scheme and has a flood gate and defence wall at its entrance.

Flooding first occurred in the Riverside public car park. This area is not protected by flood defences and is expected to flood when there are high river levels. However, the water subsequently overtopped the floodgate at this car park, reported to have occurred at 21:00 on the 5th December. This occurred after the peak on the River Cocker but before the peak on the River Derwent. Flooding in this area was caused by levels in the Cocker rising due to water backing up from high levels in the River Derwent. The flooding extended to the junction between Main Street and Market Place, as the road rises steeply beyond this location.

Defences were overtopped downstream of the Cocker Bridge. The defences at Jennings Brewery were outflanked and the floodgates at the end of Brewery Lane held water back. There is no record of the times that these defences were outflanked, but was thought to be after the time of the peak flow in the River Cocker.

There was one report of a property internally flooded from water rising through a ground floor toilet, although there were no reports of drains surcharging onto the roads in this area. Flooding to the properties on Market Place and Market Street was between 0.5m and 0.65m depth. The electricity substation at Brewery Lane was also flooded and remained live.

Sub-area C: Main Street Area

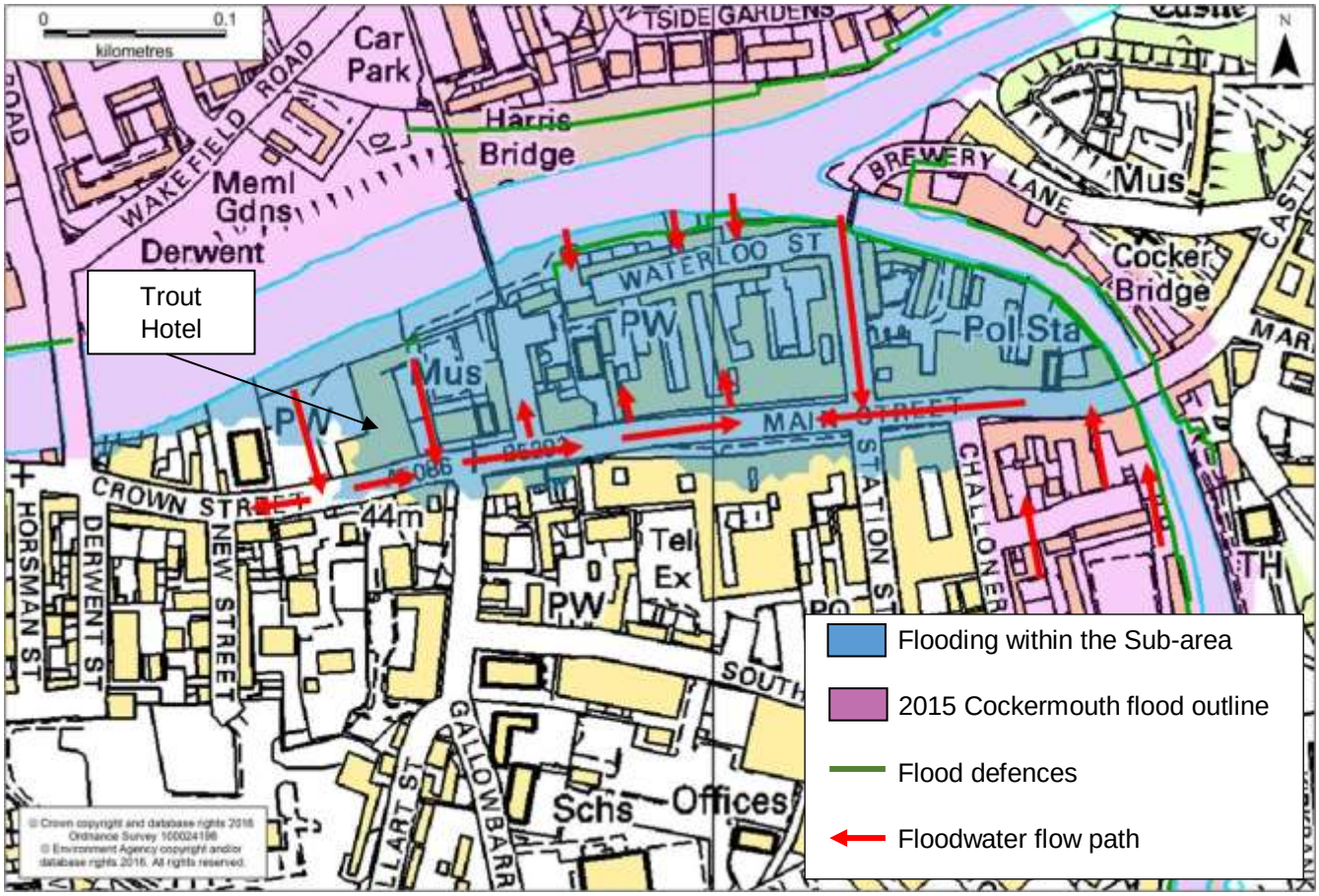


Figure 31: Flow routes into Main Street Area

Note: The flood outline identifies the maximum extent of flooding. Not all properties within the extent area were flooded.

This is the main thoroughfare in Cockermouth and is predominantly retail properties. The area is defended by a flood defence wall along the river bank that includes several floodgates. The area and the flood flow routes into this area are shown in **Figure 11**.

This area was flooded from both the River Cocker and River Derwent. Defences at this location were both overtopped and outflanked.

- The River Cocker overtopped the defences at Waterloo footbridge at 16:49 as the Severe Flood Warning was issued. This floodwater was observed flowing up High Sand Lane towards Main Street.
- From 16:55 onwards, there was continued overtopping of the River Derwent behind Waterloo Street.
- At 17:00 properties were flooding on Main Street and water was running from East to West.
- Reports indicate that the floodgate on Low Sand Lane was being overtopped by 17:20, and water flooding Main Street in a West to East direction.
- Reports of floodwater overtopping the high ground in the Trout Hotel car park indicate a time of approximately 17:40.

There was significant flow onto Main Street through the car park at the Trout Hotel. Floodwater also overtopped the flood barrier on Low Sand Lane, upstream of the hotel. This route is highlighted in **Photograph 3**. Floodwater then continued to flow down Main Street and formed the main flood route into

the area. The amount of water following through this route was increased by debris at Gote Bridge obstructing flow and leading to a higher river level at the Trout Hotel.

Flooding occurred to all properties between the River Derwent and Main Street. This flooding extended to the junction between Main Street and New Street. The depth of this flooding was approximately 0.45m within properties.

Photograph 3: River Derwent at Main Street area highlighting flow route through the Trout Hotel car park. Photograph provided by Peter Smith Photography. Taken 06/12/2015 12:37

Sub-area D: Derwentside Gardens and Derwent Mills Area

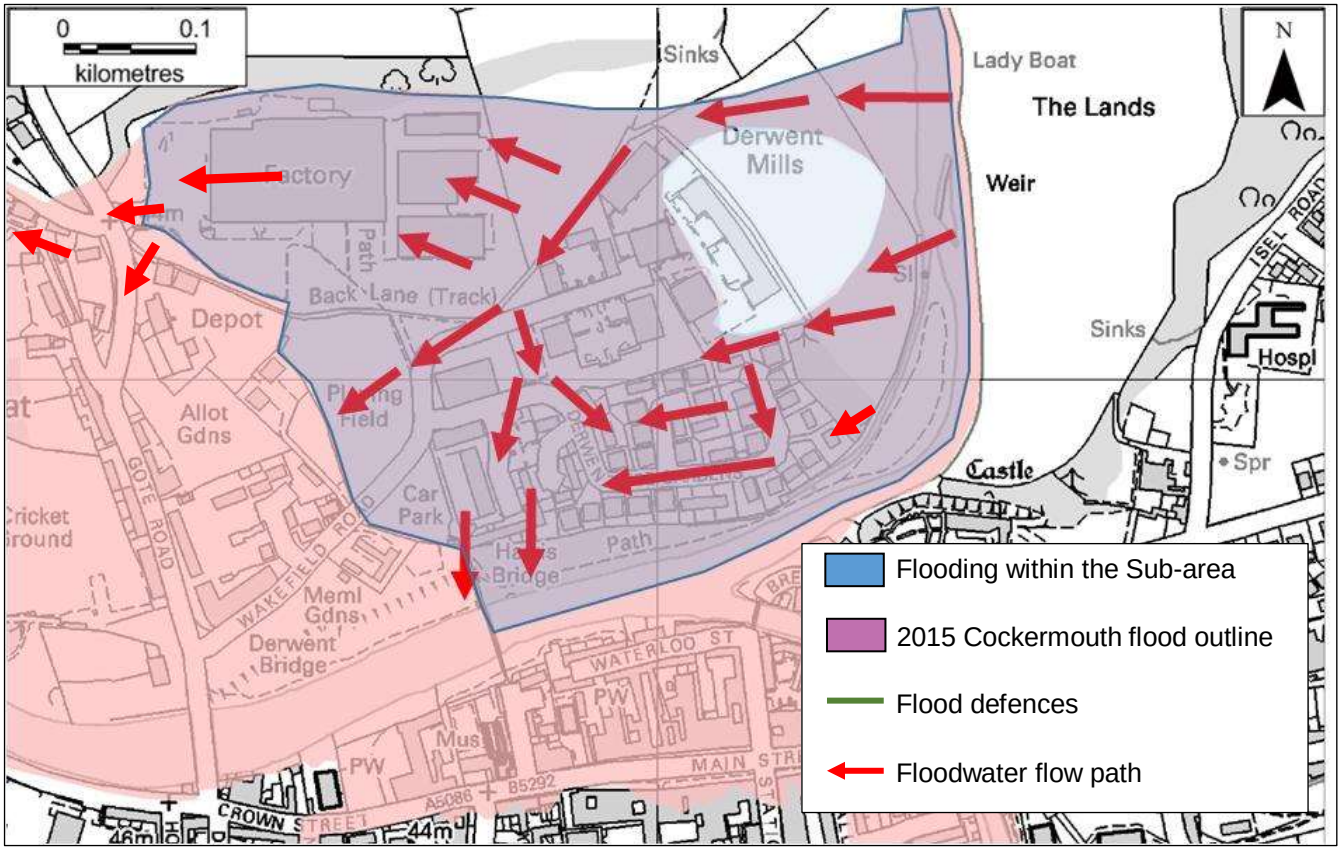


Figure 42: Flow routes in Derwentside Gardens area

Note: The flood outline identifies the maximum extent of flooding. Not all properties within the extent area were flooded.

Derwentside Gardens is a relatively new residential estate constructed in the late 1990s. This area also includes the Derwent Mills Industrial Estate and James Walkers' factory. The area and the flood flow routes into this area are shown in **Figure 12**.

Whilst this estate is sited on slightly higher ground than the main town, it is still at risk of flooding and is protected by a flood defence wall and embankment that was constructed in 2012 as part of the Cockermouth Flood Risk Management Scheme. The north-eastern extent of this wall ties into ground above the level of the defence line.

Flow on the right bank of the River Derwent overtopped the defences at this location at 17:10 on 5th December 2015. These defences were also outflanked with water travelling overland via routes upstream of Derwent Mills and at the eastern extent of the Derwentside Gardens estate. **Photograph 4** shows this area during the flood event. Flood water was observed by residents to be flowing back towards the River Derwent over the embankment at the southern extent of the estate.

All properties in Derwentside Gardens were flooded as well as the James Walkers' factory to the north and the nearby playing fields. This flow then continued downstream and overland contributing to flooding in the Gote Road area.

Flood depths in Derwentside Gardens varied due to the differing threshold heights of properties. Flooding was recorded at a depth of 1.0m in this area and in the James Walkers' factory.

Photograph 4: Derwentside Gardens during event showing flow route upstream of defence. Photograph provided by Peter Smith Photography. Taken 06/12/2015 12:37

Sub-area E: Gote Road Area

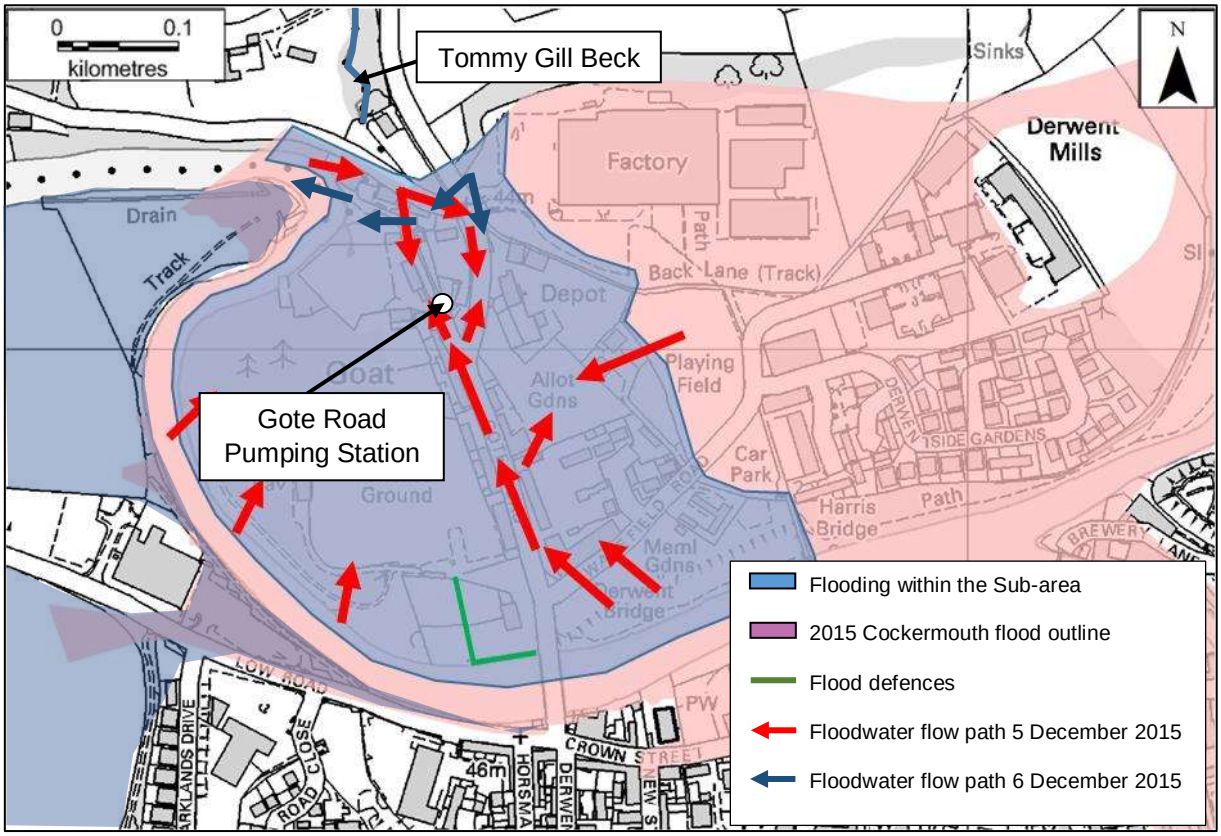


Figure 13: Flow routes in Gote Road area

Note: The flood outline identifies the maximum extent of flooding. Not all properties within the extent area were flooded.

This is an area of residential properties adjacent to the Derwentside Gardens area. Gote Road is carried over the River Derwent by Gote Bridge. The area and the flood flow routes into this area are shown in **Figure 13**.

There is an area of natural high ground on the upstream right bank of Gote Bridge. Defences have been constructed downstream of the bridge and to the west of Gote Road. There is also a pumping station alongside the Gote Road defences to pump water trapped on the dry side of the flood embankment back to the river. This embankment also has an outfall flap and penstock to drain water that accumulates on the dry side of the defences. After the flood event, there was a delay and problems in opening the penstock. This will be investigated as part of the scheme performance review.

The properties on Gote Road were flooded from the River Derwent through multiple flow paths. The pumping station within this area stopped pumping due to power failure when it was itself flooded. The location and resilience of the electrical sub-station will be investigated as part of the scheme performance review.

This area was flooded as a result of four different mechanisms:

1. The defences were outflanked at the north end of Gote Road leading to properties being flooded at approximately 15:30.

2. The embankment on the right bank upstream of Gote Bridge overtopped at approximately 16:30. This then led to floodwater flowing along Gote Road from the south, flooding all properties in this

area. This was the main flow route for floodwater. Flooding to properties in this area was recorded at depths up to 2 metres.

3. There was also flow through the Derwentside Gardens area and the James Walker factory, **Photograph 6**.

4. There was also reported flooding from a manhole on the old mill race which Tommy Gill Beck flows into before, discharging into the River Derwent.

Photograph 5: Gote Road area during event. Photograph provided by Peter Smith Photography. Taken 06/12/2015 12:35

Gote Bridge caused an obstruction to the river leading to higher river levels upstream of the bridge. This was visible during the event where there was a significant difference in levels upstream and downstream of the bridge. A number of trees and other debris partially blocked the bridge arches at peak flows, increasing the impact of this. This exacerbated the overtopping of the defences and the flow into this area.

Photograph 6: Floodwater flowing from the James Walker factory along Gote Road. Photograph provided by D Dunlop. Taken 6/12/2015 08:26

Environment Agency and Highways Flood Incident Response

Due to the nature of the river environment in Cockermouth, gravel deposition occurs on both the Rivers Cocker and Derwent. This can reduce channel capacity, which can have an impact on flood risk. Regular monitoring of gravel accumulation forms part of the Environment Agency's maintenance programme in Cockermouth. If gravel builds up to a level where flood risk is increased, then the Environment Agency undertakes gravel removal to maintain channel capacity and conveyance through the town.

Following the flood event in December 2015, the Environment Agency has undertaken a channel survey to determine the extent of gravel accumulation and identify areas of increased potential flood risk. Significant volumes of gravel have been deposited, and removal is to commence in June 2016. Following the flood event the Environment Agency has also removed blockages and obstructions (such as large trees) from the Rivers Cocker and Derwent in Cockermouth.

Immediately prior to the flood event the Environment Agency inspected watercourses and operational structures such as debris screens to ensure that there were no blockages which may have caused an increase in flood risk.

There are a number of flood gates within the Cockermouth Flood Risk Management Scheme which require closing prior to potential flooding. These flood gates were closed by the Environment Agency on the morning of 4th December, well in advance of any flooding occurring. The only operational issue reported in relation to the floodgates was leakage through the floodgate at South Street footbridge on Rubbybanks Road.

A flood alert for the Rivers Cocker and Derwent was issued on the 4th of December, at 15:30. Flood warnings were issued to the flood warning areas within Cockermouth between 14:30 and 15:30 on the 5th December. **Table 8** shows the times that flood warnings were issued for the different flood warning areas in Cockermouth. Additional details on these flood warning areas and the warnings issued are shown in Appendix 4.

Flood Alert issued	04/12/2015 15:30
Flood Warnings	
Cricket Ground and Trout Hotel Car Park	05/12/2015 01:11
Old Courthouse and Market Place Area	05/12/2015 14:27
Bridge Street, Crown Street, High Sand Lane and Main Street	05/12/2015 14:40
Gote Road to Derwent Mills Area and Low Road	05/12/2015 14:40
Challoner Street, Croft Terrace, Jubilee Court and Rubbybanks Road	05/12/2015 15:28
Severe Flood Warning issued	05/12/2015 16:49

Table 8: Times of Flood Alert and Warnings

A severe flood warning was issued for Cockermouth at 16:49 on the 5th December as flooding to the town was thought to be imminent. This severe warning was issued after some areas to the north of the town had begun to flood. A number of the affected residents felt these warnings arrived too late and did not give them enough notice to respond to the imminent flooding.

A number of properties affected by the flooding event did not receive flood warnings as these were not registered with the Environment Agency. In addition to this some properties in Derwentside Gardens were registered but did not receive flood warnings. This was thought to be due to loss of power to this area as local electricity substations had been affected by the flooding.

The Environment Agency has worked closely with the Cockermouth Flood Action Group (CFAG) for a number of years to help plan and prepare for flood events. The Environment Agency also sent messages to stakeholders via the Cumbria Community Messaging (CCM) system to raise awareness and provide advice and guidance.

Highways deployed an 8" pump, in case the new surface water system was overwhelmed. The pump was never used and was only withdrawn when the river overtopped the walls in Waterloo Street. The surface water system functioned as designed until inundated by the river.

Maintenance Activities

The Environment Agency maintains flood risk management structures and sections of river channel where maintenance actively reduces the risk of flooding to people and property. Activities we undertake are summarised below:

- We conduct yearly visual inspections of flood defence embankments and walls and deliver a variety of maintenance tasks which include, as necessary:
    - grass cutting,
    - tree and bush management,
    - invasive species control,
    - vermin control and
    - expansion joint repairs.

- We deliver targeted maintenance on River Channels where the activity is beneficial to the reduction in flood risk. This could include:
    - Weed Control,
    - Grass Control,
    - Tree and Bush Management,
    - Invasive Non Native Species Control,
    - Gravel Removal, when justified through investigation and survey.

In Cockermouth, we undertake tree and bush management and gravel management on the Derwent from Derwentside Gardens to the Gote and on the Cocker up to Victoria Bridge.

- On operational structures, we undertake:
    - quarterly operational inspections and
    - yearly mechanical maintenance

- On Culverts, which could pose a risk of flooding to properties, we monitor the risk of flooding through 6 yearly inspections, and deliver the following on a risk based approach:
    - Cleansing works
    - Repairs and reconditioning works

Facts and Figures for Cockermouth:

- Gravel naturally collects in the River Derwent upstream of Gote Bridge. We monitor this section yearly and remove gravel when it reaches a “trigger level”. We will be removing gravel from this section in June 2016.
    - On average, we remove gravel from here every 3 years, depending on the severity and frequency of floods.
- We maintain 0.5km of Flood Defence Embankment in Cockermouth.
- We maintain 1.2km of flood defence wall
- We maintain over 70 structures in Cockermouth

United Utilities: Thirlmere Reservoir

Background

Thirlmere reservoir was built in 1894 to supply drinking water for Manchester. The reservoir can store up to 40,000 megalitres (million litres) of water and approximately 700,000 people – about 10% of the region's water users - receive drinking water supplies from Thirlmere. Most are in Manchester but other communities include Blackpool and the Fylde coast, Lancaster and local communities such as Keswick and Borrowdale.

At the southern end of Thirlmere is the Thirlmere aqueduct. This is a 134 mile long gravity tunnel which links Thirlmere to Manchester. The aqueduct extracts up to 220 megalitres (million litres) of water from Thirlmere per day.

Thirlmere discharges into St John's Beck, which is a tributary of the River Greta. The River Greta flows through Keswick and joins the River Derwent just after it leaves Derwent Water as it flows towards Bassenthwaite Lake. St John's Beck accounts for about one fifth of the water in the River Greta.

How Thirlmere is operated

Thirlmere reservoir is maintained and managed according to legislation and the local arrangements agreed with Keswick Flood Action Group (KFAG). United Utilities operate to a set of flood level drawdown rules agreed with KFAG.

These rules specify reservoir levels for each month at which United Utilities will release more water into St John's Beck. Releases continue until the month target level is achieved, and further to maintain it if necessary. This is a best endeavours effort as incoming water from rainfall and the catchment may be greater than the maximum possible releases.

In November 2015 this level was 3.0m below top water level – equivalent to 76% full. The idea being that this spare capacity can absorb some of the heavy rain which falls during these months. United Utilities operated the reservoir to these agreed levels prior to the December 2015 flood event.

However, the catchment is in a delicate environmental balance and there is a natural limit to the amount of water United Utilities can release without causing damage to St John's Beck which is a Special Area of Conservation. The normal compensation flow in St John's Beck is 13.64 megalitres a day. This can be can increased this to 140 megalitres per day.

Even at this level, it causes some flooding to farmland. Any more than 140 megalitres per day will cause farmland to flood on a more frequent basis. United Utilities also have to consider the impact increased flows have on those who use the Beck for fishing. All releases, except the 13.64 megalitres litres compensation, are ceased if the reservoir starts to spill.

Nov 2015- Levels in Thirlmere Reservoir

United Utilities can increase the rate at which water is removed from the reservoir up to a certain limit. When the Thirlmere Aqueduct is open, the safe and environmental limit is 320 megalitres a day. If the rain falls faster than this then the reservoir will start to fill until it eventually overflows.

In November 2015, whilst Thirlmere reservoir releases were managed in exact accordance with the agreed KFAG protocol, the catchment experienced more than twice the normal level of rainfall expected for the month, and Thirlmere reservoir continued filling and started to spill on Monday 30 November. On 5th December alone, around 14,000 million litres of water entered the reservoir, which is more than a third of its capacity. The average rainfall for Cumbria for the month of December is 146.1mm, and more than this fell during one day. Over the course of the weekend, flows down St John's Beck were higher than ever recorded before. Given the amount of rainfall, increasing the 320 megalitres daily removal would have made little material difference.

Future investment

United Utilities have been considering options for further flood drawdown releases and possible modifications to the infrastructure at Thirlmere as part of the new pipeline scheme to West Cumbria.

Limitations to the speed of reservoir drawdown, caused by constraints at the dam outlet to St John's Beck, are well understood, and following studies potential solutions have been identified. These solutions will be considered as part of the detailed design of the modifications to abstraction infrastructure, new water treatment works and pipelines for the Thirlmere to West Cumbria transfer.

Current flood drawdown releases are approximately 140 Ml/d. The limitation is not the outflow from the low level scour valves on the dam, which can release up to 900 Ml/d in emergency draw down for reservoir safety. The issue at present is infrastructure downstream of the valves, including an operational foot bridge that provides essential access to Bridge End Water Treatment Works (WTW), which could be damaged and access be lost if flows higher than the currently agreed releases are made.

Work has progressed to develop the long term provision of water to West Cumbria which will include a solution that could allow a higher rate of release. In essence this is to engineer a channel to accommodate the higher flows, and make modifications to the valves to enable better control. This would allow approximately 500 Ml/d of flood drawdown release to be made whilst still maintaining flows to the WTW to supply customers.

United Utilities are committed to ongoing engagement with KFAG, the Environment Agency, and Natural England regarding the volumes of water that can be released in to St. John's Beck in the future.

- United Utilities have committed to undertaking a study to investigate the hydrology, geomorphology and ecology of river function at different flow rates and locations.
- We have prepared a scope for the study, which has been agreed with Natural England and the Environment Agency.
- The first stage of the study will propose the maximum drawdown release rate to provide ecological benefits, to inform design of new release infrastructure. This stage will commence in winter 2016, and is scheduled to report in summer 2017.

- The second stage of the study will include monitoring and assessments from 2017 to 2022, including during the periods when higher flood drawdown releases will be made in order to monitor the influence of these releases and determine the best high flow management regime to provide the range of flows necessary to provide ecological benefits in St John's Beck.

St John's Beck is part of a Special Area of Conservation and therefore any solution needs to be complaint with the Habitats Directive.

We currently estimate that construction of new infrastructure will begin in 2017, and take an estimated 12 months to deliver the work to accommodate the releases in to St John's Beck.

In addition, recommendations arising out of a report on Thirlmere by Aecom, commissioned by the Environment Agency following the floods in December 2015, considers the role of the Mill Gill open aqueduct in supporting flood attenuation at Thirlmere. A proportion of Mill Gill flows can be directed to bypass Thirlmere or to flow into Thirlmere depending on conditions but more detailed modelling work is required to fully understand this and to develop a protocol for management by United Utilities staff. This is being actively pursued by the Environment Agency and United Utilities following site visits in October and November 2016. In the interim United Utilities are using the initial recommendations of the Aecom report to operate Mill Gill to best advantage.

In the interim we are reviewing the potential to use the two top level scour valves in the dam at Thirlmere to increase releases and a test is planned for early 2017. This test will have to coincide with the hydrology study referred to above as the results of this will ultimately determine release rates.

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 **Figure 14** 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. For example, review of evacuation procedures / emergency response.	Complete
	Environment Agency, Cumbria County Council Highways, and Electricity North West.	Review the flood risk and resilience of critical transport and power supply infrastructure such as the Jennings Brewery substation.	2016/17
	Environment Agency and Cumbria County Council Highways	Consider means to increase flow capacity through Gote Bridge or provide a means of trapping debris upstream of the town in a location where an obstruction would not be critical.	2016/17
	Cumbria County Council	Review traffic arrangements at pinch points within Cockermouth to ensure residents are able to evacuate safely during a flood event.	2016/17
	Cumbria Planning Group, Allerdale Borough Council, Cumbria County Council, and Environment Agency	Review Local Development Plans and Strategic Flood Risk Assessment to reflect current understanding of flooding.	2016/17
	Environment Agency	Ensure all properties at risk can register to receive flood warnings and details are up-to-date.	Complete
	Environment Agency	Raise awareness/engagement with	2016/17

		community on gravel management activities.	
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.	Complete
Maintenance	Cumbria County Council, United Utilities, and Allerdale Borough Council	Review and investigate drainage and sewage systems to better understand where improvements are required.	2016/17
	Environment Agency and Cumbria County Council	Review outfalls to the river system within Cockermouth and ensure all outfalls are sealed with flap valves or non-return valves to prevent the defence scheme being compromised.	2016/17
	Environment Agency, United Utilities, and Cumbria County Council	Complete on-going inspections and repairs to assets that may have been damaged during the flood event.	2016/17
	Environment Agency	Review maintenance programme within the catchment in response to the flooding event of 2015. This will include gravel/debris removal from the river channels in Cockermouth.	March/April 2017
	Cumbria County Council	Complete outfall works to Main Street surface water system.	October 2016
Strengthening Defences	Environment Agency	Review modelling and forecasting data to ensure that models for the Derwent catchment 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.	March/April 2017
	Environment Agency	Carry out scheme performance review. The output of this review will inform a detailed action plan, with timescales, which will	January 2017

		identify potential improvements and implement necessary improvement works. This will include the following locations: • Flood defence under Victoria road bridge • Waterloo Street including footbridge • Trout Hotel car park • Gote Bridge • Gote road • Derwentside Gardens • Derwent Mills	
	Environment Agency	Investigate if Derwentwater and Bassenthwaite Lake levels can be managed differently to reduce flood risk.	March/April 2017
	Environment Agency	The Environment Agency is carrying out a series of repairs to flood defence assets that were damaged during the floods as part of the c.£10m Asset Recovery Programme which covers Cumbria and Lancashire. This programme of repairs is scheduled to be complete before winter 2016/17.	Complete

Table 9: Recommended Actions

* 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.

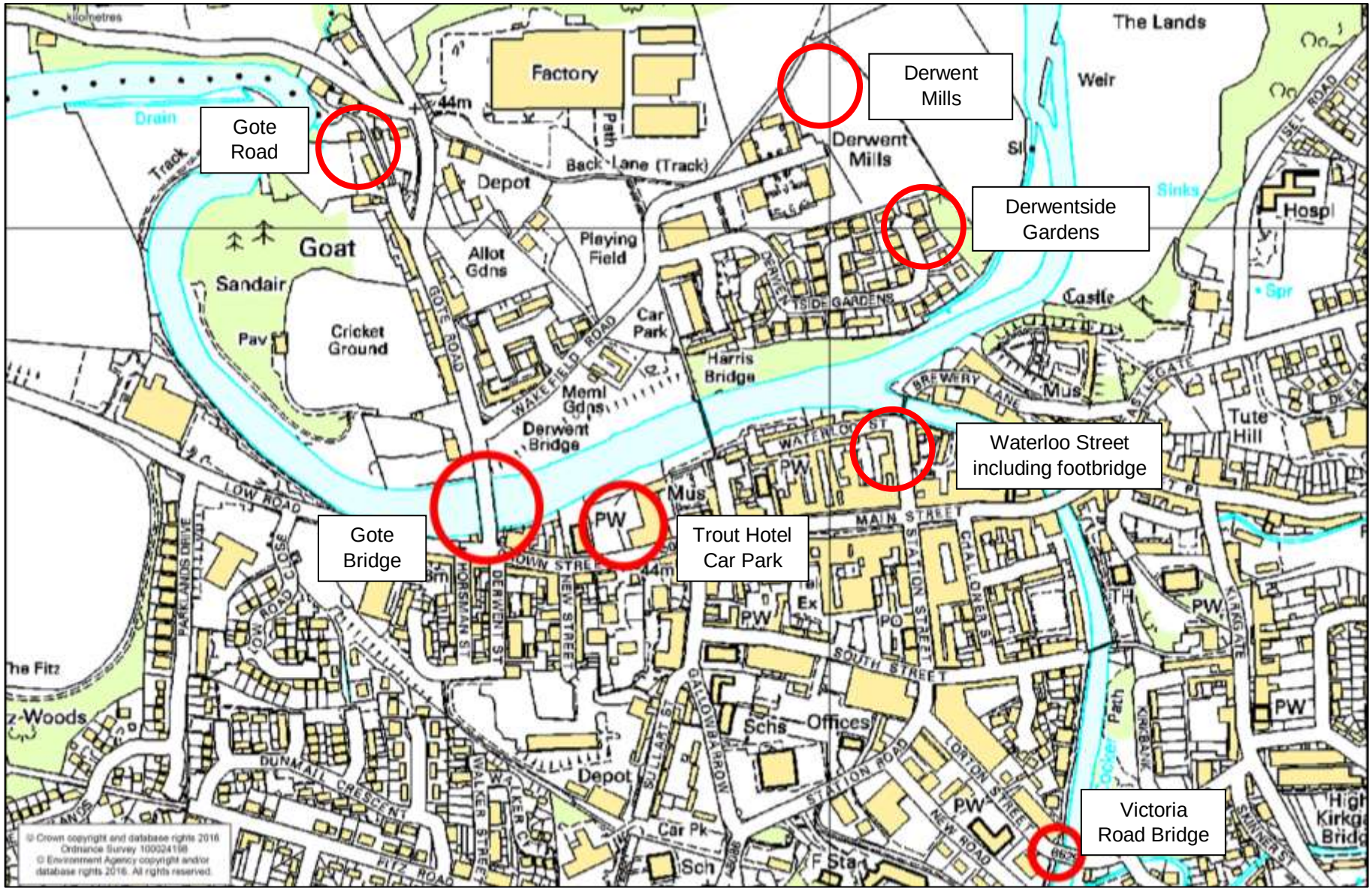


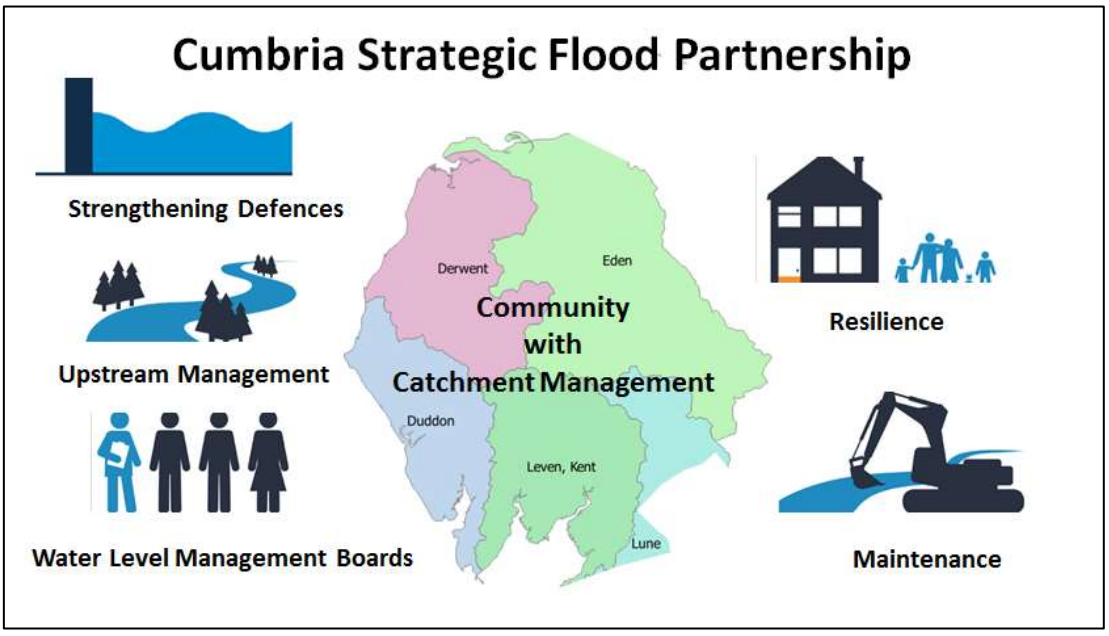
Figure 14: Recommended Actions Locations

The scheme performance review is currently being undertaken and includes the areas circled in Figure 14. The output of this review will inform a detailed action plan, with timescales, which will identify potential improvements and implement necessary improvement works.

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
AOD	Above Ordnance Datum
CCC	Cumbria County Council
CFP	Cumbria Floods Partnership
EA	Environment Agency
FAG	Flood Action Group
FWD	Flood Warnings Direct
LLFA	Local Lead Flood Authority
MsfWG	Making space for Water Group
WWTW	Waste Water Treatment Works

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)
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.

Term	Definition
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.
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.

Term	Definition
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: Additional information from the community

Cockermouth FAG: Short term recommendations		
No	Action	Timeframe
1	Flood gate upstream of Rubbybanks underneath Victoria Bridge to prevent outflanking of defences.	Short term
2	Increased height of flood gates along Waterloo Street, High Sands Lane.	Short term
3	Concerns re flap valves Waterloo Street area.	Short term
4	Defences by The Trout Hotel.	Short term
5	Completion of Main Street surface water scheme by CCC.	Short term
6	Review and improvement of flood warnings.	Short term
7	Review issue of penstock on drain down valve Gote Road defences.	Short term
8	Resilience of substation for EA pumping system on Gote Road?	Short term
9	CCC Maintenance programme of gullies and drainage systems.	Short term
10	Hatters Croft - increased flood resilience.	Short term
Cockermouth FAG: Short term recommendations		
No	Action	Timeframe
1	If Gote Road bridge was removed completely what impact would this have on flood alleviation?	Long term
2	Extended defences behind Derwentside Gardens, review of existing defences.	Long term
3	Defences to rear of Walkers factory.	Long term
4	Revisit proposal of a swale across Broomlands located down stream of Gote Bridge.	Long term
5	What impact does Barrel (Brewery) Bridge have on flooding on the Waterloo Street area.	Long term
6	Radical review of properties which are vulnerable to severe flooding.	Long term
7	Revisit gravel management policy.	Long term
8	If the channel was widened from the mouth of the Cocker to Gote bridge, what impact would this have?	Long term

Additional community recommendations	
No	Action
1	Review working of Crummock Water and its potential ability for use as attenuation. Maintenance of gravel and vegetation needs to be considered.
2	Attenuation and debris/boulder screening throughout the Lorton Valley. Use of gates on the rivers Cocker and Derwent.
3	Use of pumps to regulate/complete works to Crummock Water, similar to the Ennerdale setup.
4	Revert the River Derwent back to its original course - site of James Walker factory.
5	Raise electricity transformer on Gote Road.
6	The 2015 flood break through at the old mill culvert above the town also needs a substantial wall built as the flood came from here at the back of the housing estate and down into James Walkers factory, not from the river front where the recent bund retained the river flood.
7	Raise defences at the Trout Hotel.
8	Extend the peninsular dividing the junction of the Cocker with the Derwent to prevent the Derwent flood water backing up the mouth of the reduced Cocker, causing flooding into Market Place. A flexible metal barrier parallel to the river bank should suffice and widening of the river at this point will also ensure that the Derwent will flow straight down to the Gote Road Bridge and hence out to The Solway.

9	Widen and deepen the riverfront through Cockermouth upstream of Gote Bridge.
10	Debris formation on the South Street footbridge which caused localised level rise in the River Cocker. Base of the bridge is below the top of the self-raising flood defence wall. As a result the bridge enters the river flow path with the flood defences lift. The restriction generated by the bridge when debris started to collect along the bridge span caused water to overtop the self-raising flood defence wall and around 10 properties flooded on South Street.
11	Possible extension of floating barrier to complete sections right up to the bridge at Lorton Road.
12	Disrupt flow of water from New Road towards Victoria Jubilee Bridge by modifying/improving existing surface drainage provisions.
13	Upstream of Paddys (Victoria road) Bridge – metal fencing to be replaced with a wall of similar height.
14	Rubby Bank Road – Higher barrier and stone wall built upstream of south street footbridge.
15	Gote Bridge – if the bridge cannot be replaced with a modern steel gantry single span bridge then the river has to be deepened down below the bridge by creating a weir and all the gravel cleared downstream and kept clear by dredging in the summer.
16	River should be widened into the memorial gardens to make full use of the extra 3 arches added in the 1930s.
17	Build flood defence wall at northern end of Derwentside Gardens to prevent outflanking of current defences/higher ground.
18	More dredging in the summer.
19	Raise height of South Street footbridge. Debris formation on the South Street footbridge which caused localised level rise in the River Cocker. Base of the bridge is below the top of the self-raising flood defence wall. As a result the bridge enters the river flow path with the flood defences lift. The restriction generated by the bridge when debris started to collect along the bridge span caused water to overtop the self-raising flood defence wall and around 10 properties flooded on South Street.
20	Assess effectiveness of memorial gardens bund.
21	Rubby Banks Rd – install floodgate to seal underpass.
22	Greater transparency from EA.
23	Modify design of the pier to eliminate turbulence.
24	Large scale excavations in Lorton Valley to act as “holding lagoons”.
25	Review property level protection in Hatters Close area including increasing height of safety/flood windows, remove decking and replacing with concrete slabs enabling easy access to non-return valves and install toughened glass to windows and doors along the balcony.

Appendix 3: 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 4: 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

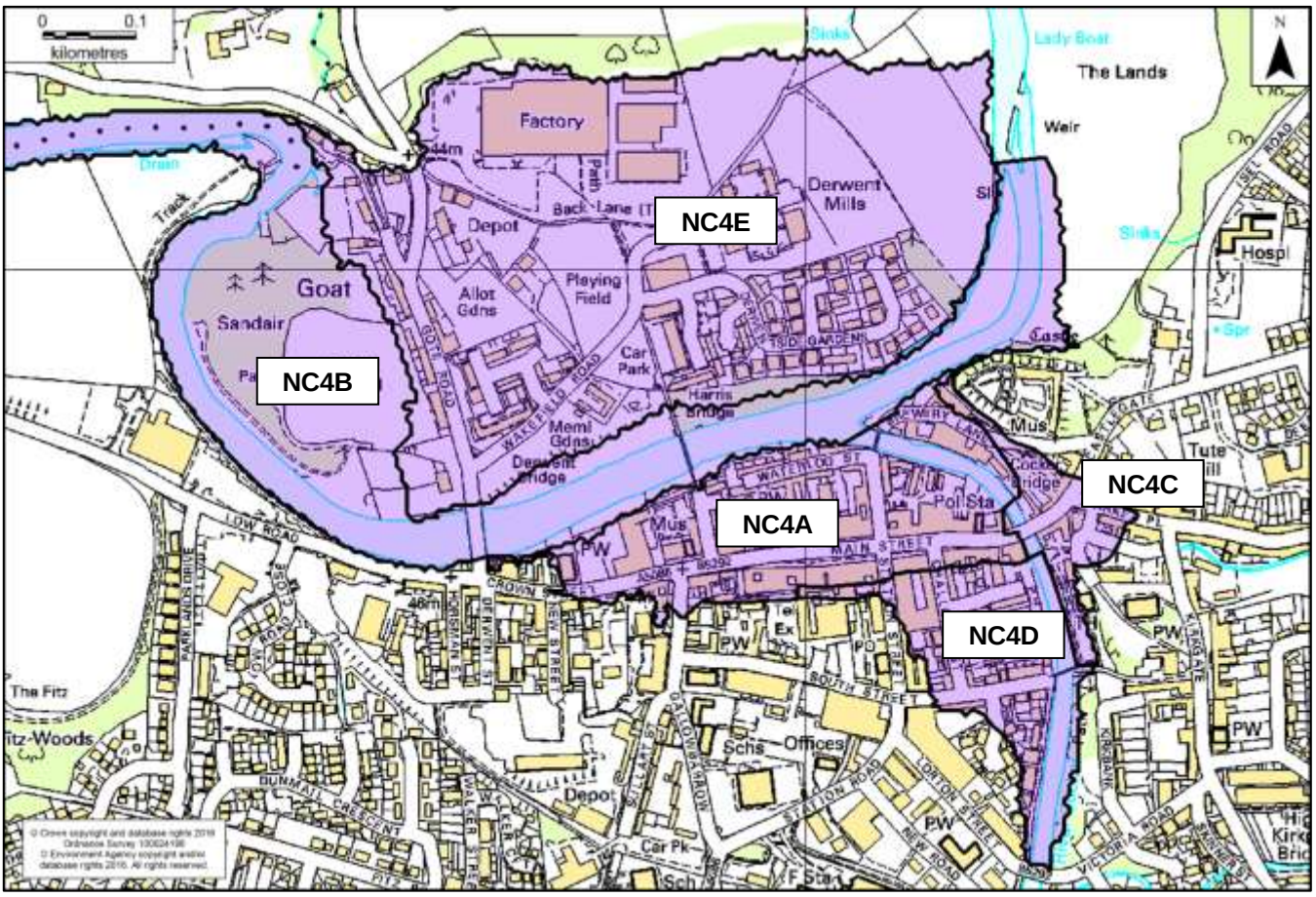
Environment Agency – Living on the Edge: A guide to the rights and responsibilities of riverside occupiers
https://www.gov.uk/government/publications/riverside-ownership-rights-and-responsibilities

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 5: Flood Warnings and Alerts



Flood Warning Areas within Cockermouth

Cockermouth is covered by a Flood Alert and certain areas are additionally served by the 5 Flood Warnings shown in the map above. Flood Warning Areas are well defined following the major flood event in 2009. Flood Warning levels will be reviewed in terms of revised modelling for the Rivers Derwent and Cocker and a Flood Forecasting Report is being undertaken; some amendments to these areas are anticipated.

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

Flood Warning Area	Flood Warning Issued (05/12/15)	Severe Flood Warning Issued (05/12/15)	Properties	Contacts	%Success*
NC4A Bridge Street, Crown Street, High Sand Lane and Main Street	14:40	16:49	422	972	72%
NC4B Cricket Ground and Trout Hotel Car Park	01:11	16:49	35	117	73%
NC4C Old Courthouse and Market Place Area	14:27	16:49	103	245	74%
NC4D Challoner Street, Croft Terrace, Jubilee Court and Rubbybanks Road	15:28	16:49	268	631	76%
NC4E Gote Road to Derwent Mills Area and Low Road	14:40	16:49	307	648	77%

The following section show additional details on the flood alerts and warnings issued during this event.

Flood Alert:

011WAFCD- Rivers Cocker, Marron and Derwent.

Alert issued on Thursday 03/12/2015 at 14:46
Alert removed on Friday 04/12/2015 at 06:47
Alert issued on Friday 04/12/2015 at 15:30

Customers in Flood Alert area registered on Flood Warnings Direct (FWD): 233
Contacts (landline, mobile, email etc) in Flood Alert area registered on FWD: 823
Successful contacts: 714
Unsuccessful contacts: 109
Alert Message:

A Flood Alert has been issued by the Environment Agency for the Rivers Cocker, Marron and Derwent. Flooding is possible for Lower Derwent from Bassenthwaite Lake to the coast at Workington. The Cocker from Crummock Water to Cockermouth. The River Marron from Ullock to its confluence with the Derwent near Bridgefoot. Low lying land and roads will be affected first.

Heavy and persistent rainfall is forecast to continue throughout today until this evening. With the ground already saturated the river levels are expected to rise and we may see some localised flooding to low lying land and roads. An outlook for the weekend shows although Friday is looking a relatively dry day, the rain will again become heavy and persistent in the early hours of Saturday continuing right through until Sunday. As River levels are already high, we may see some localised flooding throughout Cumbria.

*Contact Successful if at least one attempt to contact a fully-registered recipient registered to the property returned a status of "Acknowledged", "Successfully Received", "Successfully Sent" or "Unacknowledged"

Flood Warning Target Areas:

011FWFNC4A- Rivers Cocker and Derwent at Cockermouth, Bridge St, Crown St, High Sand Lane and Main St

Flood Warning issued on Saturday 05/12/2015 at 14:40
Severe Flood Warning issued on Saturday 05/12/2015 at 16:49
Severe Flood Warning downgraded to Flood Warning on Monday 07/12/2015 at 17:55
Flood Warning removed on Tuesday 08/12/2015 at 17:32

Date/Time Warning Level Reached: 05/12/2015 15:15
Time customers had to take action: 00:34:08
Customers in Flood Warning area registered on FWD: 422
Contacts (landline, mobile, email etc) in Flood Warning area registered on FWD: 972
Successful contacts: 696
Unsuccessful contacts: 276

Warning Message:
A Flood Warning has been issued by the Environment Agency for the Rivers Cocker and Derwent at Cockermouth, Bridge St, Crown St, High Sand Lane and Main St.
Flooding is expected for Commercial and residential properties adjacent to the Rivers Cocker and Derwent at Cockermouth, Brewery Lane, Bridge St, Crown Street, High Sand Lane, Main Street and Waterloo Street area. Immediate action required.

011FWFNC4B- River Cocker and Derwent at Cockermouth, Cricket Ground and Trout Hotel Car Park

Flood Warning issued on Saturday 05/12/2015 at 01:11
Severe Flood Warning issued on Saturday 05/12/2015 at 16:49
Severe Flood Warning downgraded to Flood Warning on Monday 07/12/2015 at 17:55
Flood Warning removed on Tuesday 08/12/2015 at 17:32

Date/Time Warning Level Reached: 05/12/2015 06:15
Time customers had to take action: 05:03:45
Customers in Flood Warning area registered on FWD: 35
Contacts (landline, mobile, email etc) in Flood Warning area registered on FWD: 117
Successful contacts: 85
Unsuccessful contacts: 32

Warning Message:
A Flood Warning has been issued by the Environment Agency for the Rivers Cocker and Derwent at Cockermouth, Cricket Ground and Trout Hotel Car Park.
Flooding is expected for Low Lying land and properties adjacent to the Rivers Cocker and Derwent at Cockermouth. Immediate action required.
Heavy and persistent rainfall is expected from Friday night and throughout Saturday. River levels will continue to rise and further Flood Warnings are likely. Please check for updates throughout the weekend.
Operational Teams have closed flood defences and are checking watercourses for blockages.

011FWFNC4C- River Cocker at Cockermouth, The Old Courthouse and Market Place Area

Flood Warning issued on Saturday 05/12/2015 at 14:27
Severe Flood Warning issued on Saturday 05/12/2015 at 16:49
Severe Flood Warning downgraded to Flood Warning on Monday 07/12/2015 at 17:42
Flood Warning removed on Tuesday 08/12/2015 at 17:32

Date/Time Warning Level Reached: 05/12/2015 15:15
Time customers had to take action: 00:47:25
Customers in Flood Warning area registered on FWD: 103
Contacts (landline, mobile, email etc) in Flood Warning area registered on FWD: 245
Successful contacts: 182
Unsuccessful contacts: 63

Warning Message:
A Flood Warning has been issued by the Environment Agency for the River Cocker at Cockermouth, The Old Courthouse and Market Place Area.
Flooding is expected for Residential and commercial properties adjacent to the River Cocker at Cockermouth. Immediate action required.

011FWFNC4D- River River Cocker at Cockermouth, Challoner Street, Croft Terrace, Jubilee Court and Rubbybanks Road

Flood Warning issued on Saturday 05/12/2015 at 15:28
Severe Flood Warning issued on Saturday 05/12/2015 at 16:49
Severe Flood Warning downgraded to Flood Warning on Monday 07/12/2015 at 17:42
Flood Warning removed on Tuesday 08/12/2015 at 17:32

Date/Time Warning Level Reached: 05/12/2015 16:30
Time customers had to take action: 01:01:18
Customers in Flood Warning area registered on FWD: 268
Contacts (landline, mobile, email etc) in Flood Warning area registered on FWD: 631
Successful contacts: 482
Unsuccessful contacts: 149

Warning Message:
A Flood Warning has been issued by the Environment Agency for the River Cocker at Cockermouth, Challoner St, Croft Terrace, Jubilee Court and Rubbybanks Rd.
Flooding is expected for Residential and commercial properties adjacent to the River Cocker at Cockermouth, Challoner Street, Croft Terrace, Croftside, Jubilee Court, Rubbybanks Rd and South Street Area. Immediate action required.

011FWFNC4E- River Derwent at Cockermouth, Gote Road to Derwent Mills Area and Low Road

Flood Warning issued on Saturday 05/12/2015 at 14:40
Severe Flood Warning issued on Saturday 05/12/2015 at 16:49
Severe Flood Warning downgraded to Flood Warning on Monday 07/12/2015 at 17:55
Flood Warning removed on Tuesday 08/12/2015 at 17:32

Date/Time Warning Level Reached: 05/12/2015 15:15
Time customers had to take action: 00:34:08
Customers in Flood Warning area registered on FWD: 307
Contacts (landline, mobile, email etc) in Flood Warning area registered on FWD: 648
Successful contacts: 498
Unsuccessful contacts: 150

Warning Message:
A Flood Warning has been issued by the Environment Agency for the River Derwent at Cockermouth, Gote Road to Derwent Mills Area and Low Road.
Flooding is expected for Commercial and residential properties adjacent to the River Derwent at Cockermouth, Gote Road, Riverside Terrace, Derwent Mills, Derwentside Gardens, Wakefield Road, Market Place and Low Road Area. Immediate action required.