

Cockermouth

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	17 th March 2016
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DRAFT

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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.

466 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 Rubby Banks 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 Rubby Banks 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 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>

Introduction

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.

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 Exceedance 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 1 month of average rainfall falling on the 19th November 2015. 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 was roughly 0.5m higher than in 2015, a peak of 4.970m compared to 4.476m 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	466	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>

Event background

This section describes the location of the flood incident and identifies the properties that were flooded.

Flooding Incident

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.

On 5th and 6th December 2015, 466 properties suffered flooding. The area affected by the flooding is shown in Figure 1. 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.

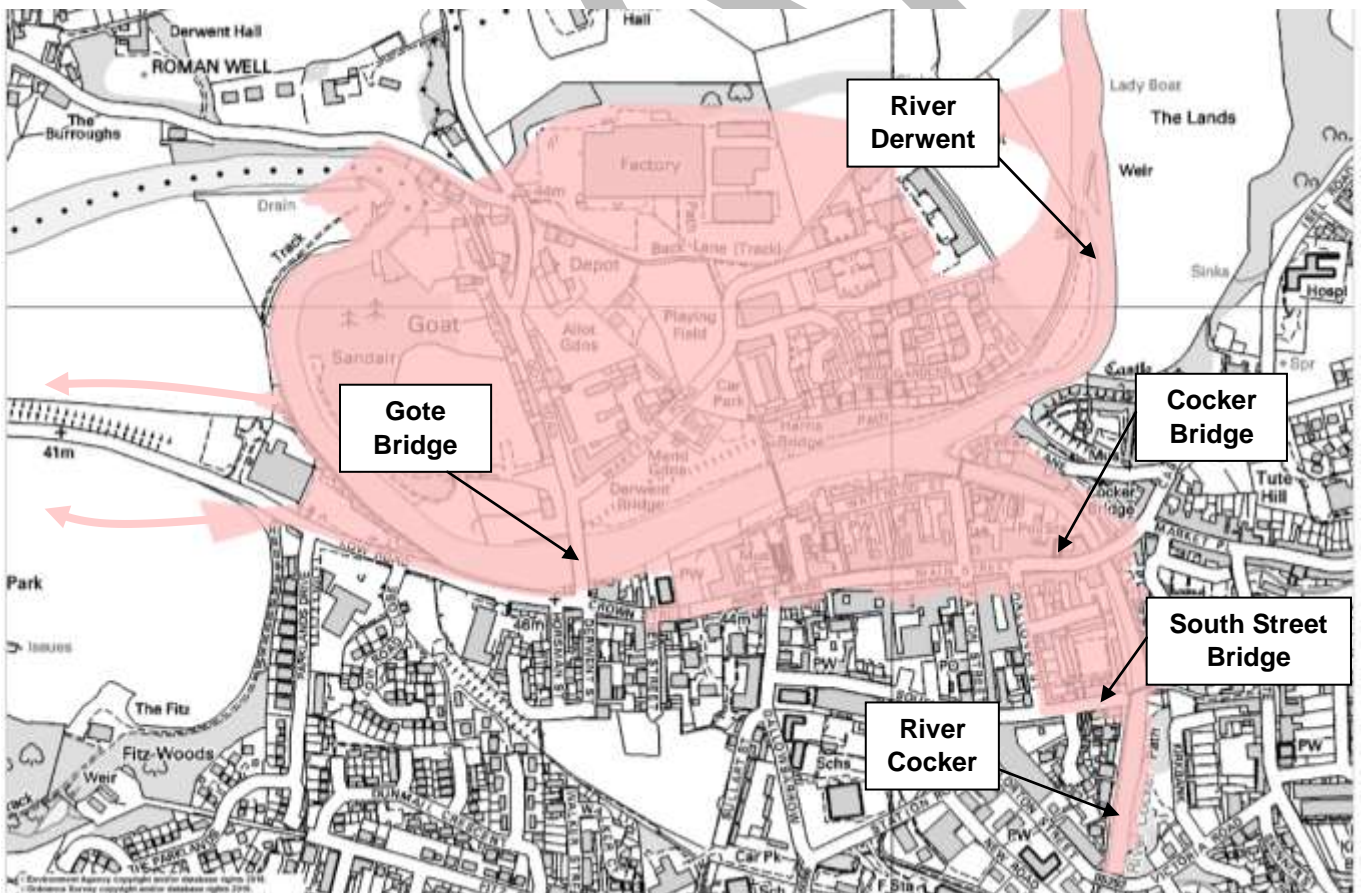


Figure 1- Extent of River (Fluvial) Flooding* in Cockermouth on 5-6th December 2015

*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 contain more flow.

For this report, the flooded area has been divided into 5 sub-areas for investigation. These are based on flood flow routes, and broadly correspond to the flood warning areas within Cockermouth. These sub-areas are shown in Figure 2:

- **Rubby Banks road** – The area on the left bank of the River Cocker upstream of Main Street Bridge
- **Jennings Brewery** – The area on the right bank of the River Cocker including Jennings Brewery itself
- **Main Street** – The area on the left bank of the River Derwent
- **Derwentside Gardens** – The eastern area on the right bank of the River Derwent including Derwentside Gardens, Derwent Mills industrial estate and the James Walkers' factory
- **Gote Road** – The remainder of the right bank of the River Derwent within Cockermouth

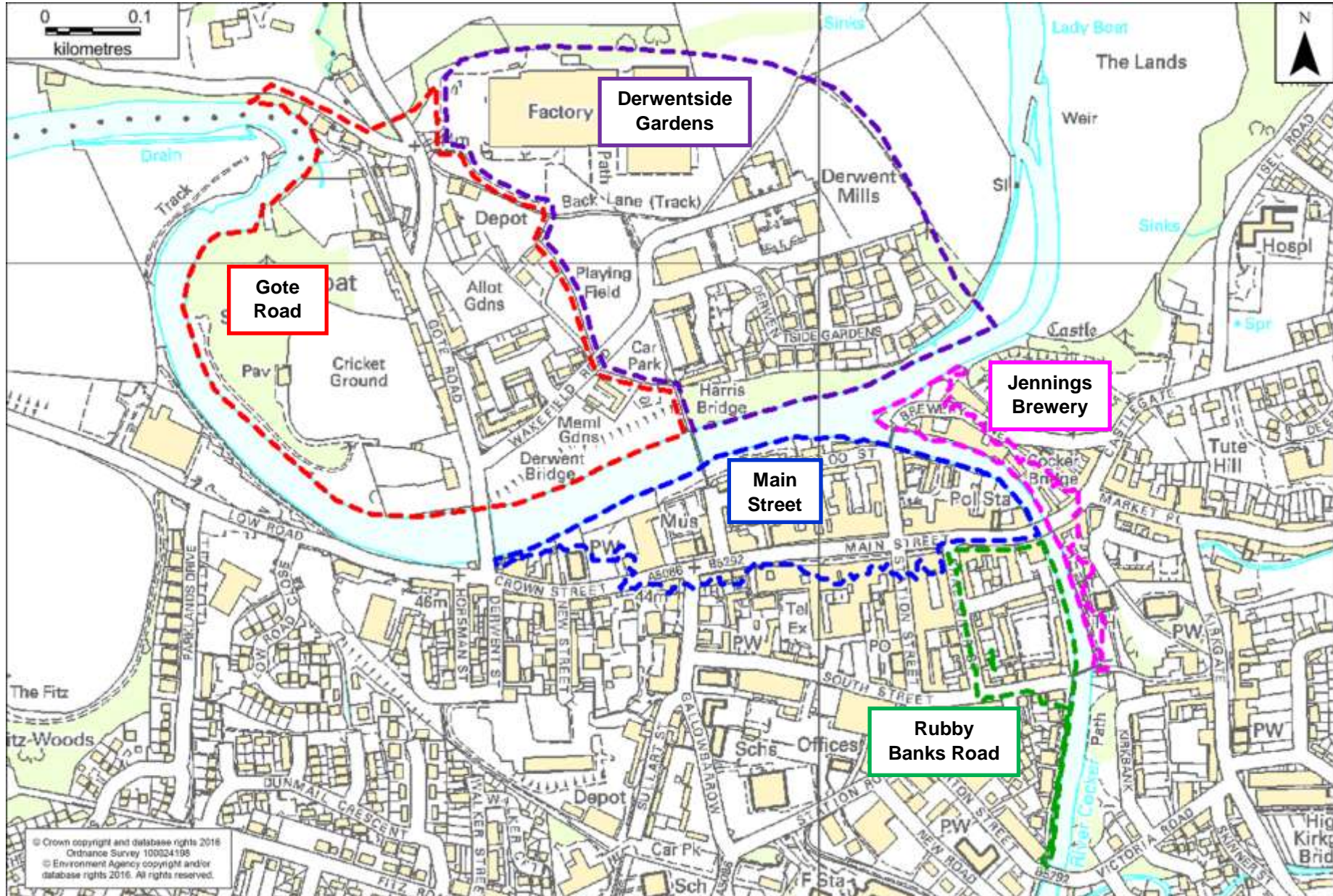


Figure 2-Identification of areas flooded

Existing Flood Defences

There are currently raised flood defences within Cockermouth, which are shown in Figure 3. 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.

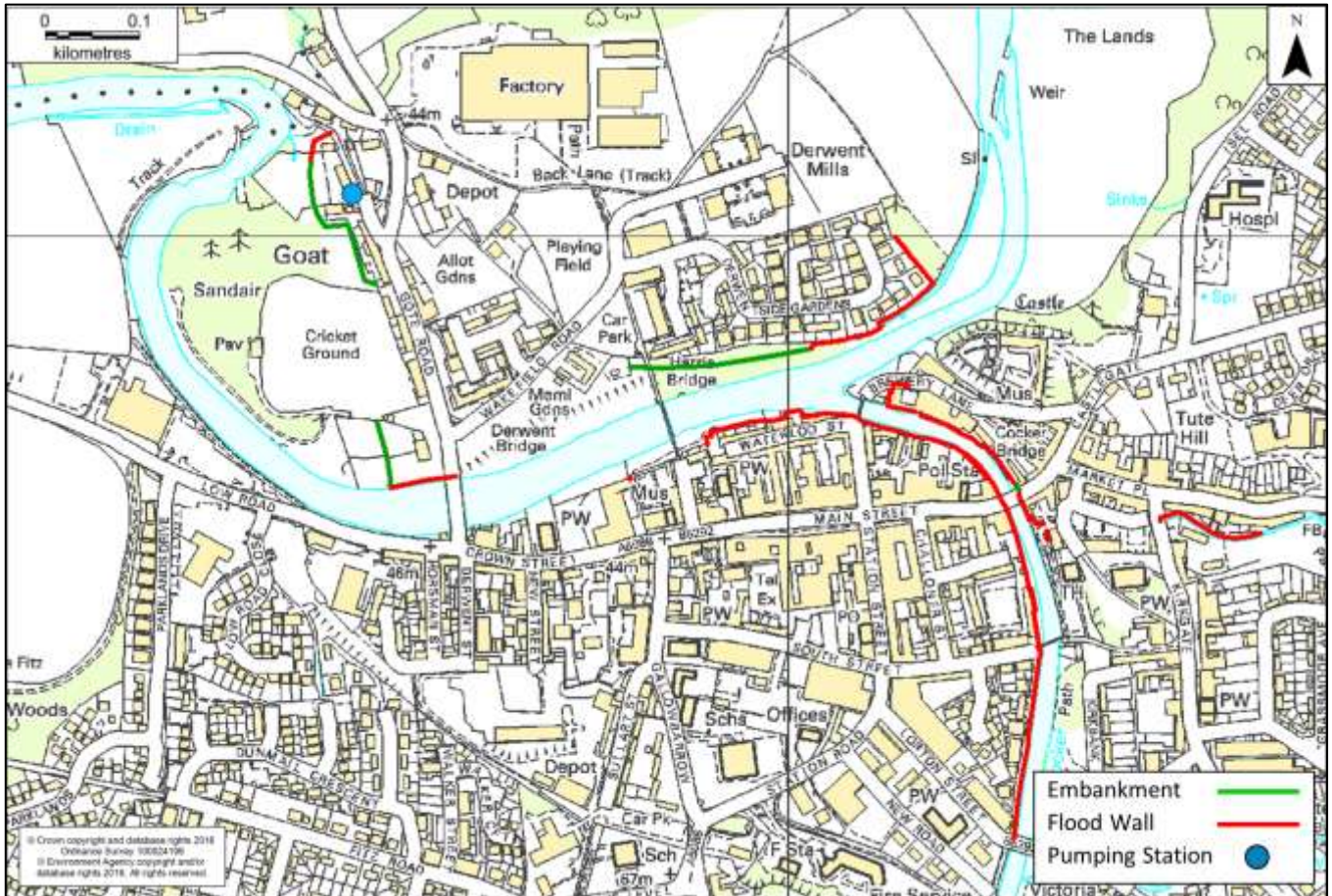


Figure 3-Flood Defences within Cockermouth

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:

- Rubby Banks 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. Properties 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.

Investigation

This section provides details of the rainfall event, the likely causes of flooding and the history of flooding in the area.

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.

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 4 shows the location of these rain gauges around Cockermouth.

	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 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.

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

Monitoring Station	Rainfall (mm)			Estimated Annual Exceedance Probability*
	4 th December	5 th December	Rolling 24 hour Rainfall	
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%

Table 4-Rainfall recorded at gauges around Cockermouth

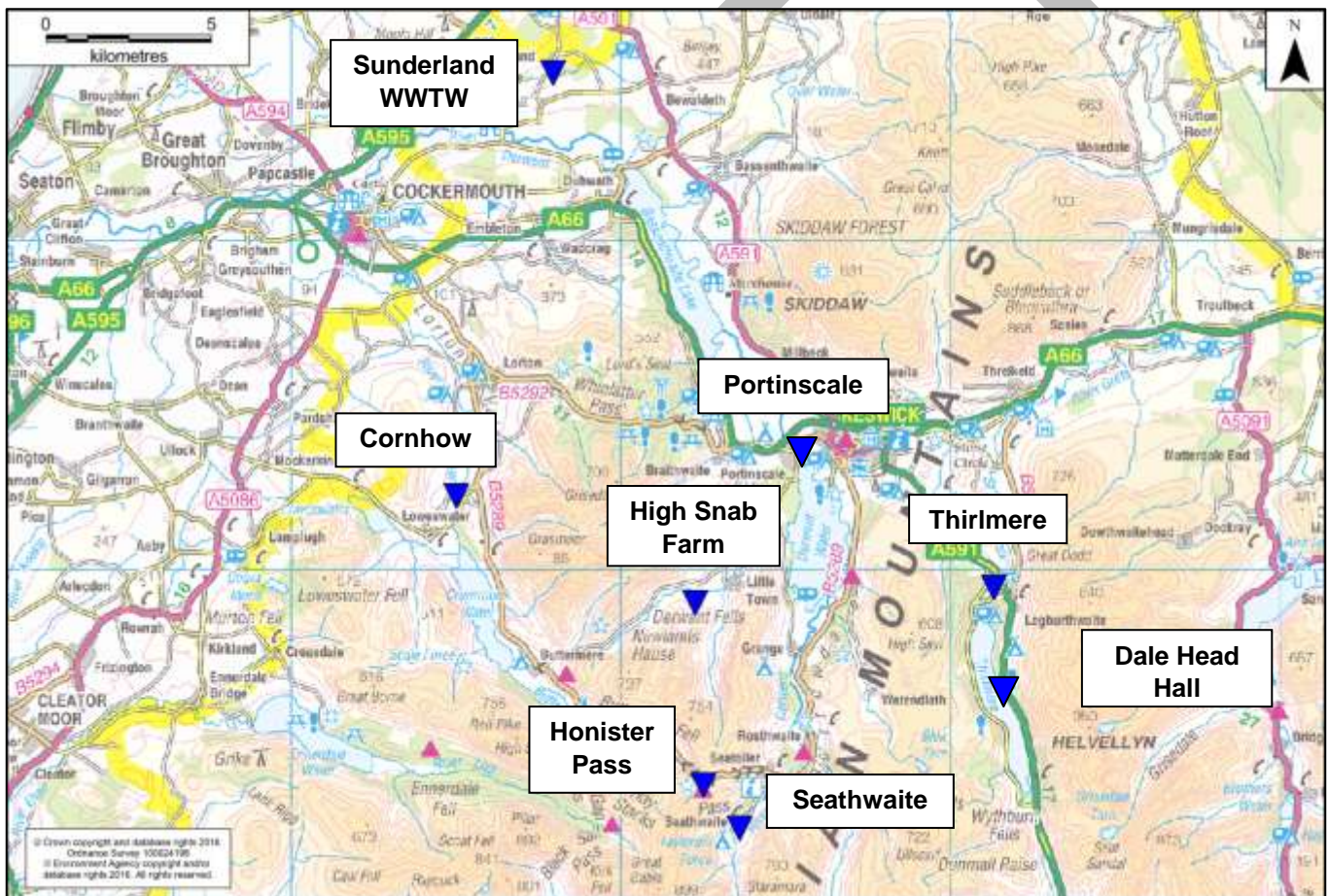


Figure 4-River Derwent catchment and locations of rain gauges

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 5.

* Calculated using FEH DDF methodology, this estimation is not calibrated for values with an AEP less than 0.1%

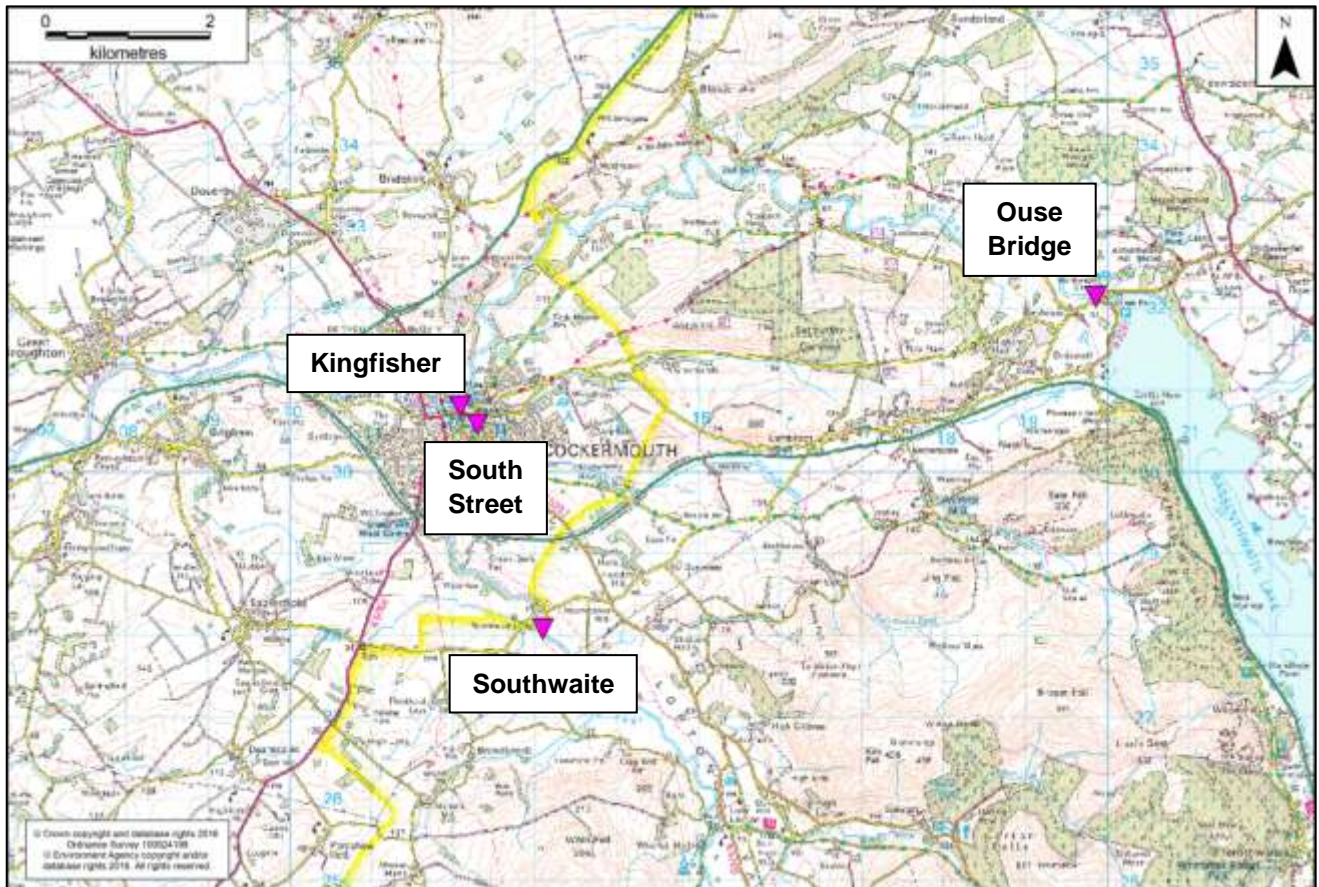


Figure 5-Location of river gauges upstream of Cockermouth

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 6 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 (m ³ /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

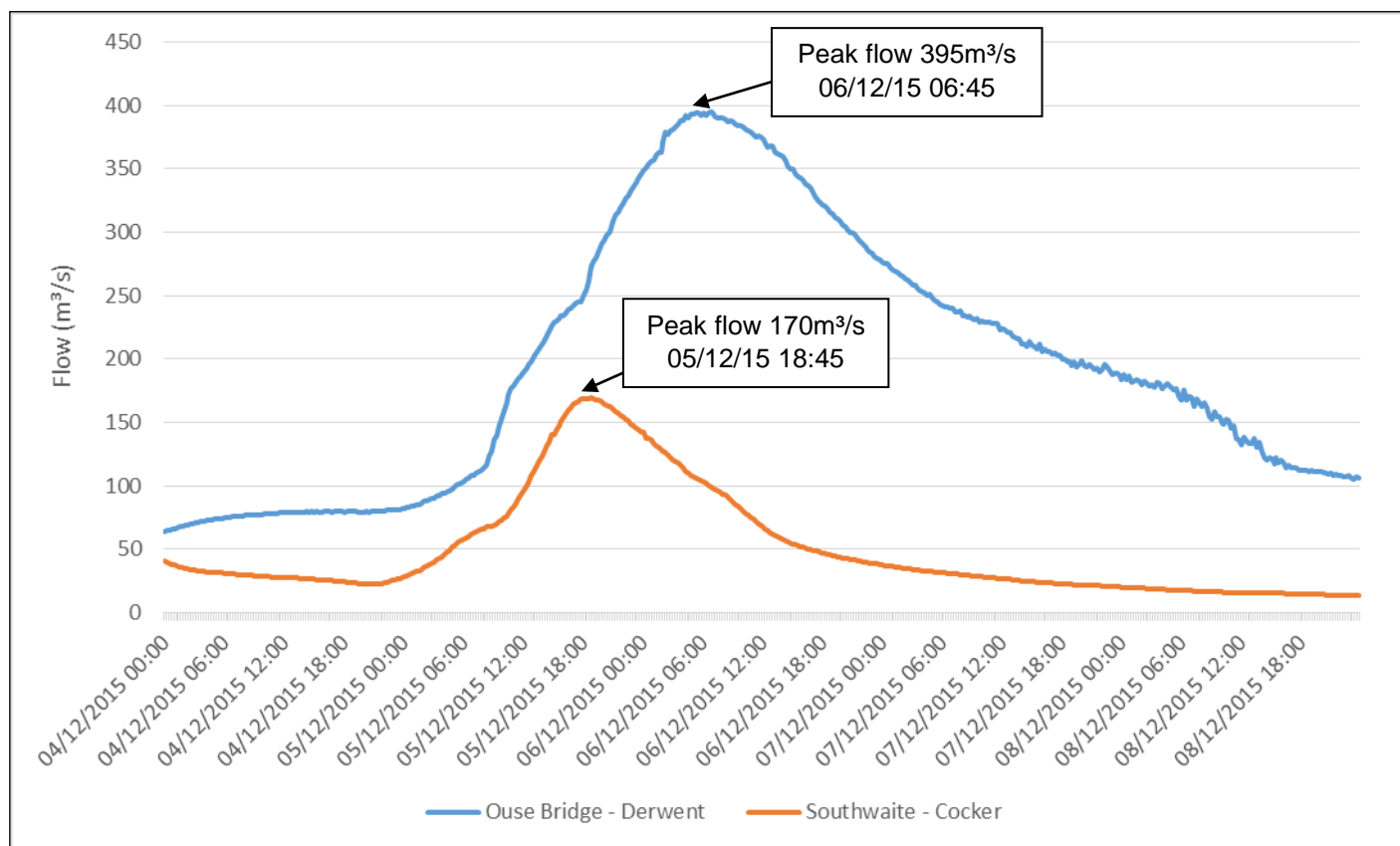


Figure 6-Flow measured at river gauges upstream of Cockermouth

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.

Map of Flow Routes

There were a number of flooding flow routes during the event, shown in Figure 7. The details of these flow routes and the flooding within each of the identified areas is discussed in the 'Impacts and Likely Causes of Flooding' section.

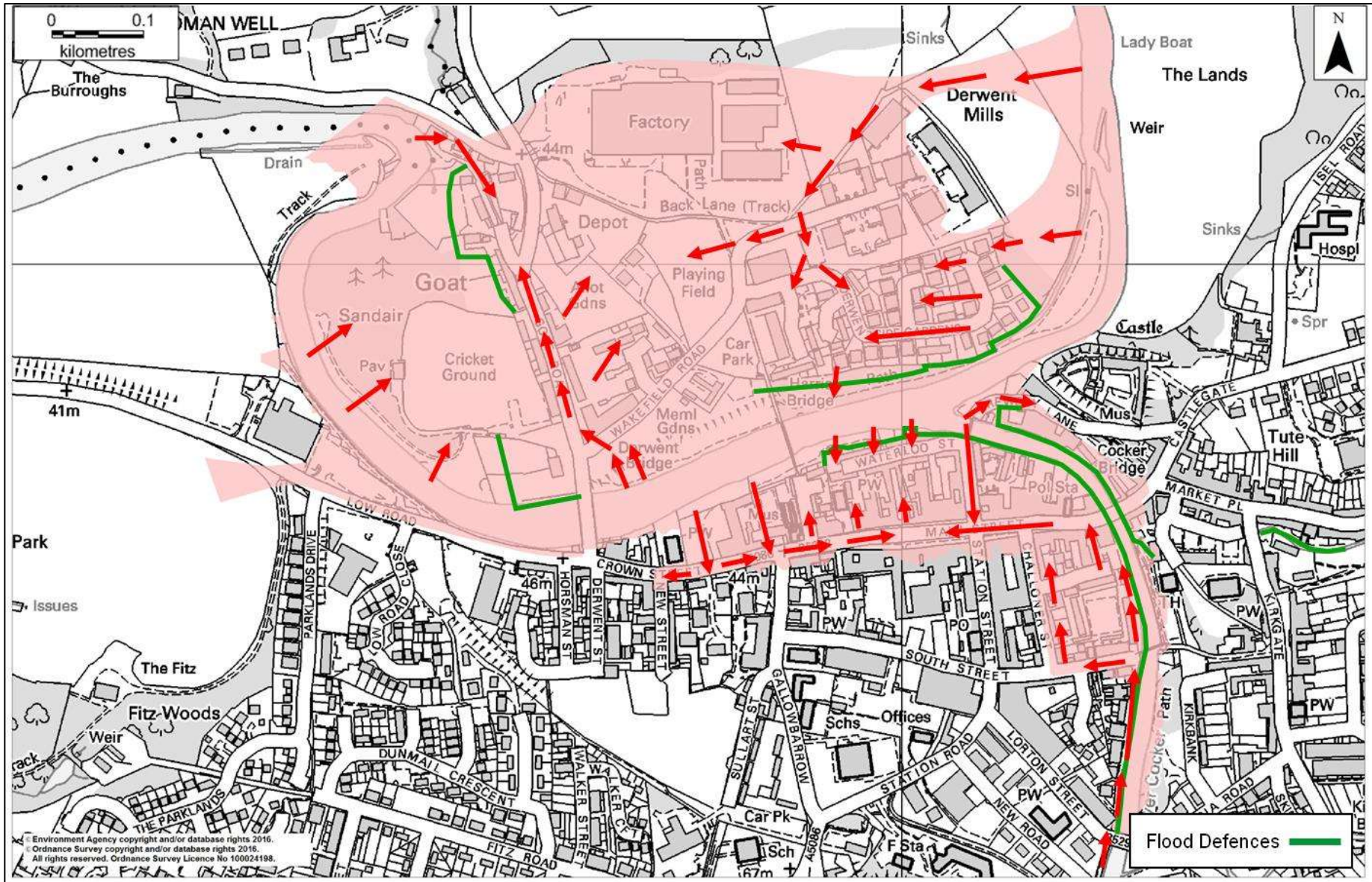


Figure 7-Map of flood flow routes

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

Impacts and Likely Causes of Flooding

Timeline

Table 6 below shows the times of key events during the Cockermouth flooding in December 2015.

4 th December	Event
	Flood gates closed
1530	Flood alert issued
5 th December	Event
1440-1530	Flood warnings issued
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	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
1720	Overtopping of the floodgate on Low Sand Lane is was reported
1740	Flow through Trout Hotel Car Park
1800	Properties on Derwentside Gardens reported to have been flooded
1800-1900	Flood flow is reported flowing down Rubby Banks Road outflanking the defences having overtopped the road hump at Victoria Road Bridge
1845	Peak flow at South Street footbridge gauging station (River Cocker) – 4.476m
2100	The floodgate at the Town Hall Riverside public car park is overtopped
6 th December	Event
0330	Peak flow at Kingfisher gauging station (River Derwent) – 4.543m

Table 6-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 Rubby Banks 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 Rubby Banks 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. Figure 8 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.



Figure 8-Cockermouth Castle showing erosion to riverbank. Taken 21/12/2015

The following sections details the sources of flooding within the sub-areas identified on Figure 3 and identifies the flood flow routes and recorded impacts.

Rubby Banks Road Area

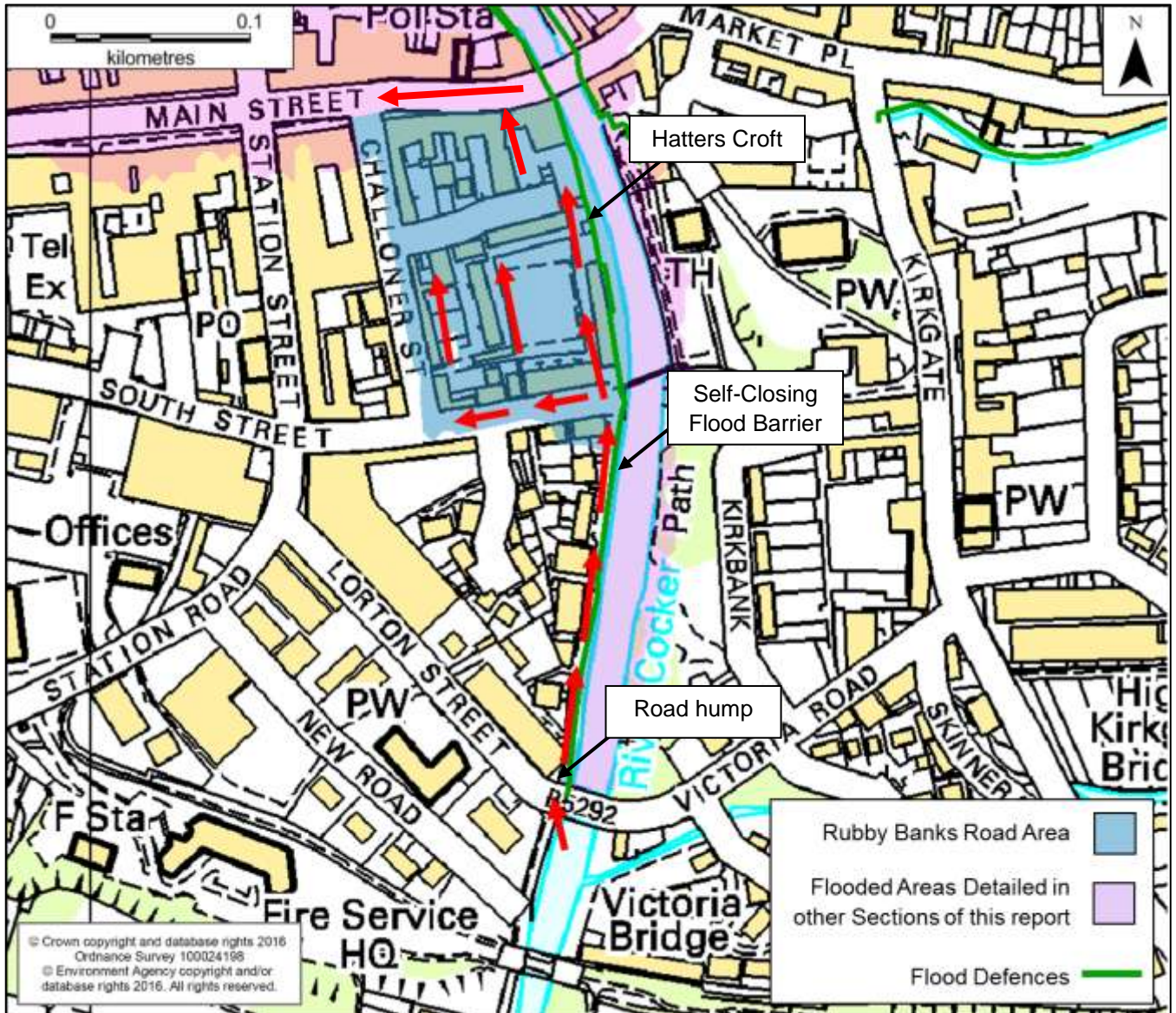


Figure 9-Flow routes from the River Cocker along Rubby Banks Road

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 alongside the river. The area and the flood flow routes into this area are shown in Figure 9.

The Rubby Banks Road area lies north of the Victoria Road (B5292) Bridge. The flood defences run alongside Rubby Banks 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 Rubby Banks 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, forming part of the defence line. At these locations, property-level protection, such as flood resilient windows, have been installed.

The self-closing flood barriers along Rubby Banks 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 Rubby Banks Road and South Street. The surface water drainage system was also surcharging in this location.

The flood resilient property windows on properties at Hatters Croft forming part of the defence line were also seen to have worked successfully, however these properties were still flooded. This occurred early in the flood event prior to the peak river level. 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.

Water from the River Cocker overflowed the riverbank between the Victoria Road Bridge and Victoria Jubilee Railway Bridge. Figure 10 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 Rubby Banks 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.

From here, water proceeded to flow down Rubby Banks Road, although the properties on this road have relatively high thresholds and were not reported to have flooded. Water then continued down Rubby Banks 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.



Figure 10-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 Rubby Banks 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 to contribute 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.

Jennings Brewery Area

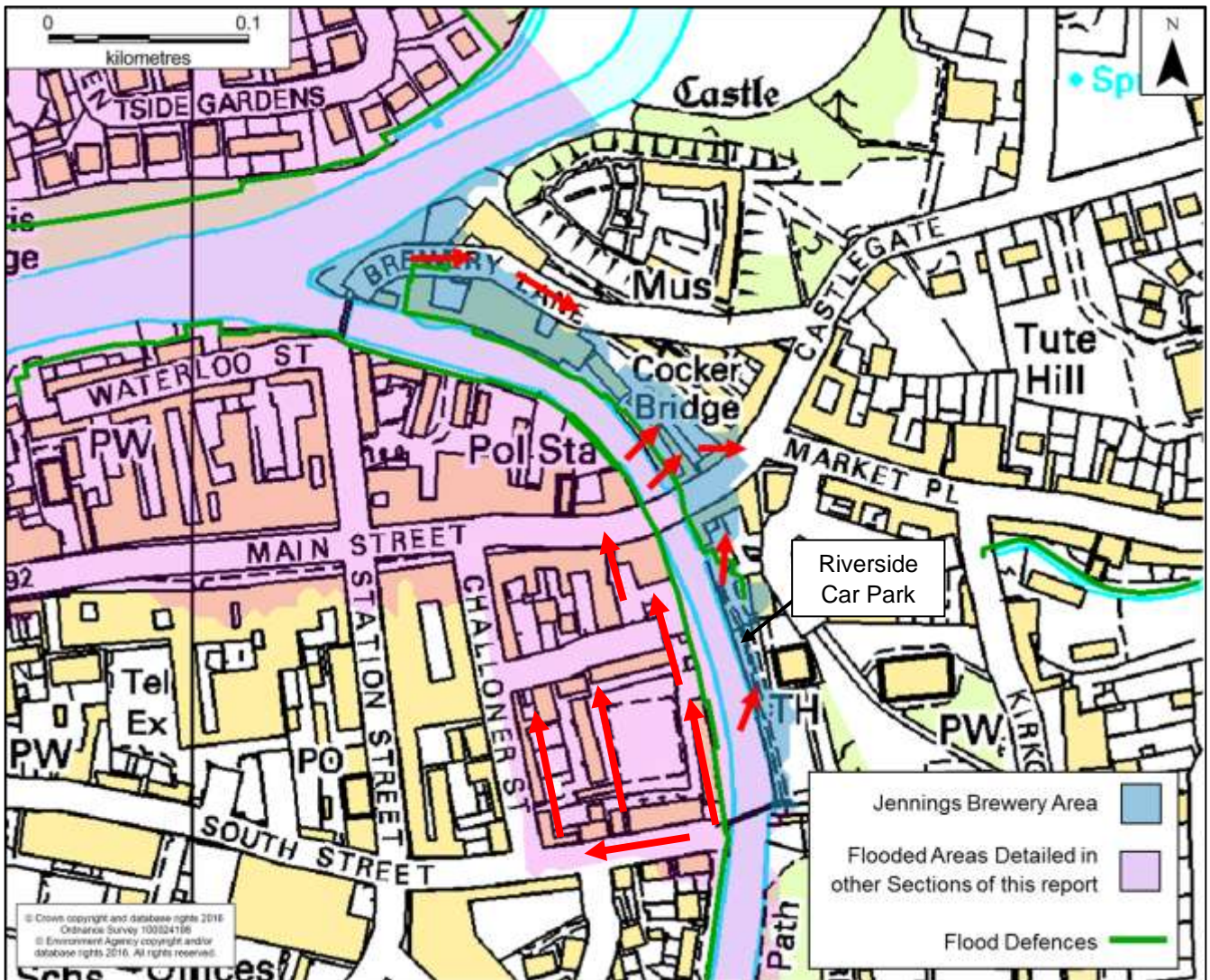


Figure 11-Flow routes on the right bank of the River Cocker

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 11.

There are flood defence walls at the river bank and at Jennings Brewery. The public car park at the town hall is allowed 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 Main Street Bridge and at Jennings Brewery. There is no record of the times that these defences were overtopped 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.

Main Street Area

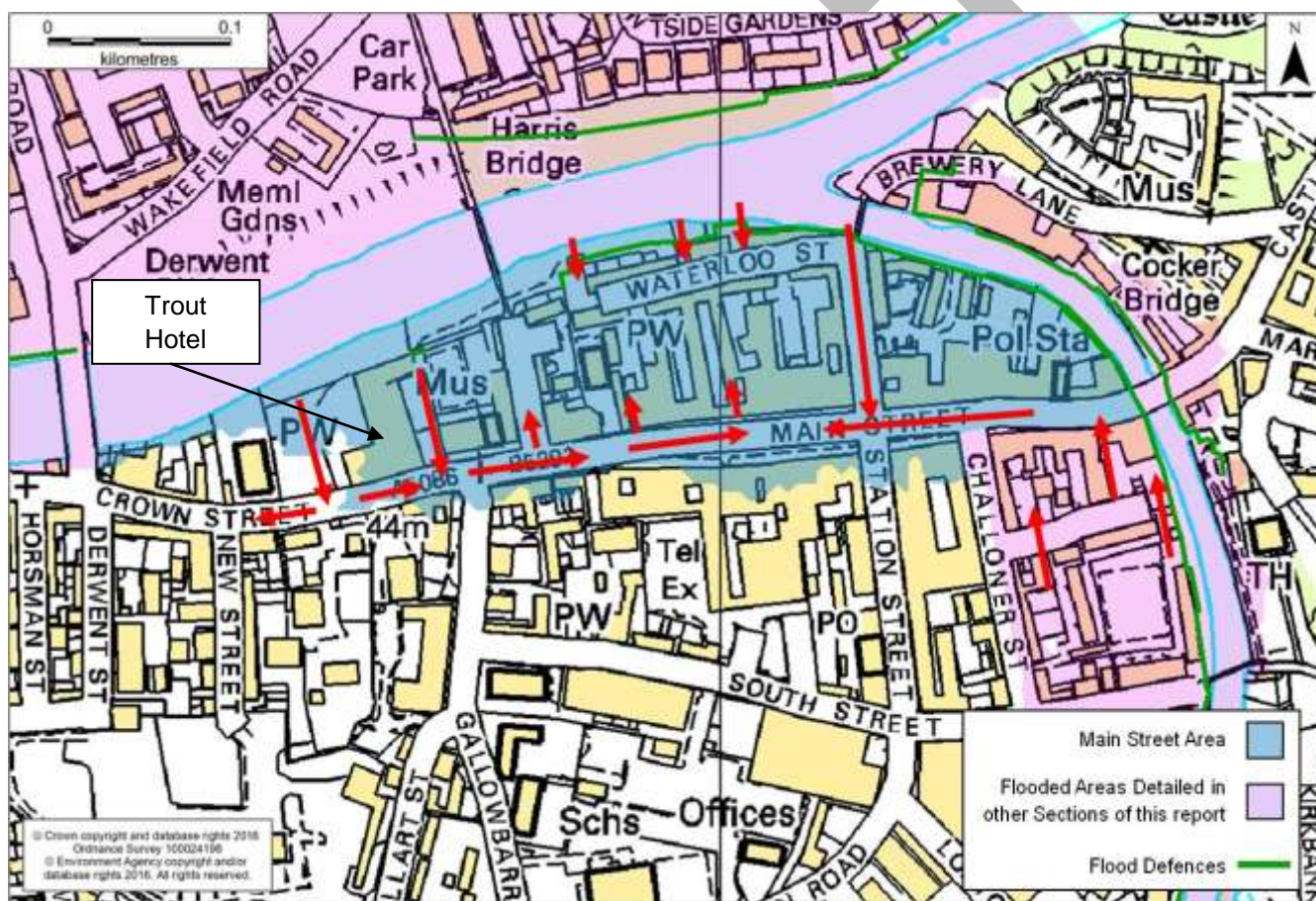


Figure 12-Flow routes into Main Street Area

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 Cokermouth 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 12.

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 Figure 13. Floodwater then continued to flow down Main Street and formed the main flood route into the area. The amount of water following 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.



Figure 13-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

Derwentside Gardens and Derwent Mills Area

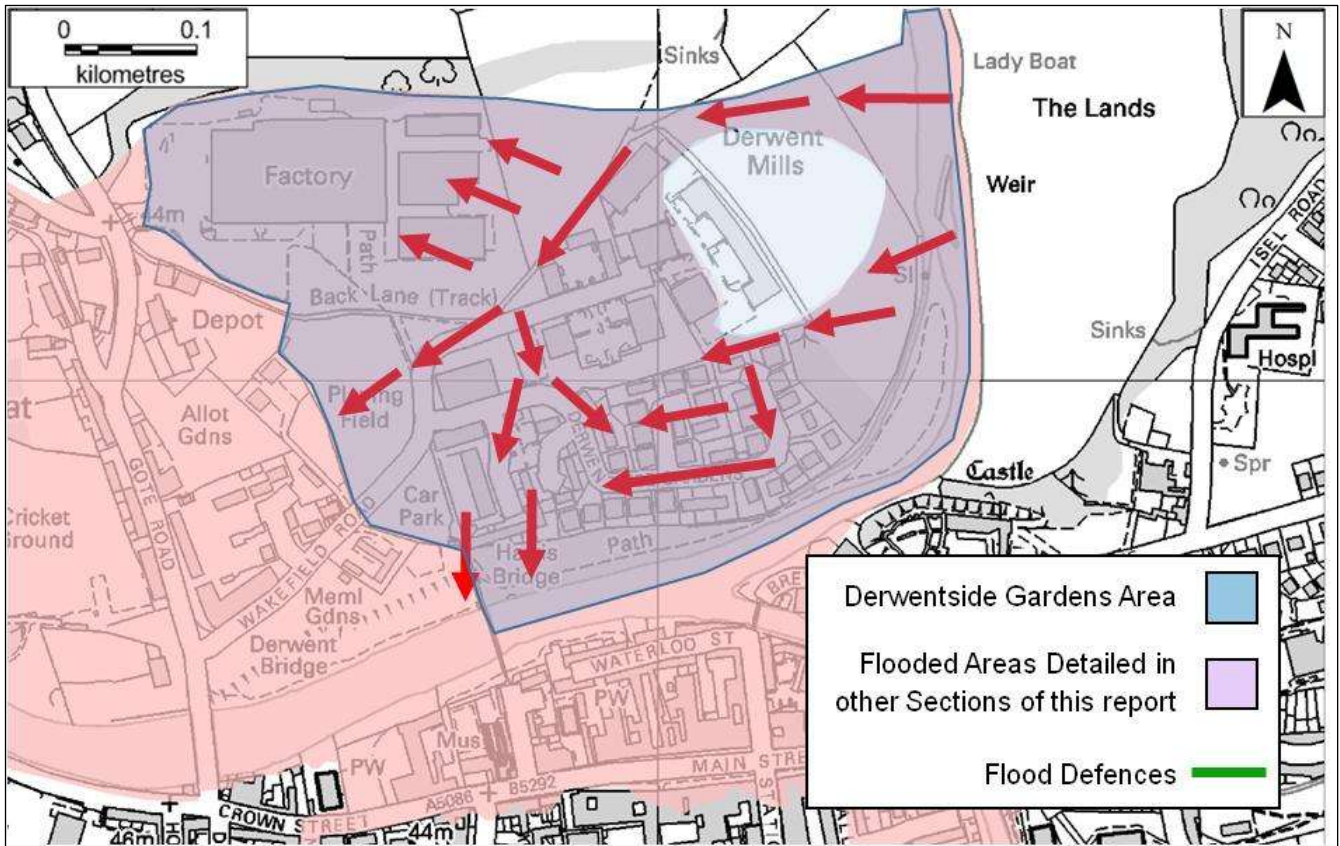


Figure 14-Flow routes in Derwentside Gardens area

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 14.

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 Cockermonth 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. 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. Figure 15 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 0.6m in this area and in the James Walkers' factory.



Figure 15-Derwentside Gardens during event showing flow route upstream of defence. Photograph provided by Peter Smith Photography. Taken 06/12/2015 12:37

Gote Road Area

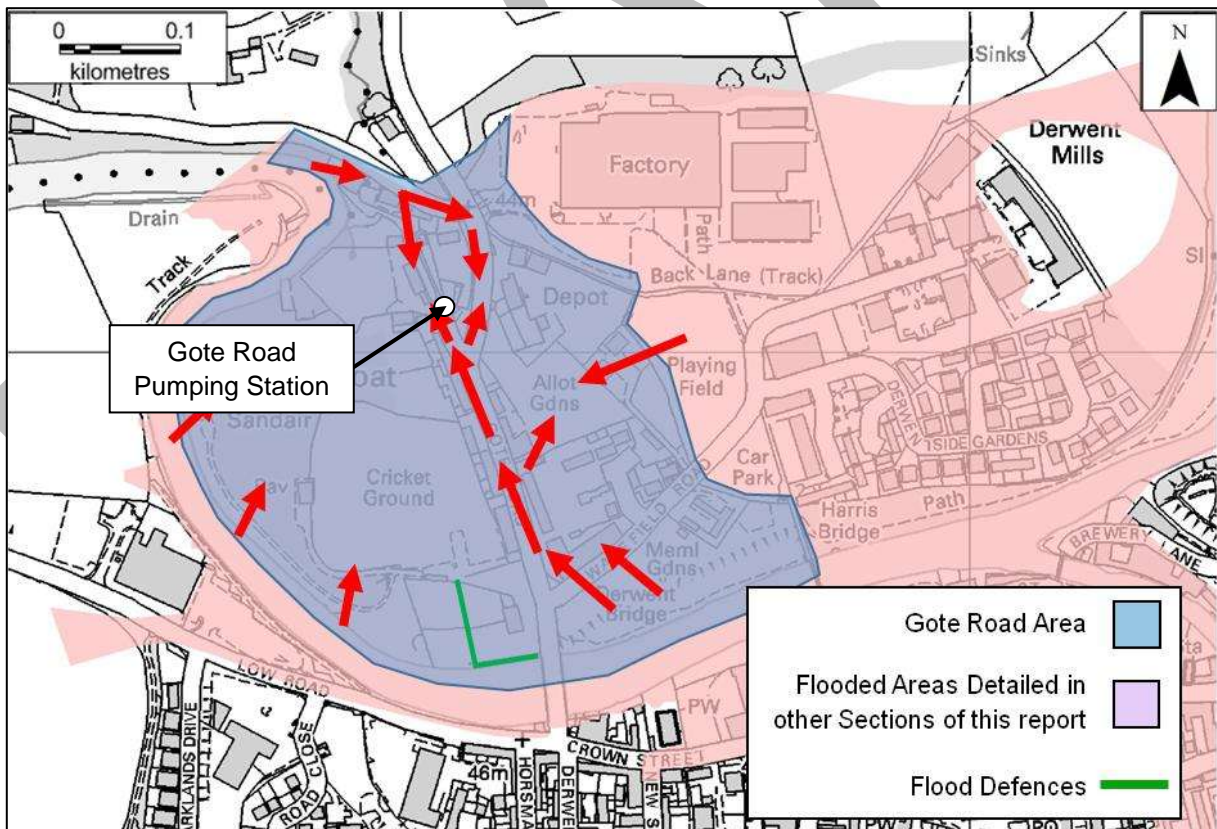


Figure 16-Flow routes in Gote Road area

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 16.

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 three 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.
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.



Figure 17-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.

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 Rubby Banks 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 7 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 Rubby banks Road	05/12/2015 15:28
Severe Flood Warning issued	05/12/2015 16:49

Table 7-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

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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 of course 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 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 (K FAG). United Utilities operate to a set of flood level drawdown rules agreed with K FAG.

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 relevant month's target level is achieved and continues in order 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, this level is 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 flood event.

However, the catchment is in a delicate environmental balance and there is a natural limit to the amount of water that United Utilities can release without causing damage to St Johns Beck which is a Special Area of Conservation. The normal compensation flow in St John's Beck is 13.64 million litres per day. United Utilities can increase this to 100 million litres per day.

Even at this level, it causes some flooding to farmland. Any more than 100 million litres per day and more farmland will 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 for the 13.64 million litres per day 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 million litres a day. If the rain falls faster than this then the reservoir will start to fill until it eventually overflows.

In November 2015, there had already been more than twice the normal level of rainfall expected for the month. Thirlmere reservoir was filling throughout November, and started to spill over on Monday 30 November. The reservoir level reached 1.56m above the weir crest during Storm Desmond, the highest recorded level. This level was still within the design parameters of the dam, and below the potential maximum flood for which it was designed. The parapet (roadside) wall is designed to be an integral part of the dam. It is a substantial, water tight structure that will retain the maximum still-water flood during the probable maximum flood. Studies and inspection reports indicate that the wall is sufficient to withstand the effects of waves to the top, and just spilling over the wall. This is how the wave wall operated during Storm Desmond, and the wall has not suffered damage.

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 Johns Beck were higher than ever recorded before. Given the amount of rainfall, increasing the outflow beyond 320 million litres per day 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 100 million litres per day. The limitation is not the outflow from the low level scour valves on the dam, which can release up to 900 million litres per day in emergency draw down for reservoir safety. The issue at present is infrastructure downstream of the valves, including a bridge that could be washed away 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 million litres per day of flood drawdown release to be made whilst still maintaining flows to the Water Treatment Works to supply customers.

United Utilities are committed to ongoing engagement with K FAG, the Environment Agency, and Natural England regarding the volumes of water that can be released into St. Johns Beck in the future. An environmental assessment will need to be conducted in to the impact of releases downstream of the reservoir and this will involve all parties mentioned above, as well as local residents who could potentially be impacted by any changes.

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

United Utilities 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.

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 18 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.	2016
	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
	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
	Cumbria County Council	Review traffic arrangements at pinch points within Cockermouth to ensure residents are able to evacuate safely during a flood event.	2016
	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
	Environment Agency	Ensure all properties at risk can register to receive flood warnings and details are up-to-date.	2016
	Environment Agency	Raise awareness/engagement with	2016

		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.	2016
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
	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
	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
	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.	June/July 2016
	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.	2016
	Environment Agency	Carry out scheme performance review. The output of this review will inform a detailed action plan, with timescales, which will	2016

		<p>identify potential improvements and implement necessary improvement works. This will include the following locations:</p> <ul style="list-style-type: none"> • 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.	2016
	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.	Winter 2016/17

Table 8-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.

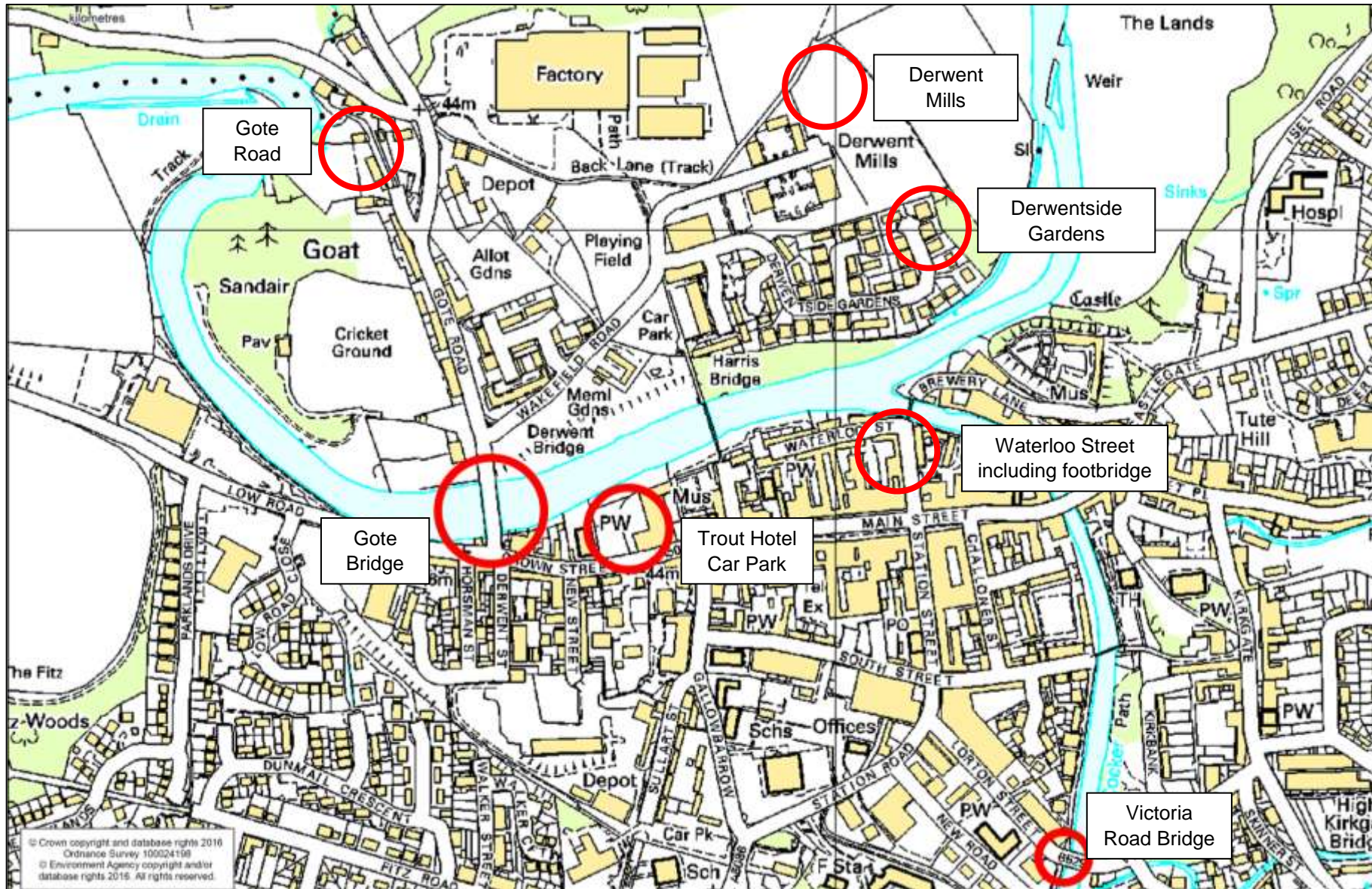


Figure 18-Recommended Actions Locations

The scheme performance review is currently being undertaken and includes the areas circled in Figure 18. 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

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.

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 2016.

The 'Cumbria Floods Partnership' was set up by Flood Minister Rory Stewart MP following December's floods, and includes all of Cumbria's Flood Risk Management Authorities. They are working alongside the existing 'Cumbria Strategic Partnership', which was formed as part of the Flood and Water Management Act 2010 and comprises of the County's Flood Risk Management Authorities (RMAs) including the Environment Agency, Cumbria County Council, Local Authorities, and United Utilities. Both partnerships are working with communities, businesses, and relevant stakeholders to understand and reduce flood risk across Cumbria.

Figure 19 below helps demonstrate how the two partnerships are working together:

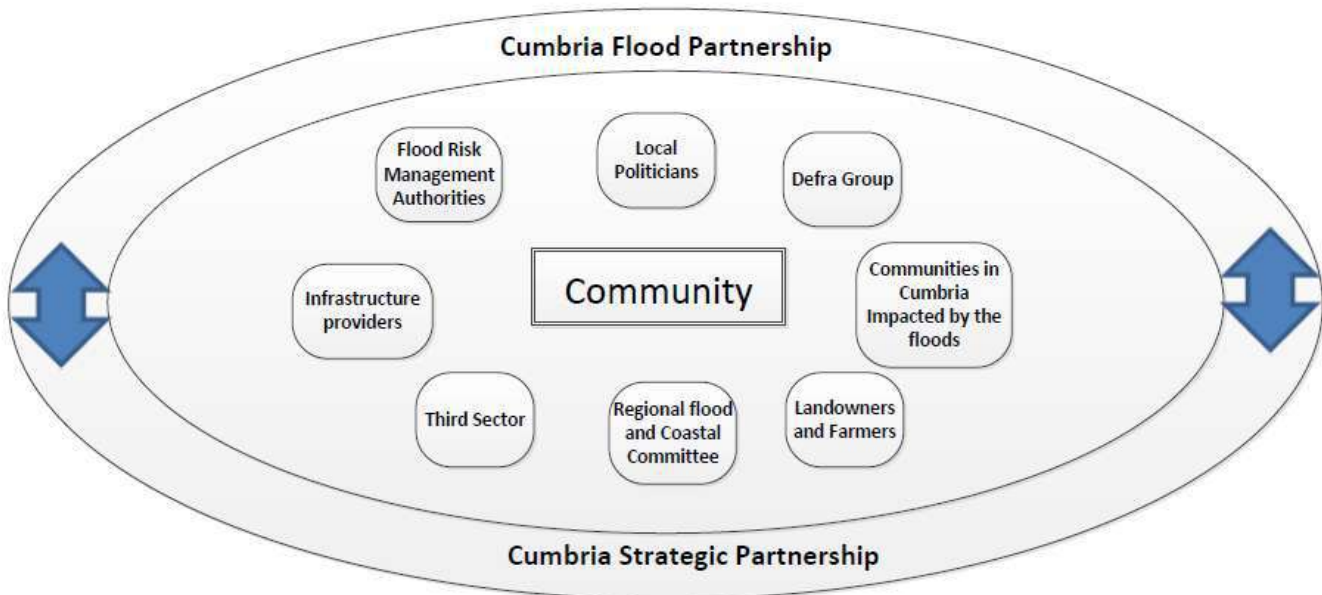


Figure 19-Cumbria Flood Partnership and Cumbria Strategic Partnership

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

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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>

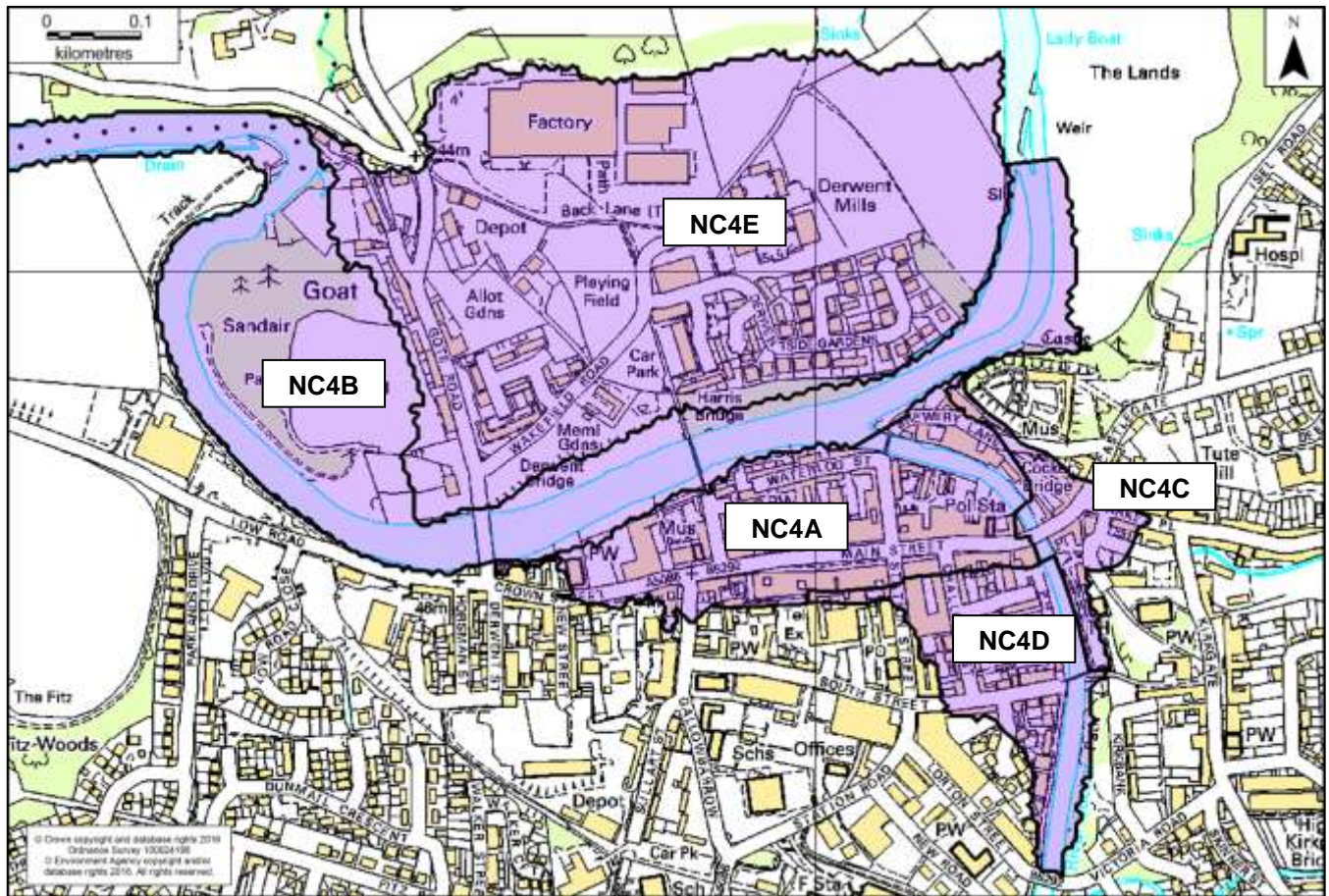
Water Resources Act 1991:

<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



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 Rubby Banks 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 Rubby Banks 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 Rubby Banks Rd.

Flooding is expected for Residential and commercial properties adjacent to the River Cocker at Cockermouth, Challoner Street, Croft Terrace, Croftside, Jubilee Court, Rubby Banks 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

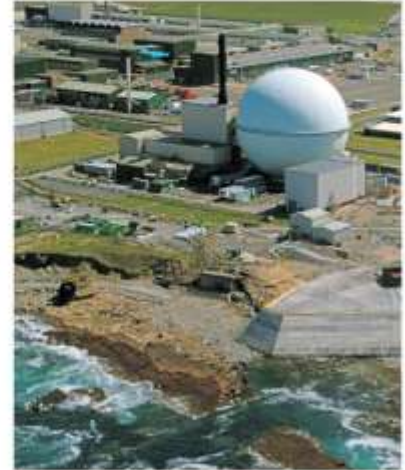
Warning Message:

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.

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

DRAFT



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 Armit, 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 £18bn 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 W&G, T&G 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 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.