Eamont Bridge

Flood Investigation Report

Flood Event 5-6th December 2015

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

Version	Prepared by	Reviewed by	Approved by	Date
Working Draft for discussion with EA	Ceri Deakes			
Version v 2.0 Incorporating EA comments and updates	Ceri Deakes	Himz Mistry	Graham Fardell	29 June 2016
Version 2.1	I Lawton	Doug Coyle	Doug Coyle	17th Feb 2017

Contents

Executive Summary

The flooding experienced in Eamont Bridge village on the 5th and 6th of December 2015 was unprecedented and was the result of the effects of Storm Desmond. This storm caused a period of prolonged, intense rainfall across Northern England, falling on an already saturated catchment which led to high river levels and flooding throughout Cumbria and beyond. The flow in the River Eamont in Eamont Bridge village on the 6th of December was the highest ever recorded, resulting in flood levels in some locations that were approximately 800mm higher than those experienced during the previous record set in January 2005.

In response to the flood event, this Section 19 – flood investigation report has been completed by the Environment Agency as a key Risk Management Authority (RMA) working in partnership with Cumbria County Council as the Lead Local Flood Authority, under the duties as set out in Section 19 of the Flood and Water Management Act 2010. This report provides details on the flooding that occurred in Eamont Bridge village 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 and river and rainfall telemetry during the flood event. This data has been compiled by CH2M, specialist consultants in flood risk management who have provided advice in understanding the event and recommendations for future action.

The residents of Eamont Bridge village that were previously affected by the November 2009 flood event secured funding for property level protection. The river levels experienced in December 2015 exceeded the standard of protection of these property defences resulting in extensive property flooding throughout the village. There are raised earth flood embankments around the Fire Fighters Charity centre. The only other formal defences that exist local to Eamont Bridge village are a flood wall bordering a caravan park upstream of the village and private defences which protect a property at Brougham downstream of the village. Both of these defences were overtopped during the December 2015 flood event.

Approximately 101 properties were directly affected by the flooding.

This report details the flooding that occurred from the Rivers Eamont and Lowther, flooding from other watercourses and from surface water. It identifies the flow routes and the causes of the flooding where flood defences were overtopped or bypassed in a number of locations in Eamont Bridge village:

- North side of the river from M6 to Skirsgill Lane
- South side of the river from M6 to Jubilee House grounds
- Mill Race Drive
- Low Mill to Brougham Mill and floodplain of Lowther and Eamont upstream of Brougham Bridge

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

Sixteen actions have been recommended in this report to manage future flood risk, which will require the involvement of a number of organisations and local communities.

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

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

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

Please note the village, Eamont Bridge, will be referred to as Eamont Bridge village throughout the report. The A6 road bridge over the river will be referred to as Eamont Bridge.

Flooding History

Eamont Bridge village is a small village situated to the south of Penrith in Cumbria. The River Eamont flows east from Ullswater, the second largest lake in the Lake District, and through Eamont Bridge village. The River Lowther is a tributary of the River Eamont and runs from Wet Sleddale Reservoir and to the south east of Eamont Bridge village. The confluence of the River Eamont and River Lowther is located a few miles downstream of the village, close to Brougham Castle.

Eamont Bridge village has a long history of flooding, with recent events occurring in 1997, 2002, 2005 and 2009. During the 2009 flood event, 43 residential properties and 2 commercial properties were flooded in the village. The Environment Agency and local community worked together to secure funding, following the November 2009 flood, to implement property level protection. Funding was made available to around 45 properties and of those, 37 accepted and obtained air brick covers and flood gates for their properties.

Figure 1 Property Level Protection installed at properties in Eamont Bridge village post 2009 flood event

Event background

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

Flooding Incident

The A6 road is major north-south road which goes from Luton to Carlisle and runs directly through Eamont Bridge village. The A6 crosses both the River Eamont and the River Lowther via two bridges named Eamont Bridge and Lowther Bridge respectively. A few miles downstream of Eamont Bridge village and immediately after the confluence of the Rivers Eamont and Lowther, Brougham Bridge spans over the River Eamont.

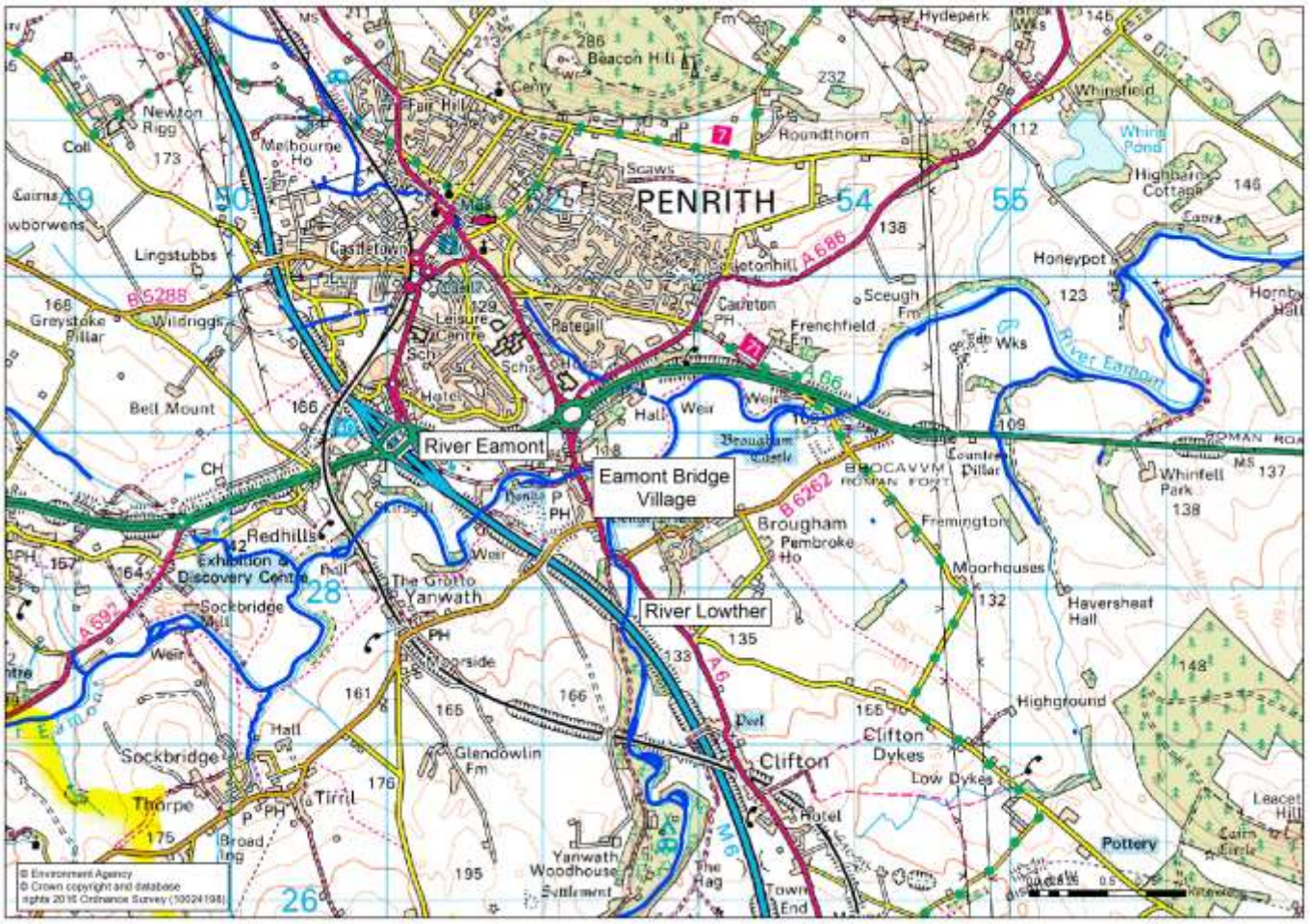


Figure 2 Location of Eamont Bridge village and Major Rivers

On 5th and 6th December 2015, approximately 101 properties suffered flooding. This flooding can be attributed to a record-breaking rainfall event from Storm Desmond which led to widespread flooding from the Rivers Eamont and Lowther, plus flooding from surface water and drainage systems. Figure 3 shows the approximate extent of the flooding.

Flooding was primarily associated with fluvial (river) sources.

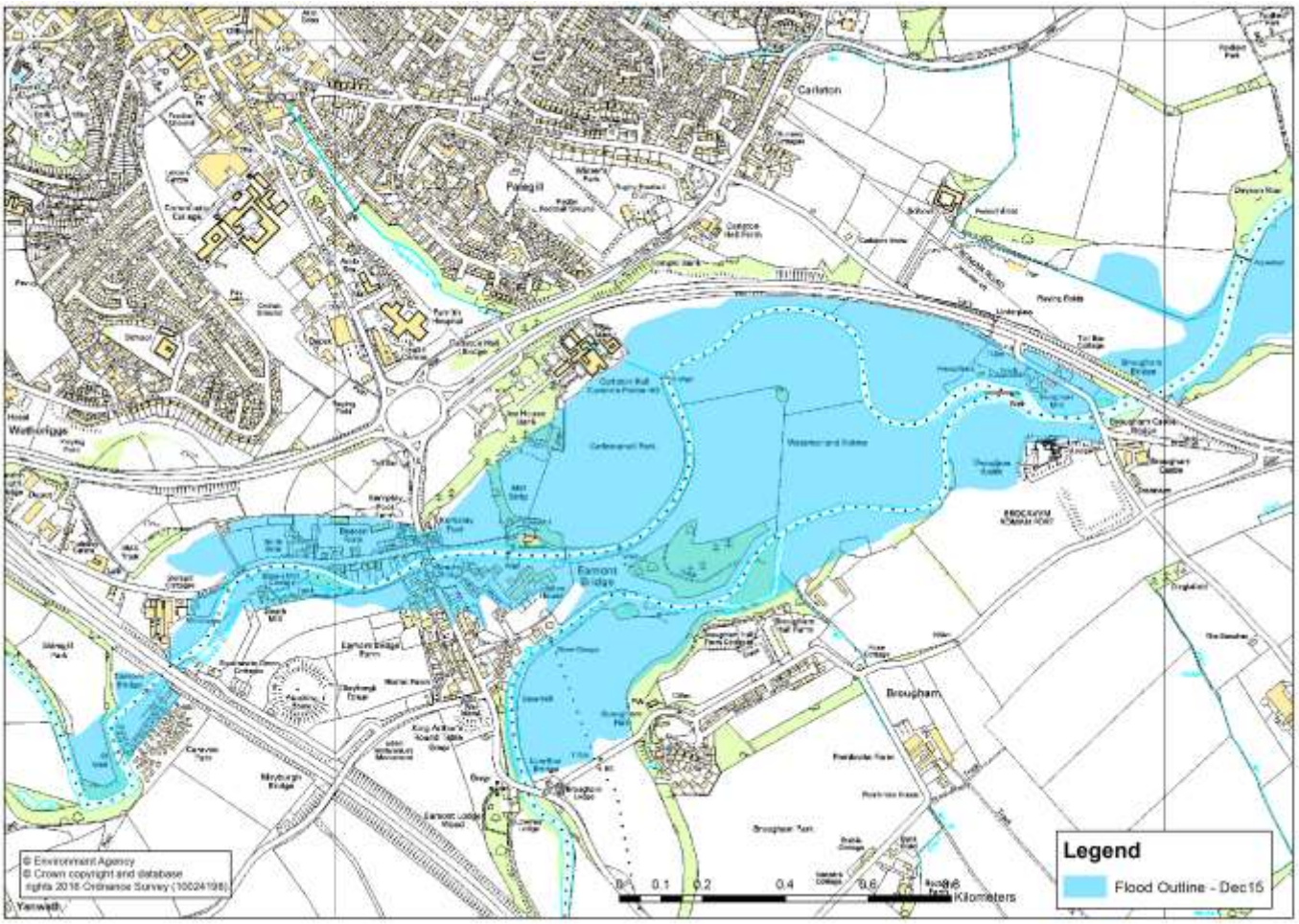


Figure 3 Extent of Fluvial (River) Flooding in Eamont Bridge village and Brougham on 5th-6th December 2015

For this report the flooded area has been divided into 4 sub-areas for investigation. These are shown in Figure 4.

- **North side of the river from M6 to Skirsgill Lane**
- **South side of the river from M6 to Jubilee House grounds**
- **Mill Race Drive**
- **Low Mill to Brougham Mill and floodplain of Lowther and Eamont upstream of Brougham Bridge**

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

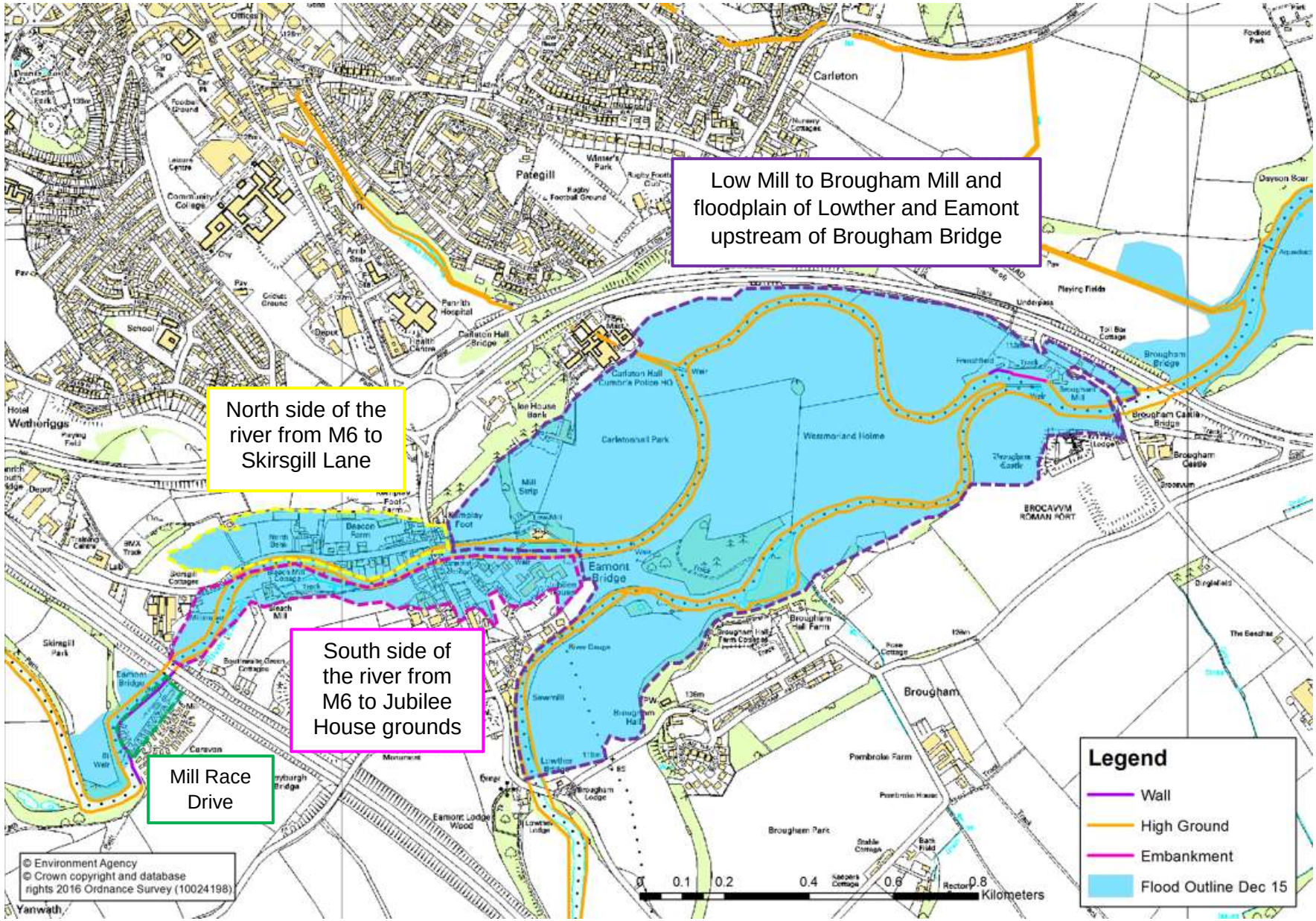


Figure 4 Identification of Areas Flooded

Current Flood Defences

There is a flood warning system currently in operation for the Eamont Bridge village area and this system is available to all properties located in areas susceptible to flooding. Additional information on the flood warning areas in Eamont Bridge Village and Brougham is shown in Appendix 4.

Upstream of Eamont Bridge, there is a flood wall on the right bank of the River Eamont which forms the boundary of a park homes site at Mill Race Drive. The flood wall is approximately 1.2m high.

At the confluence of the River Eamont and River Lowther, there are third party defences located on the left bank of the River Eamont. The upstream extent of the defences (shown in purple on Figure 5) is a flood wall which ties into an earth built embankment (shown in pink on Figure 5).

There is a Property Level Protection scheme in Eamont Bridge Village which was made available to local residents following the flood event in November 2009. There are raised earth flood embankments around the Fire Fighters Charity Jubilee Centre. There is also a Property Level Protection Scheme at Brougham Mill and a third party embankment around Frenchfield.

There are no other formal defences around Eamont Bridge Village and Brougham.

A map of existing river channels and defences is shown in Figure 5.

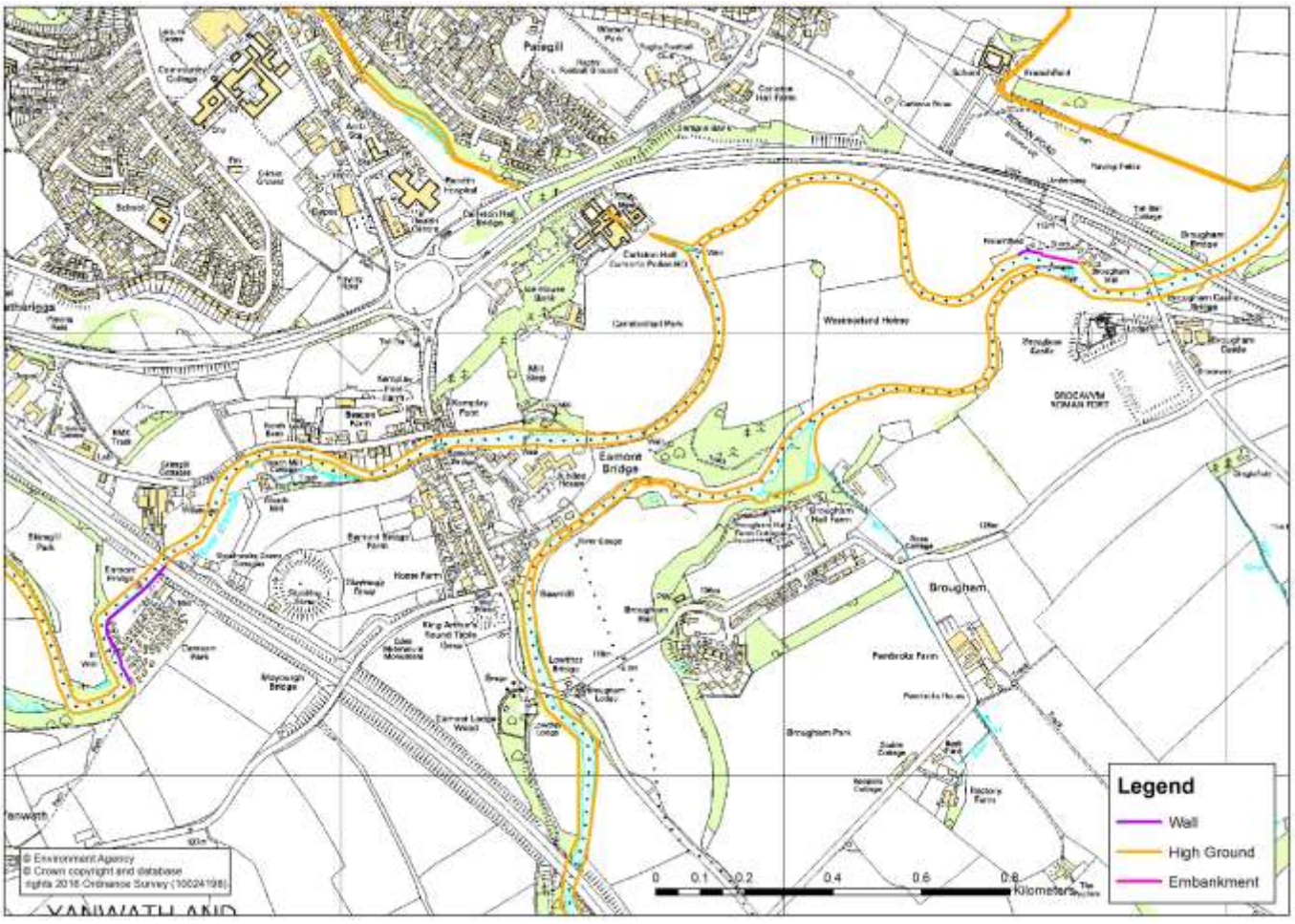


Figure 5 River banks and flood Defences in Eamont Bridge Village and Brougham on the Rivers Eamont and Lowther

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 communities affected with help from Cumbria County Council.

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

Rainfall Event

December 2015 was the wettest calendar month on record with much of the northern UK receiving double the average December rainfall. This also followed a particularly wet November and as such much of the soil 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.

Location	Maximum 24 hour Rainfall during November 2009 Event	Maximum 24 hour Rainfall during December 2015 Event	
	mm	mm	Dec Long Term Average (calculated by the Met Office)
Burnbanks	102.4	186.4	216
Brothers Water	200.8	292.4	296
Greenclose Farms	47	87.2	121
Newton Rigg	38.2	55.8	93.4

Table 1 Rainfall over 24 hours in the Eamont and Lowther catchment prior to the December 2015 event

Gauging Station	River	Peak flow (m3/s)		
		Dec 2015	Past Events*	
			June 2012	Jan 2005
Pooley Bridge	Eamont	268	34.7	107.2
Eamont Bridge Farm	Eamont	3.376m (level only)	1.527m (level only)	2.5m (level only)
Dacre Beck	Dacre Beck	58.22	42.4	56.82

Table 2 Peak Flow in River Gauges around Eamont Bridge Village

Impacts and Likely Causes of Flooding

Timeline

Timeline

3rd December	Event
19:29	**Flood alert** issued for River Eamont and Lowther
4th December	**Event**
15:14	**Flood alert** issued for River Eamont and Lowther
21:50	Flood Warning River Eamont at Eamont Bridge, Kemplay Foot, Skirsgill Lane and Southwaite Green Mill
5th December	**Event**
16:43	Flood Warning River Eamont at Eamont Bridge, Old Post Office Row and Eamont Park
6th December	**Event**
02:17	Severe Flood Warning River Eamont at Eamont Bridge, Kemplay Foot, Skirsgill Lane and Southwaite Green Mill also Severe Flood Warning River Eamont at Eamont Bridge, Old Post Office Row and Eamont Park
4:30	Toll Bar Cottage flooded
7:00	Private defences around Brougham Mill were overtopped

Flooding Flow Routes

There were a number of flood flow routes during the event. For investigation purposes, the flooded areas have been divided into the four sub areas shown in Figure 4.

The details of the flow routes into these areas, the likely causes and the properties flooded are discussed in the 'Likely Causes of Flooding' section. There may also have been other flooding mechanisms that were not identified during this investigation.

North side of the river from M6 to Skirsgill Lane

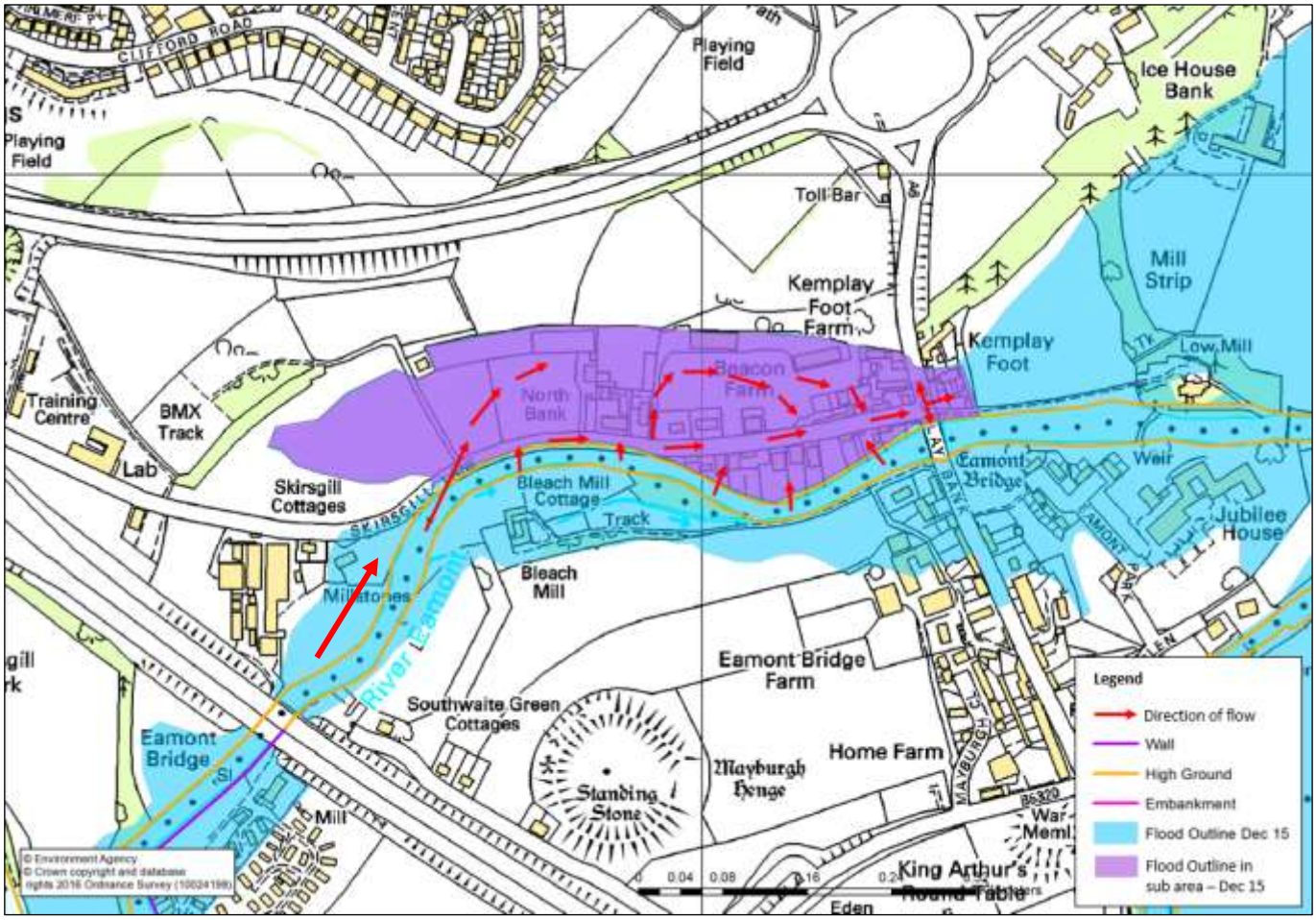


Figure 8 Flood Flow Routes at Skirsgill Lane

Skirsgill Lane runs adjacent to the left bank of the River Eamont and connects with the A6 road through Eamont Bridge village. During the flood event on 5th and 6th December 2015, flooding occurred on Skirsgill Lane from the junction with the A6 road to Skirsgill Cottages and at Kemplay Foot across the A6.

The River Eamont overtopped its banks during the flood event in December 2015. At the far west side of the flood extent, shown in Figure 8, the river overtopped the left bank at the point where the River Eamont flows out of the M6 road bridge. The flood water flowed across the fields towards the properties on Skirsgill Lane. The River also overtopped its banks further downstream and ran east down Skirsgill Lane towards the A6. Beacon Farm flooded via the private road leading north from Skirsgill Lane. The water flowed along the private road and flooded the land at Beacon Farm and the properties to the east of Beacon Farm. Flood water flowed through fences and across property boundaries towards and across the A6 towards Kemplay Foot.

Eamont Bridge is a narrow masonry arch road bridge on the A6, consisting of three arches, which crosses over the River Eamont. On the downstream face of the bridge, there is a steel truss footbridge to allow pedestrian access over the River Eamont.

Under normal circumstances, the River Eamont passes under the bridge via the archways, however the bridge and associated access ramp on the Skirsgill Lane also acts as a constriction to flow when river levels are high by reducing the capacity of the channel at that point. During the flood event in December 2015, river levels were high due to the excessive amount of rainfall. Eamont Bridge constricted the flow

and caused water to back up at the upstream face of the bridge. This caused water to overtop the banks at the side of the bridge and flow around the bridge and also down the A6 road in both directions towards local residential properties. Debris was deposited adjacent to the properties directly next to Eamont Bridge (see figure 9) and across the field at Kemplay Foot.

The flood event caused damage to Eamont Bridge which resulted in the closure of the bridge. The full extent of the damage was not assessed during the event as the river levels were too high to carry out a safe detailed structural assessment. During the closure of Eamont Bridge, a diversion route was set up through Brougham.

Figure 9 Eamont Bridge on the A6 road over the River Eamont. On the left, upstream face with pedestrian footbridge. On the right, downstream face with debris along the side of residential properties.

Figure 10 Aerial Photo of flooded properties on Skirsgill Lane

South side of the river from M6 to Jubilee House grounds

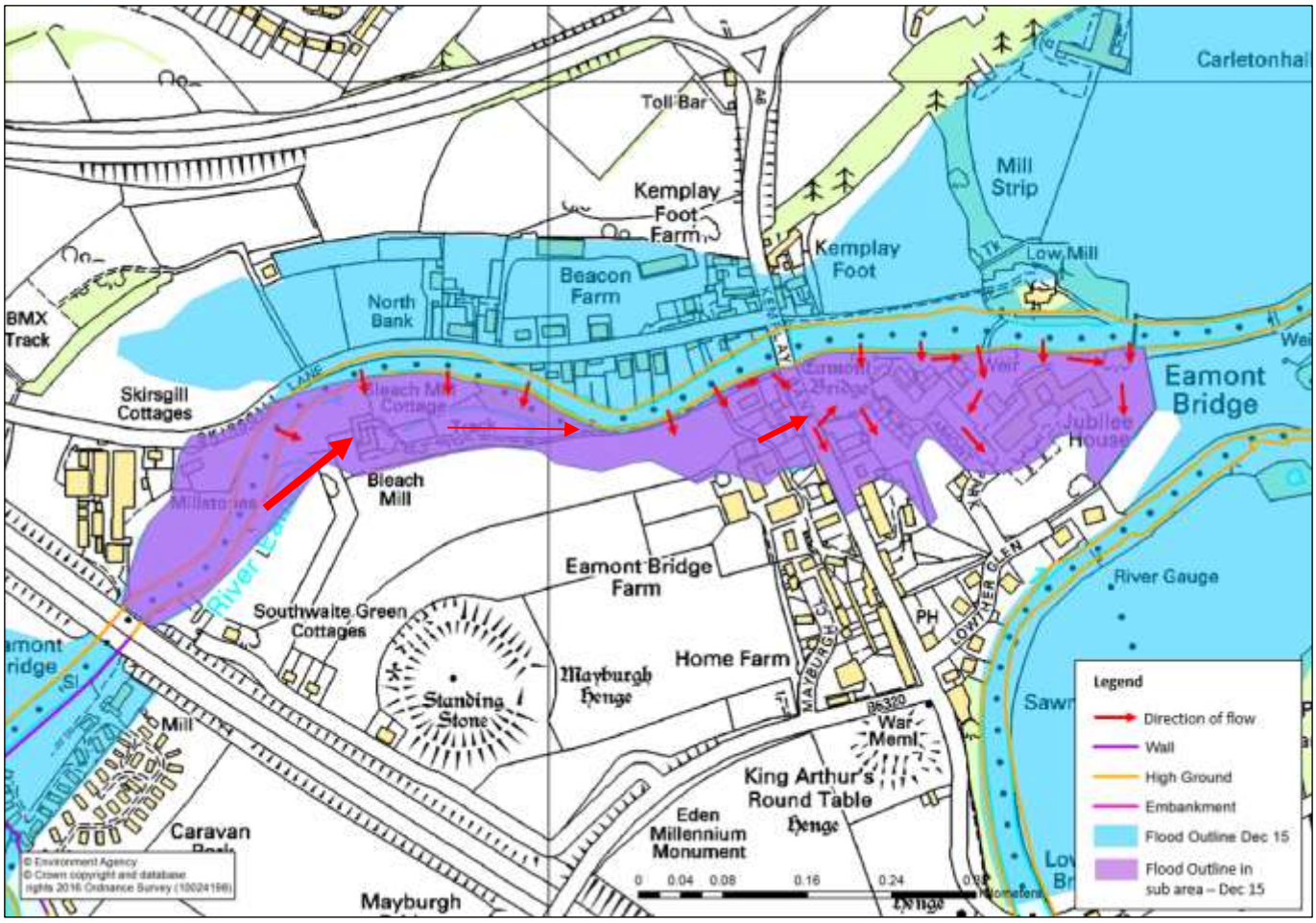


Figure 6 Flood Flow Routes in Jubilee House area

This area is situated on the right bank of the River Eamont and extends both upstream and downstream of Eamont Bridge over the River Eamont towards the M6 in the west and to Jubilee House to the East.

Flood water flowing out of Mill Race Drive beneath the M6 access tunnel joined the main flow in the River Eamont channel briefly before leaving the channel again at the western boundary of Bleach Mill. Extensive erosion occurred to the boundary of Bleach Mill and the land to the west at Southwaite Green Mill. Earth works that had been undertaken at Southwaite Green Mill in the Autumn were washed away, as were trees that had been present.

The A6 road bridge represents a constriction to flow on the River Eamont. At the peak of the event flood water was flowing onto the A6 through small lanes and paths running between the A6 and the back lane to Eamont Bridge Farm as well as the main opening immediately adjacent to the bridge. The boundary wall between the A6 and Jubilee House grounds formed a barrier to flood water which funnelled through an access gate and also burst a hole through the rear garden wall at 1 Post Office Row. These flow routes then by-passed the flood defences at Jubilee House causing flooding to Eamont Park.

Low Mill Weir, located downstream of Eamont Bridge, acts as an obstruction to flow and causes elevated river levels upstream

A resident of Jubilee House advised that the main flow of water came from properties at Eamont Park, located upstream of Jubilee House, rather than directly from the River Eamont. The water flowed around Jubilee house and surrounded the property. The water depth at Jubilee House was approximately 300mm and came to just above the air bricks on the wall adjacent to the car park. A number of grips were dug into the embankment at the rear of Eamont Park properties to allow water to drain back into the river once river levels had reduced.

Immediately upstream of the A6 road, on the right bank of the River Eamont, water flooded properties to approximately the level of window sills on the ground floor. Figure 7 shows the maximum depth of water advised by local residents which was confirmed by water marks on the brickwork of properties. The main cause of flooding to the properties upstream of Eamont Bridge was the volume of water in the channel flowing over the river banks and the bridge causing an obstruction to flow which resulted in water backing up at the upstream face of the bridge and overtopping the river banks.

Figure 7 Local residents advised maximum depth of flood water came to ground floor window sill (level shown in red) at properties upstream of A6 road, right bank.

During the flood event on 5th and 6th December 2015, Eamont Bridge and the A6 remained closed before opening briefly but was then closed for 3 months in order for repairs to be undertaken.

Mill Race Drive

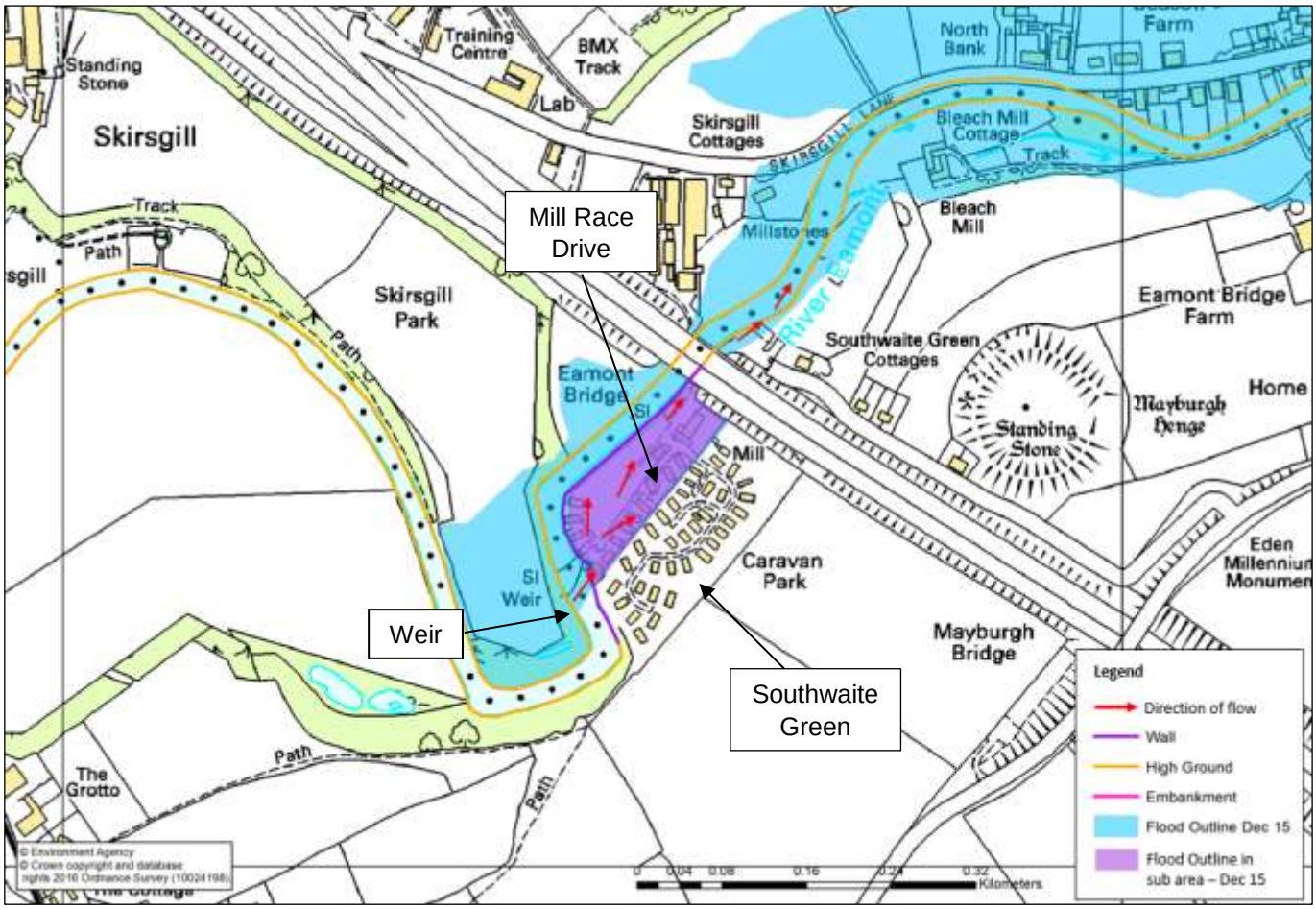


Figure 11 Flood Flow Routes at Mill Race Drive

Mill Race Drive is located upstream of Eamont Bridge village and the M6 and sits within a bend on the right bank of the River Eamont. There is a park home site at Mill Race Drive and the site extends to just north of the M6 motorway. The majority of the site, which is situated south east of the M6, is protected by a flood wall, which can be seen in figure 5. The flood wall forms the boundary of the caravan site on the banks of the River Eamont and ties into the M6 bridge.

At the upstream end of the flood wall, there is a weir which forms an obstruction to flow. During the flood event in December 2015, there was a period of prolonged, intense rainfall in Cumbria which resulted in higher than normal river levels. As the weir forms an obstruction to flow, it caused elevated river levels immediately upstream which resulted in the river overtopping both banks (see figure 12). The raised flood wall was also damaged by a tree which breached the flood wall. Floodwater entered the caravan site at the end of Mill Race Drive, which is the upstream end of the flood wall, and flowed through the site. The water flowed through the caravan park, flooded Mill Race Drive and ran under the M6 motorway bridge. The flood water then entered the section of the caravan park which is downstream of the M6 bridge, where there are no formal flood defences, and this is where the flood water re-entered the River Eamont once levels reduced. Access to Southwaite Green was impossible as Mill Race Drive was flooded meaning the only access road was under water.

During the flood event, residents were rescued by helicopter from the caravan park by the coastguard.

Figure 12 Aerial photo of flooding at Mill Race Drive

Low Mill to Brougham Mill and floodplain of Lowther and Eamont upstream of Brougham Bridge

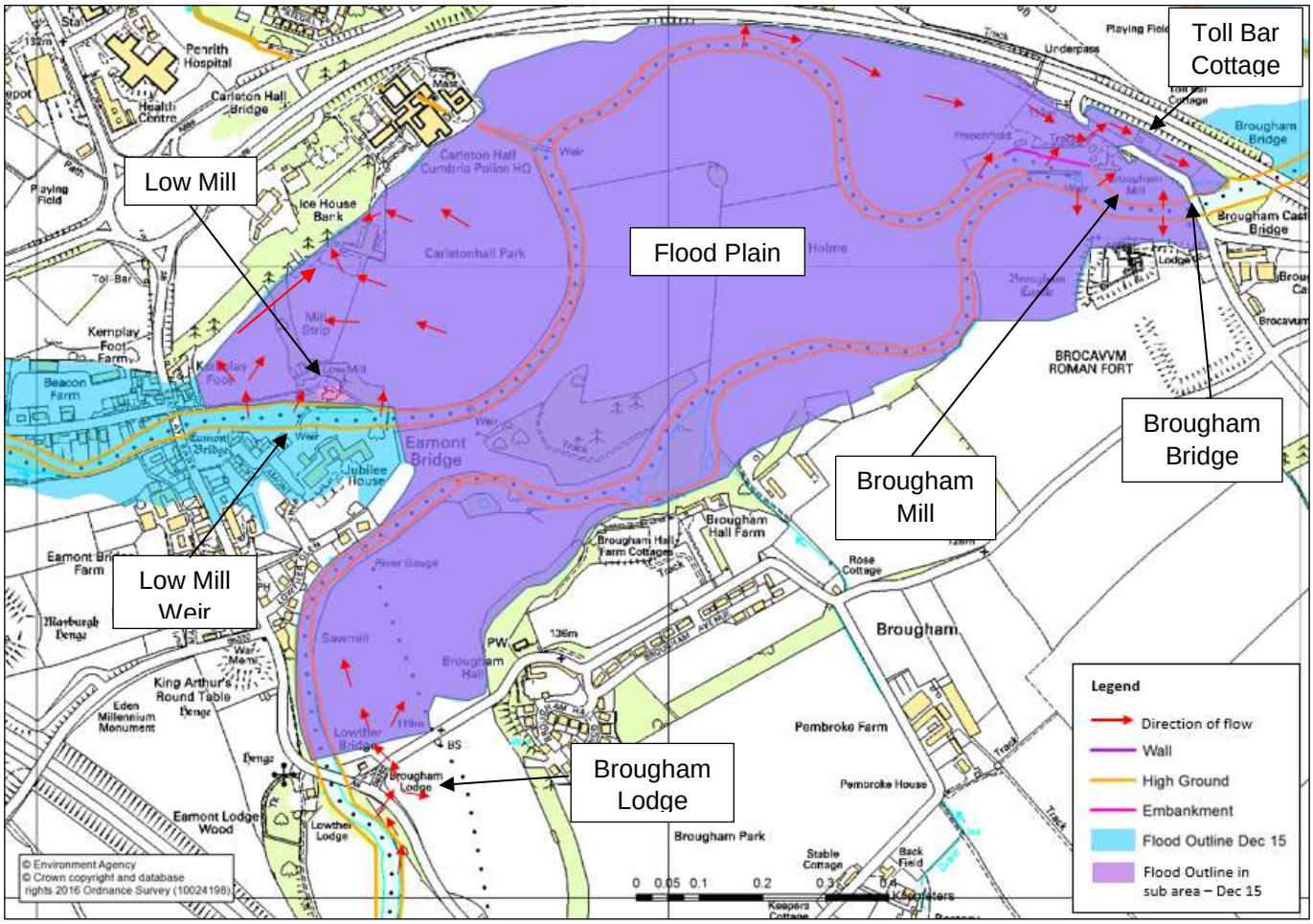


Figure 13 Flood Flow Routes at Low Mill to Brougham Mill and floodplain of Lowther and Eamont upstream of Brougham Bridge

Brougham Mill is situated on the left bank of the River Eamont, between the confluence of the Rivers Eamont and Lowther and the A66 road over the River Eamont. The owners of Brougham Mill and Frenchfield have their own purpose built flood defences around their property.

During the flood event on 5th and 6th December, both the River Eamont and River Lowther overtopped their banks and filled the flood plain upstream of Brougham Mill. As shown in figure 13, water flowed from the flood plain towards residential properties.

The residents at Toll Bar Cottage recorded flood levels of 0.6-0.9m at their property. The main flow of water into their property came from Moor Lane, the road leading up to their property, from the direction of the flood plain upstream.

As a result of the flood event, debris was deposited in the flood plain upstream of Brougham Mill. Figure 15 shows debris in the field adjacent to the A66 which was used to assess the flood extent of the event in December 2015.

Figure 14 Flood flow route from floodplain upstream. Water flowed down Moor Lane towards residential properties. Toll bar cottage located on right of photograph.

Figure 15 Debris line in field next to A66 looking upstream

Brougham Bridge on Moor Lane was damaged during the December 2015 flood event. The bridge constricted the flow of the river during the flood event which caused water to back up at the upstream

face of the bridge. The left pillar on the upstream face of the bridge collapsed during the flood event (shown in figure 16).

Figure 16 Upstream face of Brougham Bridge showing damage to left pillar

Low Mill is located on the left bank of the River Eamont and is situated downstream of the A6. Low Mill sits immediately downstream of the Low Mill Weir, shown in Figure 13.

During the flood event on 5th and 6th December 2015, the weir at Low Mill acted as an obstruction to flow that caused elevated river levels immediately upstream which overtopped the river banks. Flood water flowed across the fields to the west of Low Mill and also around the property itself. Carletonhall Park and the Police Fire Arms centre, to the east of Low Mill, flooded from the River Eamont overtopping its banks and water flowed across the park towards Low Mill and Ice Bank House.

Brougham Lodge is located on the right bank of the River Lowther, next to the Lowther Bridge on the A6. The junction of the A6 and B6262 is located immediately south of Brougham Lodge.

During the flood event on 5th and 6th December 2015, the River Lowther overtopped its banks approximately 150m upstream of Brougham Lodge. Flood water flowed along the land on the right bank of the River Lowther, next to the A6 road until it found a low spot in the A6 road and crossed over towards the field south of Brougham Lodge. The stone wall which forms the boundary of the field south of Brougham Lodge was breached by the flood water just south of the B6262 and A6 junction. The field was flooded to the extent shown on Figure 18.The flow of water ran towards the northern most extent of the field and breached the stone wall adjacent to the B6262 road (see Figure 17).

Figure 17 Breach in stone wall on B6262 opposite Brougham Lodge and flood water in field post event

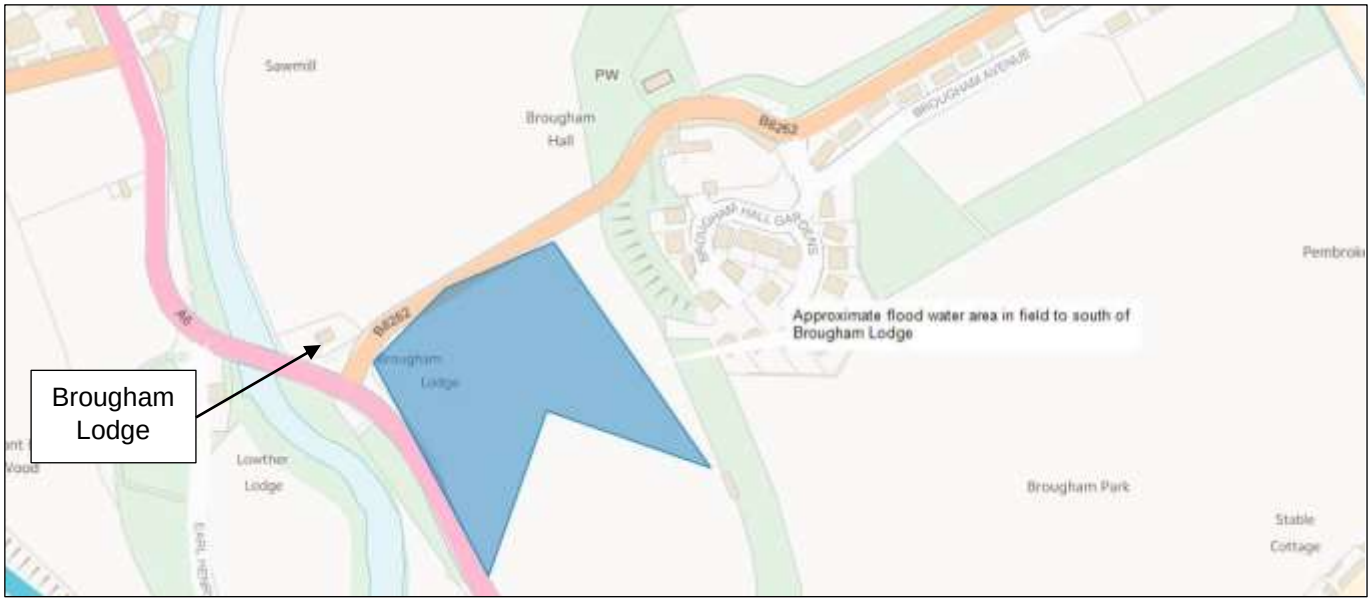


Figure 18 Approximate extent of flooding to land south of Brougham Lodge

Environment Agency Flood Incident Response

The Environment Agency's response to the flood event on the 5th and 6th December 2015 started well in advance of the event.

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

Flood Alerts were issued for Rivers Lowther and Eamont on 03/12/15, 19:29 and 04/12/15, 15:14

A flood warning for the River Eamont, at Kemplay Foot, Skirsgill Lane and Southwaite Green Mill, was issued on the 4th of December at 21:50. Also a Flood warning was issued for Old Post Office Row and Eamont Park on the 5th December at 16:43. The details of the flood warning areas and the timings of these warnings is shown in Appendix 4.

A severe flood warning was issued on the 6th December at 02:17. The majority of properties reported that they had received these warnings within good time.

There were additional challenges with flood warnings, due to parts of the village flooding overnight. A number of residents did not respond to flood warnings because of this, and they therefore wrongly assumed that as the area was not flooded on Saturday evening following the severe flood warning, the risk of flooding had passed.

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

Recommended Actions

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

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

Cumbria Flood Partnership Theme	Action by	Recommended Action	Timescale
Community Resilience	Cumbria Local Resilience Forum *	Review and update plans to enable homes & business to be better prepared for flooding & reduce the impacts of flooding	2016
	Environment Agency and Cumbria County Council Highways and Electricity North West.	To review the flood risk and resilience of critical transport and power supply infrastructure.	2016 - 2017
	Environment Agency and Cumbria County Council Highways	Investigate potential to increase the flood flow capacity of Eamont Bridge and Brougham Bridge	On-going
	Eden Rivers Trust Environment Agency and Cumbria County Council	Investigate potential of removal of Low Mill Weir	On-going
	Cumbria Planning Group, 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.	Summer 2016
	Environment Agency	Review the need and practicalities of deploying temporary defences in certain locations as an interim or longer term measure to help reduce flood risk	2016 - 2017
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.	2017

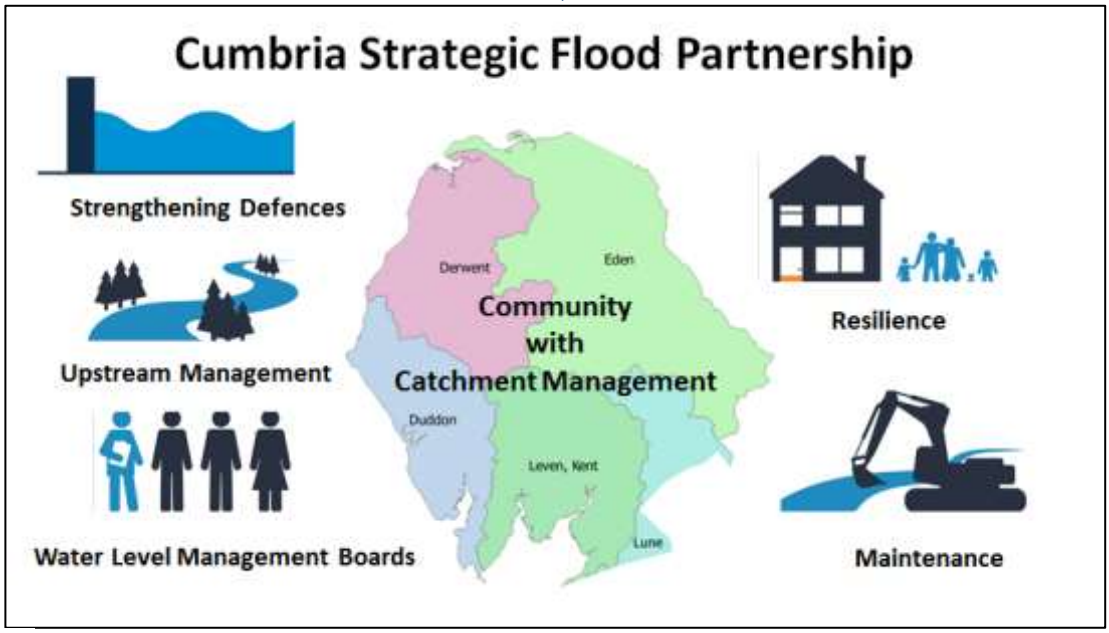
	River Restoration Programme (Eden Rivers Trust & Environment Agency)	Continue to work with Eden River Trust on River Restoration Strategy upstream of Eamont Bridge	On going
Maintenance	County Council and United Utilities	Review and investigate drainage and sewage systems, including service crossing of the river to better understand where improvements are required.	On-going
	Environment Agency, United Utilities and Cumbria County Council	Complete on-going inspections and repairs to assets which may have been damaged during the flood event	2016
	Environment Agency	Review modelling data to ensure that models for Eamont Bridge village and Brougham reflect real conditions as accurately as possible and use this information to make any improvements to the flood warnings service. This will be used to inform future investment plans.	On-going
	Environment Agency	Tree works and mill leat clearance at Bleach Mill island	Spring '17
	Environment Agency	Undertake review of geomorphology to better understand gravel movement in the river to inform the existing gravel management plan.	On-going
Strengthening Defences			
	Environment Agency	Begin developing business case to support flood defence scheme at Eamont Bridge	On-going
	Environment Agency (and Fire Fighters Charity)	Support Fire Fighters Charity in their flood defence improvement works at Jubilee House. Proposed scheme offers wider benefits to the village.	On-going

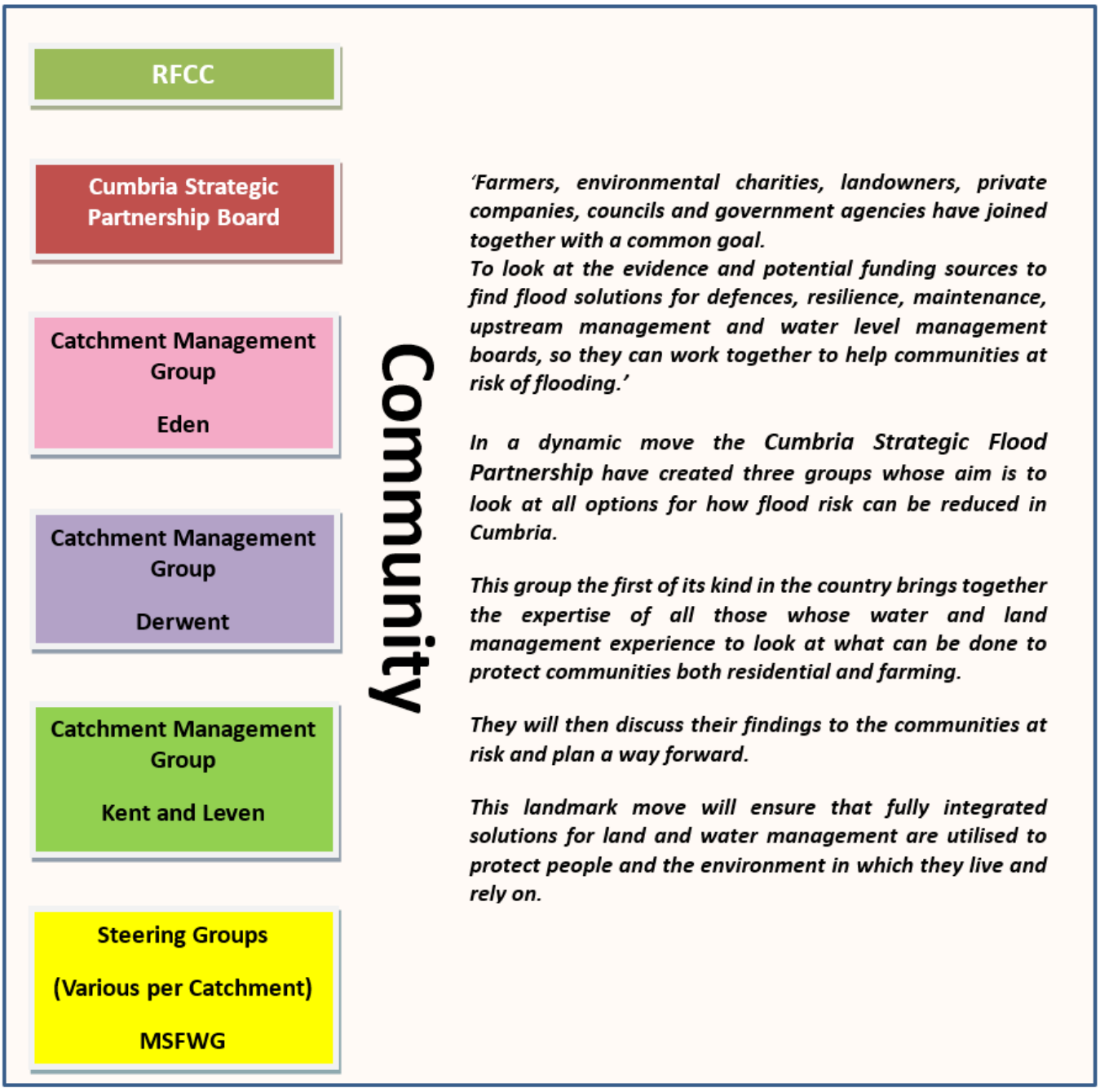
* The Cumbria Local Resilience Forum includes emergency services, local authorities, Cumbria County Council, Environment Agency, Maritime Coastguard Agency and health agencies along with voluntary and private agencies. Under the Civil Contingencies Act (2004) every part of the United Kingdom is required to establish a resilience forum.

Next Steps – Community & Catchment Action Plan

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

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




RFCC
Cumbria Strategic Partnership Board
Catchment Management Group
Eden
Catchment Management Group
Derwent
Catchment Management Group
Kent and Leven
Steering Groups
(Various per Catchment)
MSFWG
Community
'Farmers, environmental charities, landowners, private companies, councils and government agencies have joined together with a common goal.
To look at the evidence and potential funding sources to find flood solutions for defences, resilience, maintenance, upstream management and water level management boards, so they can work together to help communities at risk of flooding.'
In a dynamic move the Cumbria Strategic Flood Partnership have created three groups whose aim is to look at all options for how flood risk can be reduced in Cumbria.
This group the first of its kind in the country brings together the expertise of all those whose water and land management experience to look at what can be done to protect communities both residential and farming.
They will then discuss their findings to the communities at risk and plan a way forward.
This landmark move will ensure that fully integrated solutions for land and water management are utilised to protect people and the environment in which they live and rely on.

Appendices

Appendix 1: Glossary

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

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 ot 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

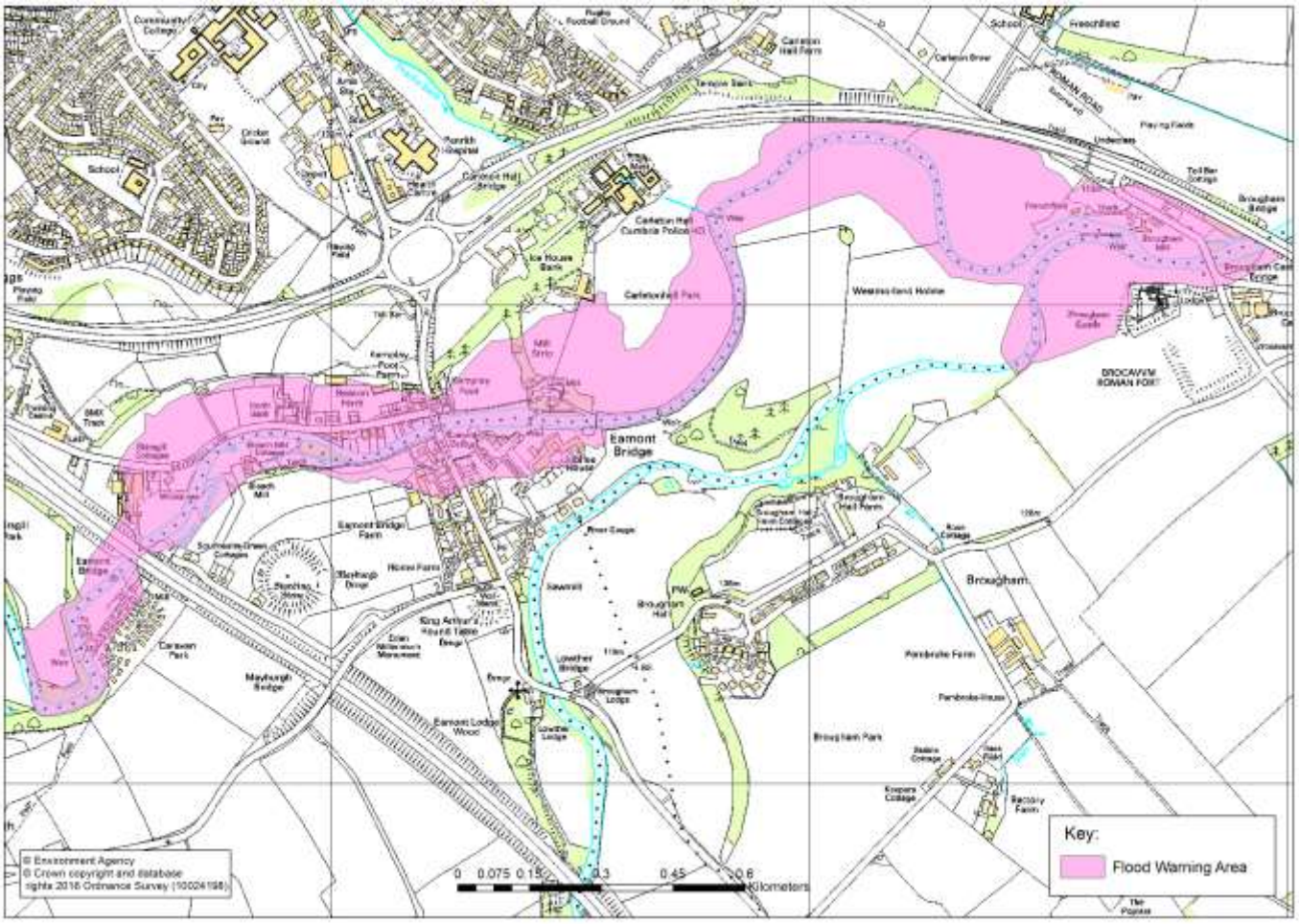


Figure 19 Flood warning area

011WAFLO – Rivers Lowther and Eamont

Flood Alert issued 03/12/15 19:29 and 04/12/15 15:14

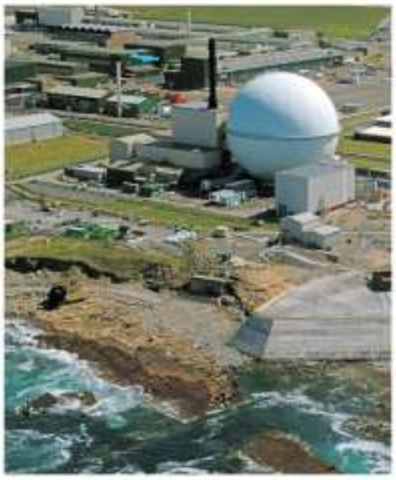
011FWFNC7A - River Eamont at Eamont Bridge, Kemplay Foot, Skirsgill Lane and Southwaite Green Mill

Flood warning issued on Friday 04/12/15 at 21:50
Severe Flood Warning issued Sunday 06/12/15 at 02:17

011FWFNC7B - River Eamont at Eamont Bridge, Old Post Office Row and Eamont Park

Flood warning issued on Saturday 05/12/15 at 16:43
Severe Flood Warning issued Sunday 06/12/15 at 02:17

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



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- 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.

Transport

Crossrail

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

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

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

High Speed 2 (HS2)

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

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

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

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

We provide services for your success

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

Water Resources-Ecosystem Management Services

Flood Risk Management

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

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

A core focus is delivering fully integrated solutions that maximize both direct and indirect benefits for the clients that we serve in WBG, 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 flooding displaced 100,000 people and is estimated to cost $6 billion.
- According to the House of Commons library, £2.34 billion has been spent on new flood defenses in England alone since 2011.