

Troutbeck Bridge

Flood Investigation Report



Bell Beck, looking downstream towards Troutbeck Bridge, January 2016

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.

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Contents

Executive Summary	4
Flooding History.....	6
Event background	7
Flooding Incident	7
Current Flood Risk Management & Existing Defences.....	11
Investigation	14
Rainfall Event	14
Sources of Flooding, Flood Flow Routes and Event Timeline	18
Likely Causes of Flooding.....	19
Environment Agency Flood Incident Response	25
Pre-event Warning and Preparation.....	25
Post-event Repairs and Maintenance	25
On-going Maintenance Activities.....	26
Recommended Actions	27
Next Steps – Community & Catchment Action Plan	30
Appendices	32
Appendix 1: Acronyms and Glossary.....	32
Appendix 2: Summary of Relevant Legislation and Flood Risk Management Authorities.....	35
Appendix 3: Links to Other Information on Flooding	37
Appendix 4: Flood Warnings and Alerts.....	38
Appendix 5: CH2M Hill UK Projects and Flood Risk Management brochure.....	39

Executive Summary

Troutbeck Bridge experienced flooding on two separate occasions in December 2015. These events occurred on the 5th and 22nd December, and affected several properties in the area. The initial event on 5th December was the most significant of the events, and was the result of the effects of Storm Desmond. This storm caused a period of prolonged, intense rainfall across Northern England, falling on already saturated catchments, and led to high river levels and flooding in Troutbeck Bridge and beyond.

In response to the flood event, this *Flood Investigation Report* has been completed by Cumbria County Council as the Lead Local Flood Authority (LLFA), working in partnership with the Environment Agency as a key Risk Management Authority (RMA), 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 Troutbeck Bridge on the 5th of December, and has used a range of data collected from affected residents, site visits, surveys of the area, data collected by observers, as well as river and rainfall telemetry during the flood events.

There are no formal flood defences within Troutbeck Bridge, however the Environment Agency inspect and, if required, subsequently remove gravel from the Bell Beck culvert following flood events. The Environment Agency also clear the trash screen at the inlet to the Bell Beck culvert, situated in a field upstream of Brook Street, to minimise the risk of potential blockages, on receipt of forecast heavy rainfall as a 'high priority' site. Following the extreme rainfall and subsequent flooding in December 2015, gravel removal took place within the Bell Beck culvert, and an estimated 30 tonnes of material was removed. There is an overflow arrangement within the Bell Beck culvert downstream of Calgarth View on the A591, which provides additional culvert capacity to alleviate some of the flooding.

The 5th December flood event affected seven properties directly. This was largely due to issues on Bell Beck, where gravel and stone mobilised from erosion in the open channel upstream of the culvert inlet had washed downstream to reduce the capacity of the Bell Beck culvert, which could not cope with the significant volume of water flowing towards Troutbeck Bridge during the storm. In addition, there were also flooding impacts from surface water runoff, in particular flowing down Sun Lane and the A591 towards Calgarth View and Broadfield. There were also reported impacts from local ordinary watercourses and from the local sewer system overflowing. Calgarth Park retirement flats, situated to the west of Troutbeck Bridge village, were affected by groundwater flooding to the basement area, leading to the loss of heating and resulting in the evacuation of residents.

This report details the flooding that occurred from these various sources. It identifies the flow routes and the causes of the flooding within Troutbeck Bridge.

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.

A draft version of the Troutbeck Bridge Flood Investigation Report was published online in July 2016 for public consultation. Following the draft publication, a public meeting chaired by Cumbria County Council was held in Troutbeck Bridge on the 19th July, where the Environment Agency formally presented the report to the local community. Other Risk Management Authorities were also present at the meeting to

answer any questions raised during a question and answer session following presentation of the report. Through the public meeting and local consultation with the community, including with the Troutbeck Bridge Flood Action Group, a range of feedback has been provided on the report. The Environment Agency and Cumbria County Council have reviewed this feedback and, where appropriate, updated the Final version of the report to reflect the required amendments.

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

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>

Flooding History

Troutbeck Bridge has developed around two watercourses; Trout Beck and Bell Beck. Troutbeck Bridge has a long history of flooding, mainly associated with impacts from Bell Beck, which enters culvert upstream of the village behind Brook Street and joins Trout Beck downstream of the Broadfield estate to the south of the A591. The areas in Troutbeck Bridge that are particularly prone to the effects of flooding are Brook Street, Calgarth View and Broadfield, which are all located in close proximity to the Bell Beck culvert.

The following flood events have been recorded in Troutbeck Bridge, with a notable increase in the frequency of flooding from the February 2004 flood event: June 1953, January 1975, February 2004, January 2005, January 2006, October 2008 and November 2009. Local residents also reported a 'near miss' from flooding on 20th November 2015 and 22nd December 2015.

Table 1 shows the recorded data from the gauging station located on Trout Beck, situated downstream of Troutbeck Bridge, at a point downstream of where Bell Beck joins Trout Beck. There is currently no gauging station located on Bell Beck.

Flooding Event	Number of Properties Flooded	Peak flow recorded at the Calgarth Gauge Station (m³/s)	Peak level recorded at the Calgarth Gauge Station (m)	Time of Recorded Peak on 5th December
5 th December 2015	7	50.7	2.23m	18:15

Table 1 – Gauged data from the 5th December flood event affecting Troutbeck Bridge

Event background

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

Flooding Incident

Troutbeck Bridge is a village within the South Lakeland District of Cumbria. It is located between the two popular tourist towns of Windermere and Ambleside on the A591. In distance, it is approximately 1.3 miles to the north west of Windermere. Figure 1 shows the location of Troutbeck Bridge.

The village consists mainly of residential properties, but there are also commercial properties and a school in the area.

Bell Beck flows through the village mostly in a culverted (piped) channel through a built-up, mainly low lying area of residential properties and a school. Bell Beck flows into Trout Beck downstream of the Broadfield estate, which discharges into Lake Windermere downstream of the village. Figure 2 shows the main watercourses around Troutbeck Bridge.



Figure 1 - Location of Troutbeck Bridge

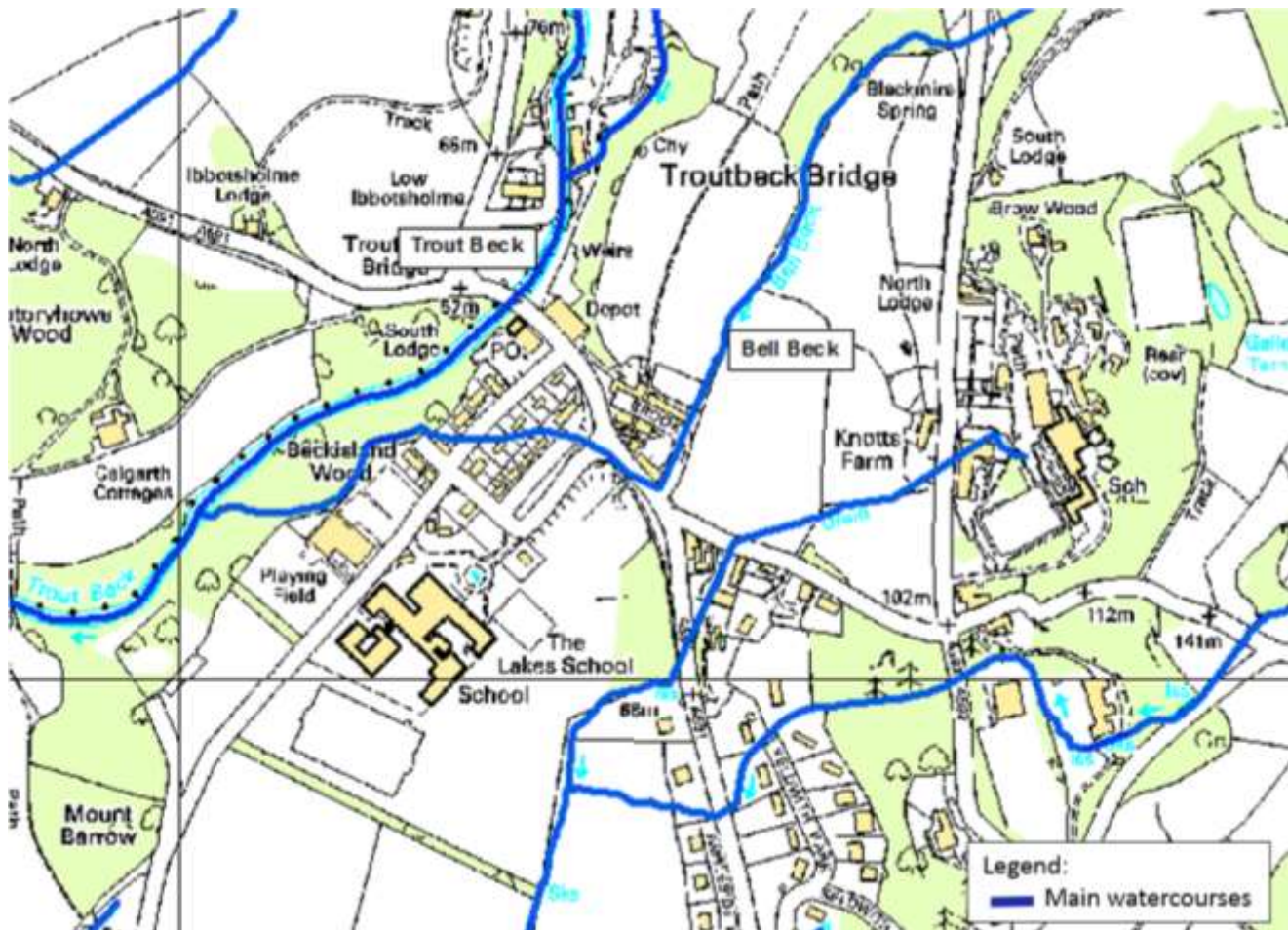


Figure 2 - Location of Watercourses in Troutbeck Bridge

Troutbeck Bridge was affected by flooding on two occasions through December 2015; on the 5th and 22nd.

On the 5th December 2015, seven properties are known to have suffered flooding. This flooding can be attributed to a record-breaking rainfall event from Storm Desmond. This led to flooding from Bell Beck, plus flooding from surface water, other local 'ordinary' watercourses and local drainage systems, and reports of flooding from the sewage network. Calgarth Park retirement flats were also affected by groundwater flooding to the basement.

Flooding was primarily associated with the Bell Beck watercourse, with other sources contributing to the flooding impacts experienced. Calgarth Cottages at Calgarth View, and Pedro's restaurant, which were affected by flooding, are situated in low lying areas and are in close proximity to the Bell Beck watercourse.

Figure 3 shows the approximate extent of the flooding. For this report, the flooded areas have been considered as one area covering Brook Street, Calgarth View, the A591, Broadfield, The Lakes School and Calgarth Park. The areas affected by flooding in Troutbeck Bridge are shown in Figure 4.

Below is a summary of the locations that were affected by flooding:

- Calgarth Cottages at Calgarth View were affected twice in December, on the 5th and 22nd.
- Access issues to Lowther House and 1 Calgarth View.
- Gardens of houses on Broadfield, with water entering the cavity of some houses.
- The Lakes School grounds were affected by flooding, but no internal flooding was experienced.
- Pedro's restaurant (formerly the Sun Hotel) was affected on the 5th of December 2015, resulting in the business being closed.
- Calgarth Park retirement flats were affected by groundwater flooding to the basement area, leading to the loss of heating and resulting in the evacuation of residents.
- Highways drains to the front of Pedro's on the A591 were blocked. There were also issues with the culverted ordinary watercourse in the field to the north east of Pedro's.
- Residents reported that there were other occasions throughout the month of December, such as on the 22nd, when properties, especially on Calgarth View, would have been affected, but local residents took action to prevent properties from flooding.
- Rough Lane, an access track to the east of Sun Lane across the A592, suffered significant erosion due to flow originating from an ordinary watercourse that flows from Howe Hill.

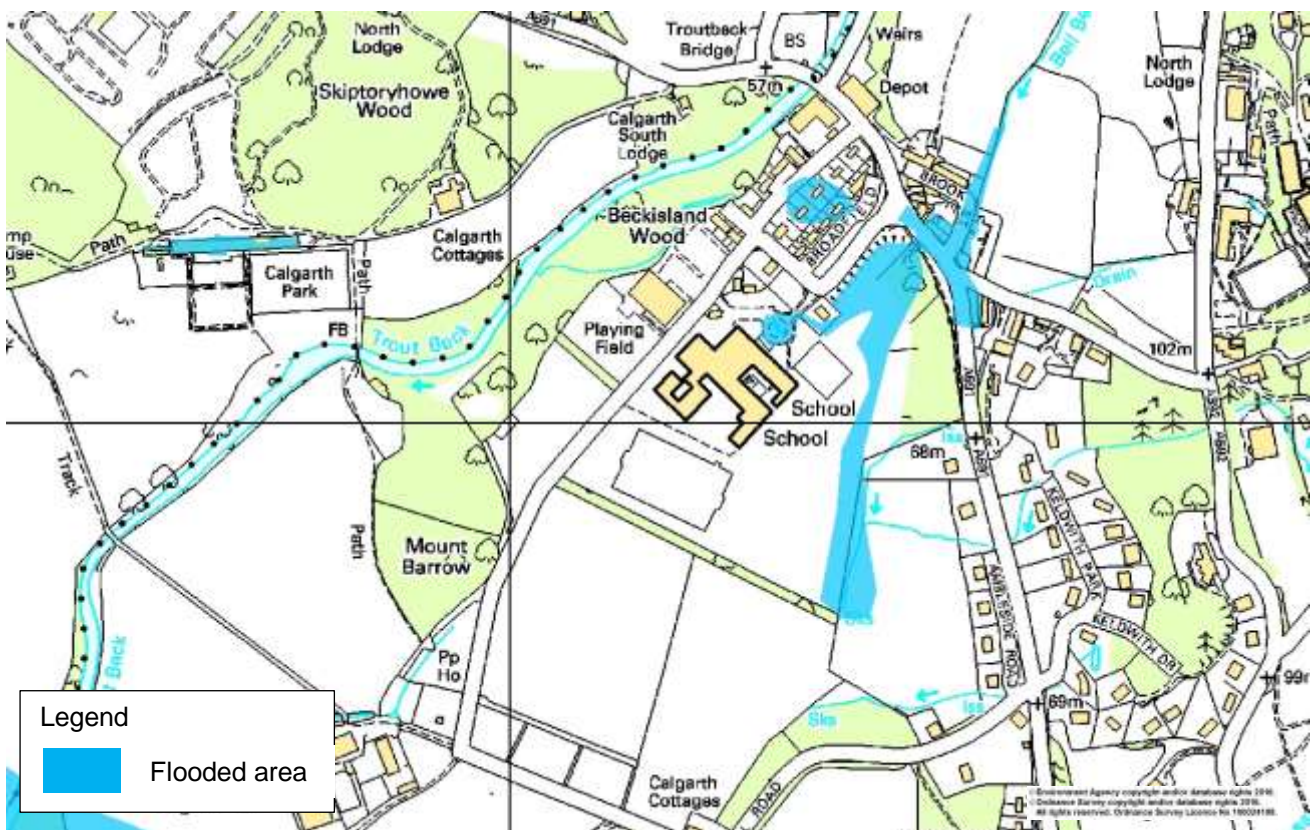


Figure 3 - Extent of Flooding in Troutbeck Bridge on 5-6th December 2015

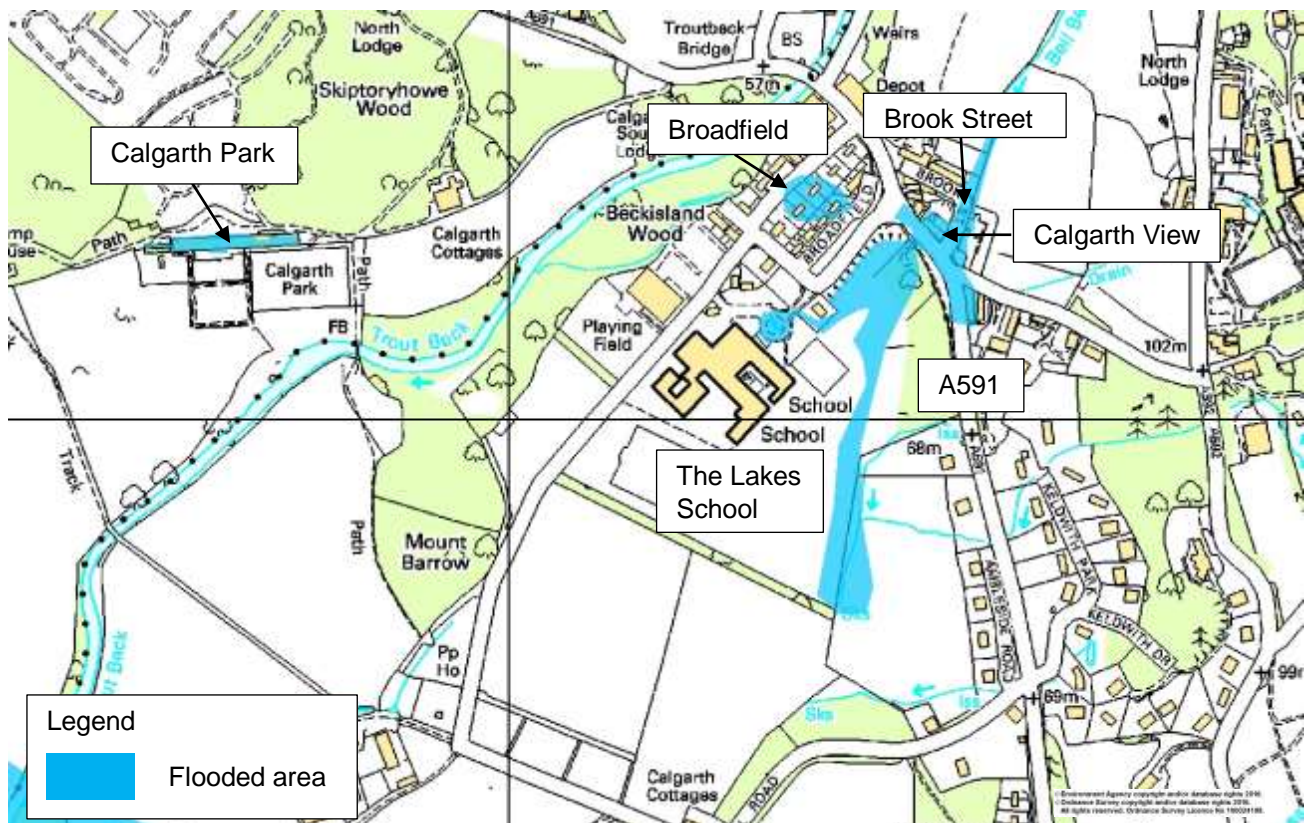


Figure 4 - Identification of Flooded Areas

Current Flood Risk Management & Existing Defences

There are no formal flood defences within Troutbeck Bridge. There is a short length of raised ground upstream of Brook Street adjacent to the Bell Beck culvert inlet, as well as a flow interception trench in the field upstream of Brook Street on the left bank floodplain of Bell Beck. These are shown in Figures 5 and 6.



Figure 5 – Short length of raised ground next to the Bell Beck culvert inlet



Figure 6 – Flow interception trench on the left bank floodplain of Bell Beck

The Environment Agency Operations Team inspect the Bell Beck culvert inlet, particularly before and after bad weather, as a 'high priority' site. This is in addition to routine inspections that are carried out as part of the Environment Agency's ongoing role in proactive operational management to reduce flood risk.

In addition to the operational and incident response of the Environment Agency, the following lists the activities carried out to November 2015, prior to Storm Desmond, on Bell Beck:

- 2004 - Bell Beck is designated as a 'main river' and scheduled on a maintenance programme with a CCTV inspection – designation of 'main river' meant that permissive powers transferred from SLDC to the EA.
- 2008 - CCTV inspection.
- 2009 - Bell Beck maintenance and inlet improvement.
- 2009 – Post-November 2009 flood event recovery work.
- 2010 - CCTV culvert inspection with maintenance work carried out.
- 2011 – Repairs undertaken to the Bell Beck culvert on Brook Street.
- 2011 - Riparian land owners made aware of responsibilities with regards to culvert repairs.
- 2011 - Funds secured by EA from the Cumbria Community Foundation to contribute to cost of work identified.

- 2014 - UU diverts sewer and removes obstruction within Bell Beck culvert, providing additional culvert capacity.
- 2014 - Allocation of Local Levy funding to undertake improvements on Bell Beck.
- 2014 – Cumbria County Council proposal for culvert overflow to reduce flooding and to rebuild pipe network to improve highway drainage.
- 2015 – Twin pipe overflow from Bell Beck culvert installed under A591 downstream of Calgarth View, with improvements to highway drainage.

In 2010, following the November 2009 flooding, Cumbria County Council and the Environment Agency removed stone debris from the Bell Beck culvert. In 2011, the Environment Agency carried out further work to remove masonry debris by digging into the culvert at various locations. By the summer of 2014, United Utilities diverted a sewer that passed through the culvert under Brook Street, removing a significant blockage on Bell Beck (estimated at 30% of the culvert capacity).

In November 2015, Cumbria County Council carried out the installation of a twin pipe overflow from Bell Beck, with support from the Environment Agency. The overflow was designed to operate during high volume flows and during incidents of high water levels, and provides flood relief for the households of Calgarth Cottages on the A591. This work also included rebuilding the pipe network from Calgarth Cottages to further improve the drainage on the A591 and at the Cottages. Cumbria County Council also propose to carry out work on The Lakes School property to facilitate the occasional discharge of flow from the culvert overflow. Cumbria County Council have negotiated with The Lakes School and agreed to undertake some work to the school grounds drainage as part of the scheme to reduce flood risk in the area.

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 and South Lakeland District Council. The Troutbeck Bridge Flood Action Group (FLAG), led by Janet Chapman, have also provided information to Risk Management Authorities (RMA's) following the flood incident at partnership meetings hosted by the Environment Agency. Their input is greatly appreciated.

This report has been compiled by CH2M from the data collected by the Environment Agency. CH2M are a global civil engineering consultancy providing a full range of flood management consultancy services in the UK and overseas. CH2M's range of experienced specialists have provided input into understanding this event and producing recommendations for future flood management in Troutbeck 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. The 'near miss' flood event reported by the local community on 20th November provides further evidence of this.

From 4th to 7th 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, as illustrated in Table 2.

Rainfall Period	Storm Desmond			Previous Record		
	Date	Location	Total rainfall (mm)	Date	Location	Total rainfall (mm)
24 hour rainfall	December 2015	Honister Pass	341.4	November 2009	Seathwaite	316.4
48 hour rainfall	December 2015	Thirlmere	405.0	November 2009	Seathwaite	395.6

Table 2 - UK Rainfall Records

Holehird rain gauge is situated in the upper Bell Beck catchment, and records monthly rainfall totals. During December 2015, Holehird rain gauge recorded a record total of 685mm of rainfall, far exceeding the previous record monthly total of 493mm, recorded during November 2009. Table 3 below shows the record monthly totals recorded at the Holehird rain gauge.

Month	Rainfall Total
December 2015	685mm
November 2009	493mm
January 1928	476mm

Table 3 – Record monthly rainfall totals for Holehird rain gauge

Approximately 3.6km south east of the Holehird rain gauge is the Windermere Blackmoss daily read rain gauge. The Windermere Blackmoss rain gauge recorded a new record 24 hour rainfall total of 111mm on 5th December 2015, far exceeding the previous record gauging of 87mm from 25th October 2008. Table 4 below shows the record daily rainfall totals recorded at the Windermere Blackmoss rain gauge.

Date	Rainfall Total
5 th December 2015	111mm
25 th October 2008	87mm
5 th January 1999	78mm

Windermere Blackmoss is a daily read rain gauge, with 24 hour recordings taken for the 24 hour period from 9am to 9am.

Table 4 – Record rainfall totals for Windermere Blackmoss rain gauge

The location of the Holehird and Windermere Blackmoss rain gauges is shown in Figure 7.

The record breaking rainfall across Cumbria and the local river catchments described above caused exceptionally high river flows, resulting in widespread flooding. The level of Trout Beck peaked at 2.23m on the Calgarth river level gauge, situated downstream of where Bell Beck joins Trout Beck, at 18:15 on Saturday 5th December. The 2.23m peak level recorded at Calgarth gauging station exceeded the 2.09m record level previously set during the November 2009 event. As there is currently no river level gauge on Bell Beck, this provides the best available information relating to the timing of the peak flows on Trout Beck and Bell Beck during the flood event.

The location of Calgarth river level gauge is shown in Figure 7.



Figure 7 - Location of local rainfall and river level gauges

Table 5 shows the recorded data from the Calgarth gauging station.

Flooding Event	Number of Properties Flooded	Peak flow recorded at the Calgarth Gauge (m ³ /s)	Peak level recorded at the Calgarth Gauge (m)	Time of Recorded Peak on 5 th December
5 th December 2015	7	50.7	2.23	18:15

Table 5 – Gauged data from Calgarth gauging station on Trout Beck

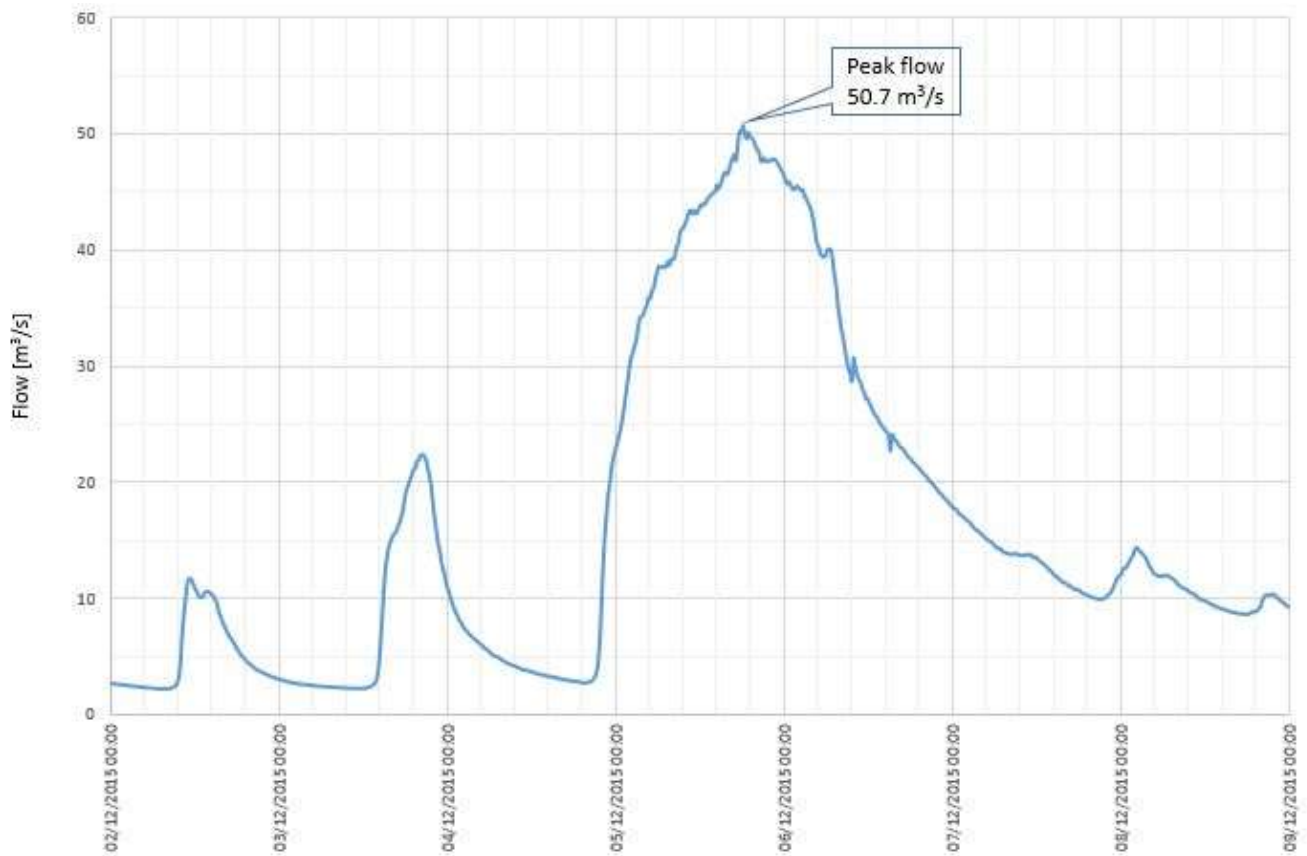


Figure 8 - Flow recorded on Trout Beck during the December flood event at Calgarth gauging station

Sources of Flooding, Flood Flow Routes and Event Timeline

There were a number of flood flow routes during the event. For investigation purposes, the flooded areas have been covered as one area covering Brook Street, Calgarth View, the A591, Broadfield and Calgarth Park, as shown in Figure 9.

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

Table 3 provides a summary timeline of the key events as the flooding affected Troutbeck Bridge.

4th December	Event
15:22	Flood Alert issued for the Brathay, Rothay & Winster catchments
5th December	Event
Late morning	Bell Beck overflowing and running down the side of Calgarth Cottages on Brook Street.
15:30	Trash screen on entrance to Bell Beck culvert completely submerged and blocked with rubble.
18:15	Water level in Trout Beck at the Calgarth gauging station peaks.
6th December	Event
09:00	Water still by-passing the Bell Beck culvert inlet and flowing down Brook Street.

Table 3 - Summary timeline of key events during the Troutbeck Bridge flooding

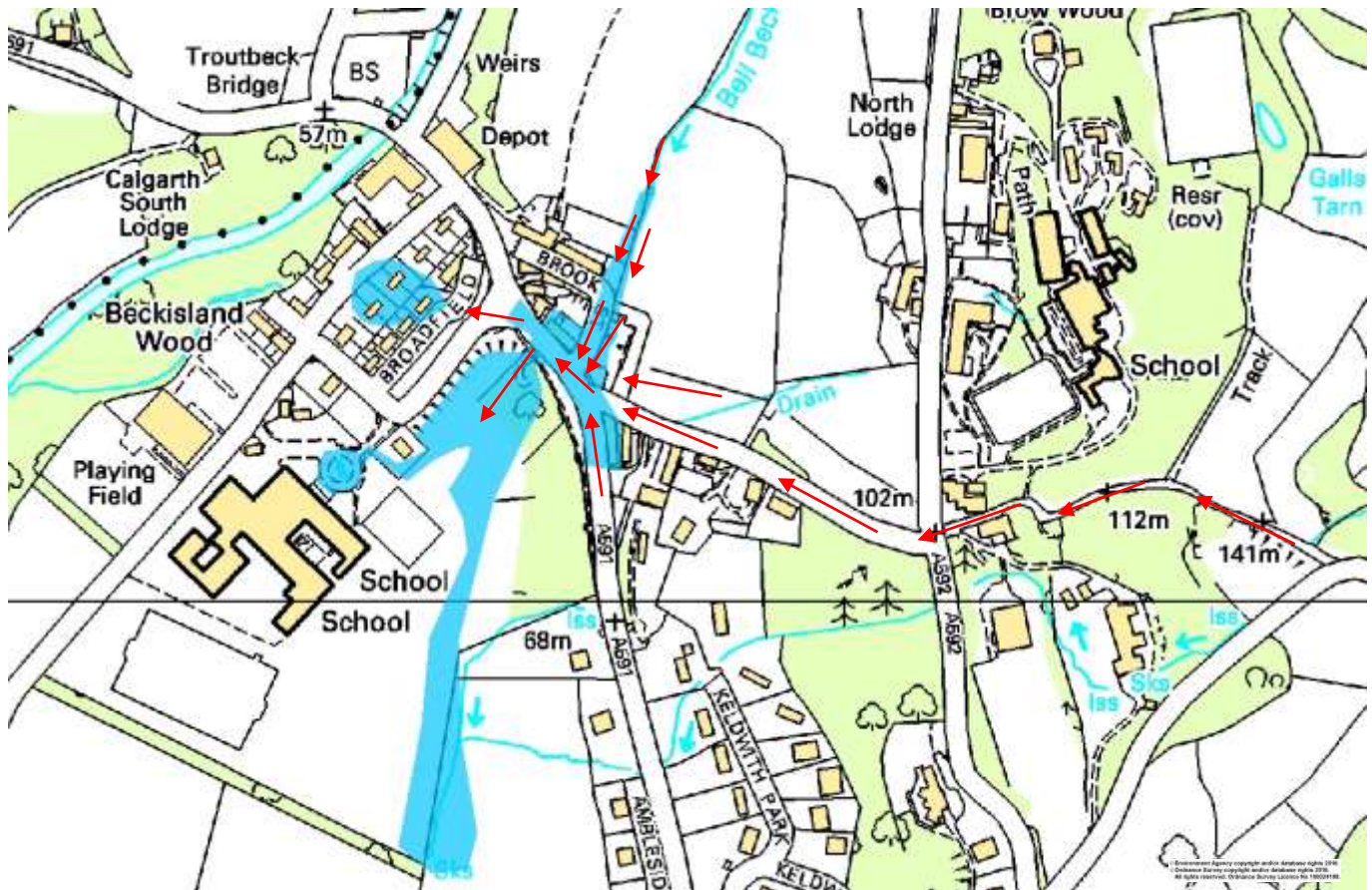


Figure 9 - Flood flow routes observed in Troutbeck Bridge during the flood event

Likely Causes of Flooding

Flooding from Bell Beck occurred when it overtopped its banks after becoming overwhelmed with high volume flows. At the location of the culvert inlet upstream of Brook Street (see Figure 10), the capacity of the culvert was exceeded by the sheer volume of water flowing down the hillside. Culvert capacity was reduced by large quantities of gravel and stone, mobilised from erosion in the open channel upstream of the culvert, which had been washed downstream into the Bell Beck culvert. Once the culvert capacity had been exceeded in the field upstream of Brook Street, water flowed down Brook Street and through the adjacent fields (Back Acre), towards the Pedro's car park and properties on Calgarth View.

Reports indicate that Calgarth Cottages were inundated to the rear by overland flow from the surcharging Bell Beck culvert and surface water flows. In addition, seepage through the Bell Beck culvert walls was reported at 7 Calgarth Cottages. Due to the ground levels in the rear yards of Calgarth Cottages, which vary between each property, flood levels at each property ranged from between 100mm to 700mm.



Figure 10 - Bell Beck, looking downstream towards Brook Street (17th December 2015)

There was a contribution to flooding from surface water run-off from the high ground in the upper Bell Beck catchment, which descends towards the A591 at Calgarth View. Local residents reported significant flows down Sun Lane, which is a steep access road that links the A591, from a junction next to Pedro's, to the A592 to the east. Flow down Sun Lane is likely to be from a combination of sources, including surface runoff from the upper catchment and also the highway drainage network not being able to cope with the huge volume of water.

A large contributor of flow down Sun Lane also appears to have originated from an ordinary watercourse, which enters culvert at the top of Rough Lane. Rough Lane is a steep access track to the east of the A592, situated directly opposite the junction of the A592 and Sun Lane. As such, the natural topography and location of Rough Lane and Sun Lane provide a flow route for water towards the A591 and properties in Troutbeck Bridge situated adjacent to the road. The culvert inlet at the top of Rough Lane appears to have been overwhelmed by the volume of water flowing in the ordinary watercourse from Howe Hill, with the resulting flow down Rough Lane causing significant damage to the access track as illustrated in Figure 11. In addition, investigations post-event indicated that the culvert inlet and culvert downstream of Rough Lane were blocked with debris, which will have reduced the ability of the culvert to convey flow during the flood event. The damage caused to the access track on Rough Lane gives an illustration of the volume and velocity of water flowing down the lane and onwards down Sun Lane towards Troutbeck Bridge during the flood event.



Figure 11 – Damage on Rough Lane, looking downstream towards the A592

Some of the flows from the catchment upstream of the A592 flow across the fields to the north of Sun Lane, and are channelled towards a culvert inlet upstream of Pedro's. The existing culvert pipe has a limited capacity, and evidence of debris around the trash screen post-event suggests that the inlet was partially blocked during the flood event (see Figure 12). Reports from local residents suggest that when this culvert reaches capacity, flow across the fields to the north of Sun Lane is directed in a westerly direction down Sun Lane, and towards Brook Street and Calgarth View.



Figure 12 – Culvert inlet and trash screen upstream of Pedro's

Flows from the upper catchments then converged on the A591 at Calgarth View, combining with flows from Bell Beck. Flows then travelled across the A591 towards Broadfield and The Lakes School. It is possible that the Broadfield area was also affected by flooding from surcharging (overflow) of the Bell Beck culvert that passes beneath it. No internal flooding of property was reported on Broadfield, with impacts limited to the flooding of gardens and water entering the cavity underneath some properties.

Local residents at Calgarth View reported that during the flood events in December water was backing up through toilets and utilities in houses, and that raw sewage was visible in the area during the flood events.

Calgarth Park retirement flats, situated to the west of Troutbeck Bridge village, were affected by groundwater flooding to the basement area, leading to the loss of heating and resulting in the evacuation of residents.

The Lakes School reported that flooding affected the school grounds during the flood incident, however no internal flooding to the school buildings was experienced.

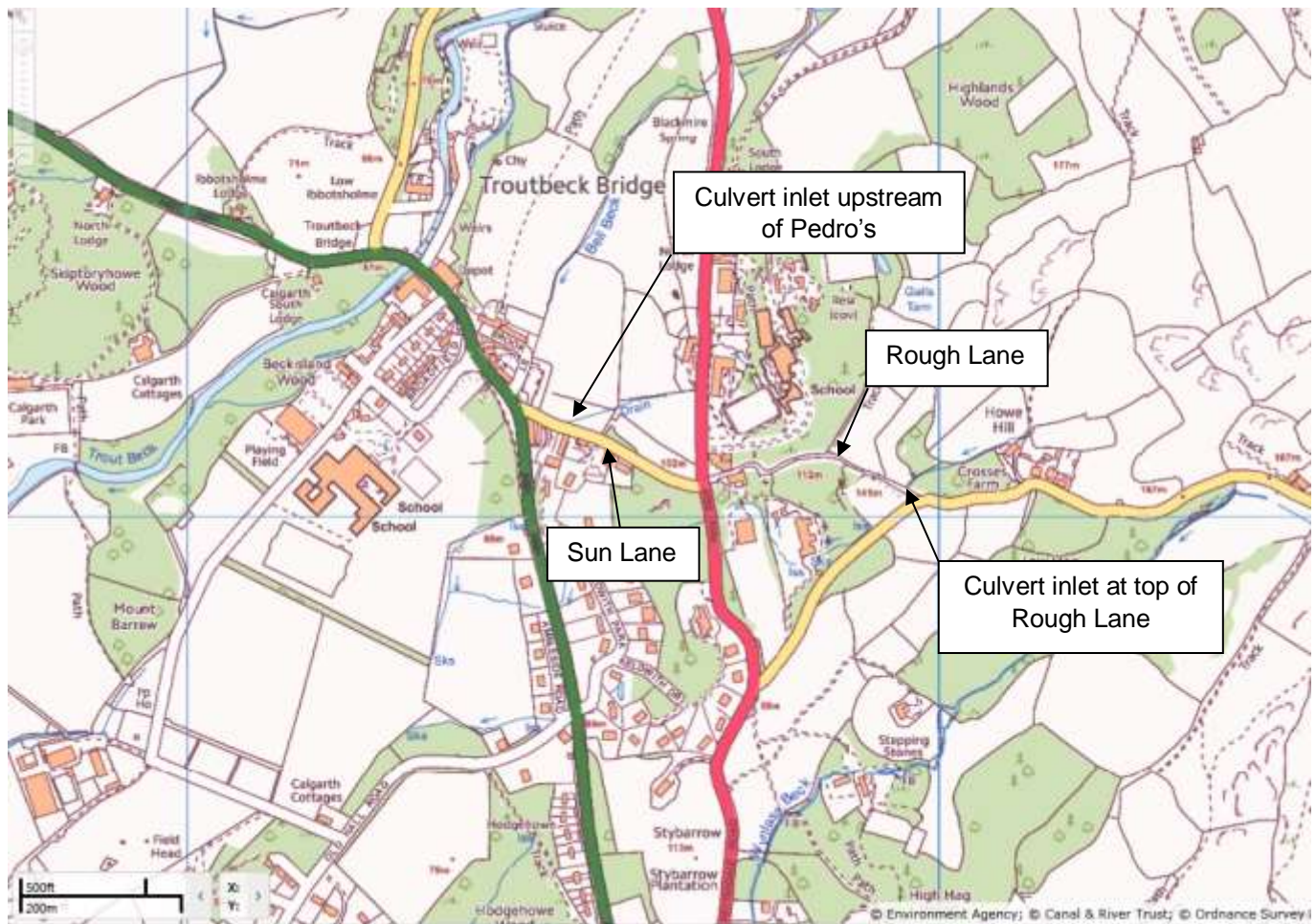


Figure 13 – Location of Rough Lane, Sun Lane and culvert inlet at top of Rough Lane

Although the overflow pipes from the Bell Beck culvert reportedly worked well during the flood event, resulting in lower water levels in some houses, the overflow is only able to operate to maximum capacity when Bell Beck is 'in culvert'. To maximise performance, the culvert inlet therefore needs to be clear. However, due to the steep nature of the Bell Beck watercourse and catchment, and the amount of material that is mobilised during flood events in the open channel upstream of the culvert inlet, it is inevitable that some blockages may occur, despite the Environment Agency's best efforts to keep the inlet trash screen clear.

Below is a summary of eyewitness comments:

5th December 2015, late morning

At inspection late morning, Bell Beck was overflowing and running down the side of the cottages on Brook Street. Water was also coming over and through the wall at the right hand side of the block of three garages with quite a force.

5th December 2015, 3.30pm

The trash screen on the culvert entrance upstream of Brook Street was completely submerged and blocked with rubble washed downstream. Water was flowing over and through the adjacent field and building up behind the wall at the rear of Back Acre, to approximately 230mm of the top of the wall. From here it was passing through a pedestrian access gate, but debris which had built up on it was restricting some of the flow. From the field it flowed towards the pub car park. Water quickly built up behind the wall adjacent to the garages; it was overtopping the wall as well as seeping through weak

points in the wall, until part of the wall collapsed causing a large volume of water to flow down the lane, causing further damage to the lane.

6th December 2015

At 9am water was still flowing with some force down the lane and over the wall adjacent to the garages. The drain cover at the corner of Calgarth Cottages, at the bottom of Brook Street where it meets the A591, was completely blocked with a thick layer of gravel. Local residents cleared this blockage, which allowed water flowing down the lane to enter the drain. The sandbag 'catcher' around the drain was already in place at the front corner of Calgarth Cottages prior to the flood event to help protect them.

At about lunch time local residents cleared the debris off the trash screen to the Bell Beck culvert. This allowed water to flow back into the culvert and the water that had been flowing down the lane and over the wall by the garage immediately stopped.

Environment Agency Flood Incident Response

Pre-event Warning and Preparation

The Environment Agency's response to the flood event on the 5th and 6th December 2015 started well in advance of the event. This response included provision of sand bags and clearing the Bell Beck culvert inlet ahead of the forecast heavy rainfall.

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.

The Environment Agency issued a Flood Alert for the Rivers Brathay, Rothay and Winster catchments on Friday 4th December at 15:22. A Flood Alert provides advance notice of possible flooding to low lying land and roads, and also acts as an early notification that river levels are expected to rise and that the Environment Agency are monitoring the situation closely. There are currently no Flood Warning Areas for Troutbeck Bridge, so during the December flood event the Environment Agency updated the Flood Alert daily with relevant information. Further details of the Flood Alert issued can be found in Appendix 4.

Post-event Repairs and Maintenance

Following the flood event, the Environment Agency removed approximately 30 tonnes of gravel from the Bell Beck culvert as part of emergency recovery works. Following this, CCTV survey was undertaken to identify further remaining material within the culvert, which was subsequently removed in June 2016. Following the removal of this material, a further detailed CCTV survey of the Bell Beck culvert was undertaken to fully assess the condition of the culvert.

The CCTV culvert survey identified that the culvert section from the inlet to the manhole upstream of the A591 (adjacent to 7 Calgarth Cottages) was in poor condition. As well as being in poor condition, the existing culvert along Brook Street is extremely difficult to maintain, and is prone to blockages, all of which causes an increase in flood risk to the local community and places an ongoing financial burden on the Environment Agency to maintain the free flow of water through the culvert. As a result of the poor condition of the culvert, the Environment Agency have secured funding through their Asset Recovery Programme to return the culvert to a serviceable standard. Undertaking the proposed culvert replacement and associated works will deliver a more sustainable solution to manage flood risk going forward, and will greatly reduce the risk of blockage or collapse of the culvert.

The Environment Agency submitted a planning application for the replacement of the section of Bell Beck culvert and associated works in January 2017. A consultation meeting with the local community on the proposals is due to be held at The Lakes School in Troutbeck Bridge on 9th February 2017.

In addition to the above proposals, Cumbria County Council, working in partnership with the Environment Agency and South Lakeland District Council, have developed proposals for a low level wall to the front of Calgarth Cottages. The low level wall would provide additional flood protection to the properties, which would be of great benefit given the local flood mechanisms described in this report. These proposals would also incorporate the formalising of the sandbag 'catcher' around the manhole adjacent to 7 Calgarth Cottages. The local community will also be consulted on these proposals at the 9th February meeting.

On-going 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 deliver targeted maintenance on river channels where the activity is beneficial to the reduction in flood risk. This could include:
 - Weed Control
 - Grass Control
 - Vegetation Management
 - Invasive Non-Native Species Control
 - Gravel Removal, when justified through investigation and survey

Recommended Actions

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

Cumbria Flood Partnership Theme	Action by	Recommended Action	Timescale
Resilience	Cumbria Local Resilience Forum*	Review and update plans to enable homes and businesses to be better prepared for flooding and reduce the impacts of flooding. For example, review of evacuation procedures / emergency response.	2016 - Ongoing
	Local Community and Environment Agency	Work with the Troutbeck Bridge Flood Action Group to complete an emergency plan. Continue to work with all communities to establish a network of Action Groups to share learning and best practice.	2016 – EA continue to work with the local community to plan and prepare for future incidents.
	Residents and South Lakeland District Council	Implement flood resilience measures within flooded properties to reduce the impacts of future flooding. South Lakeland District Council is administering the Flood Recovery and Resilience Grants of up to £5000 per property to help people better protect their homes. A further £2000 top up grant can also be applied for from the Cumbria Flood Recovery Fund.	Closing date for grant applications is end of March 2017
	Lake District National Park Authority, Cumbria County Council and Environment Agency	Review Local Development Plans and Strategic Flood Risk Assessment to reflect current understanding of flooding.	2016 complete
	Cumbria County Council, United Utilities, Environment Agency and Electricity North West.	Review the resilience of critical transport, utility and power supply infrastructure in relation to flood risk.	2016-2017

Cumbria Flood Partnership Theme	Action by	Recommended Action	Timescale
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.	Action Plan published Summer 2016
Maintenance	Environment Agency, United Utilities and Cumbria County Council	Carry out inspections and repairs to assets which may have been damaged during the flood event. In particular, undertake repairs to the damaged Bell Beck culvert and remove deposited material from the Bell Beck culvert.	EA completed Bell Beck culvert clearance summer 2016. Local community to be consulted on Bell Beck culvert replacement works Feb 2017.
	Environment Agency	Review the gravel and channel maintenance programme within the catchment in response to the flooding event of 2015.	2016-2017
	Environment Agency	A new Environment Agency system is being developed to make it easier for communities to understand what maintenance work is being carried out in their area. Improvements will show exactly when, where and what maintenance is being planned each year. Make sure that communities understand how they can access information on planned maintenance at: https://www.gov.uk/government/publications/river-andcoastal-maintenance-programme	2017
Strengthening Defences	Cumbria County Council, South Lakeland District Council and United Utilities	Review the performance of the existing drainage and sewerage systems during the event to better understand where improvements are required.	2016-2017
	Environment Agency in partnership with Cumbria County Council and South Lakeland District Council	Undertake an appraisal of possible flood risk management options to improve the existing Standard of Protection in Troutbeck Bridge. Defence options to be appraised include; replacement of the Bell Beck culvert, flow routing measures to direct flow away from properties, upstream storage and raised defences such as raised walls.	2016-2017. The community are being consulted on a range of options to provide an improved level of flood protection.

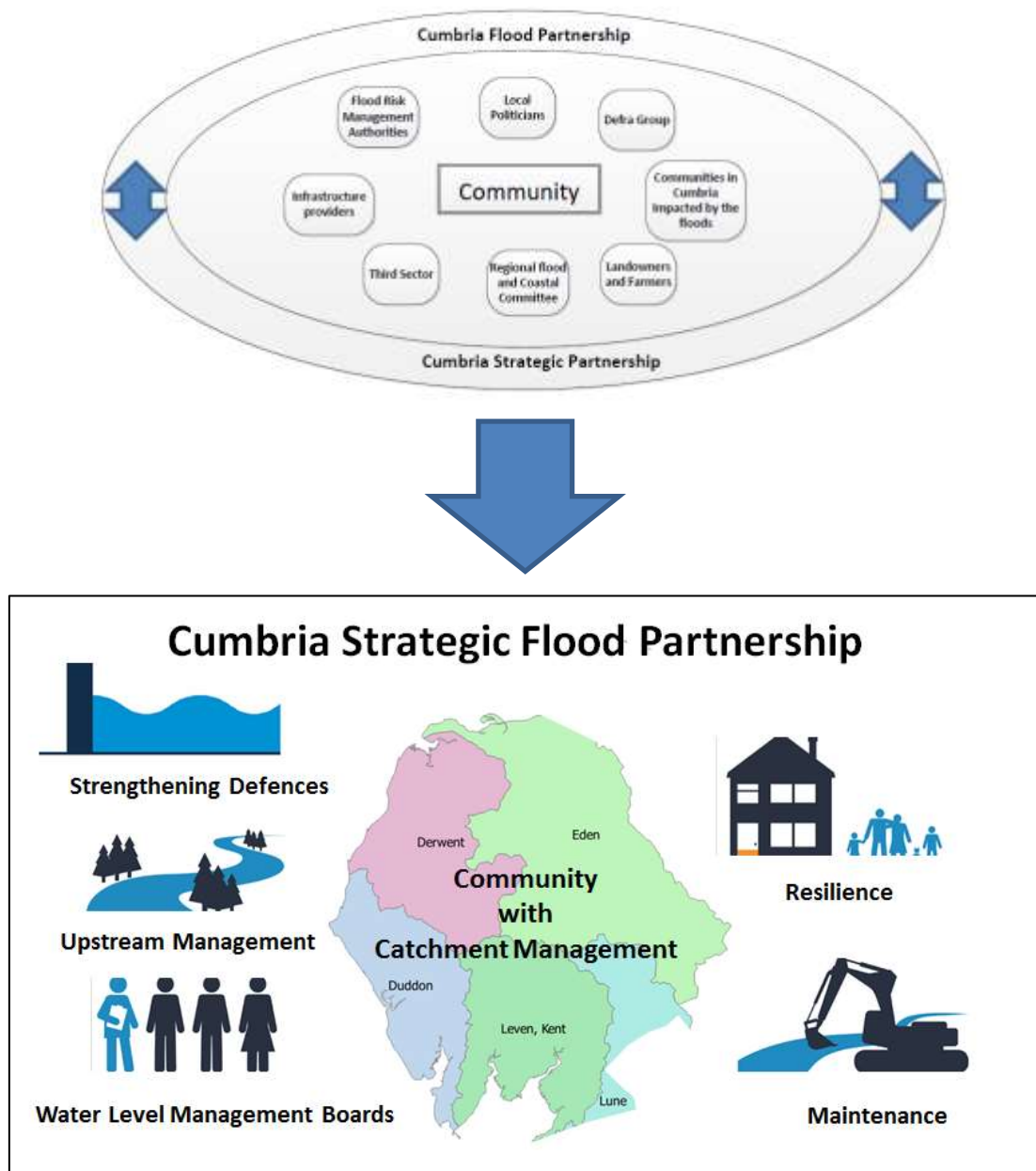
Table 4: Recommended actions for consideration

* 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

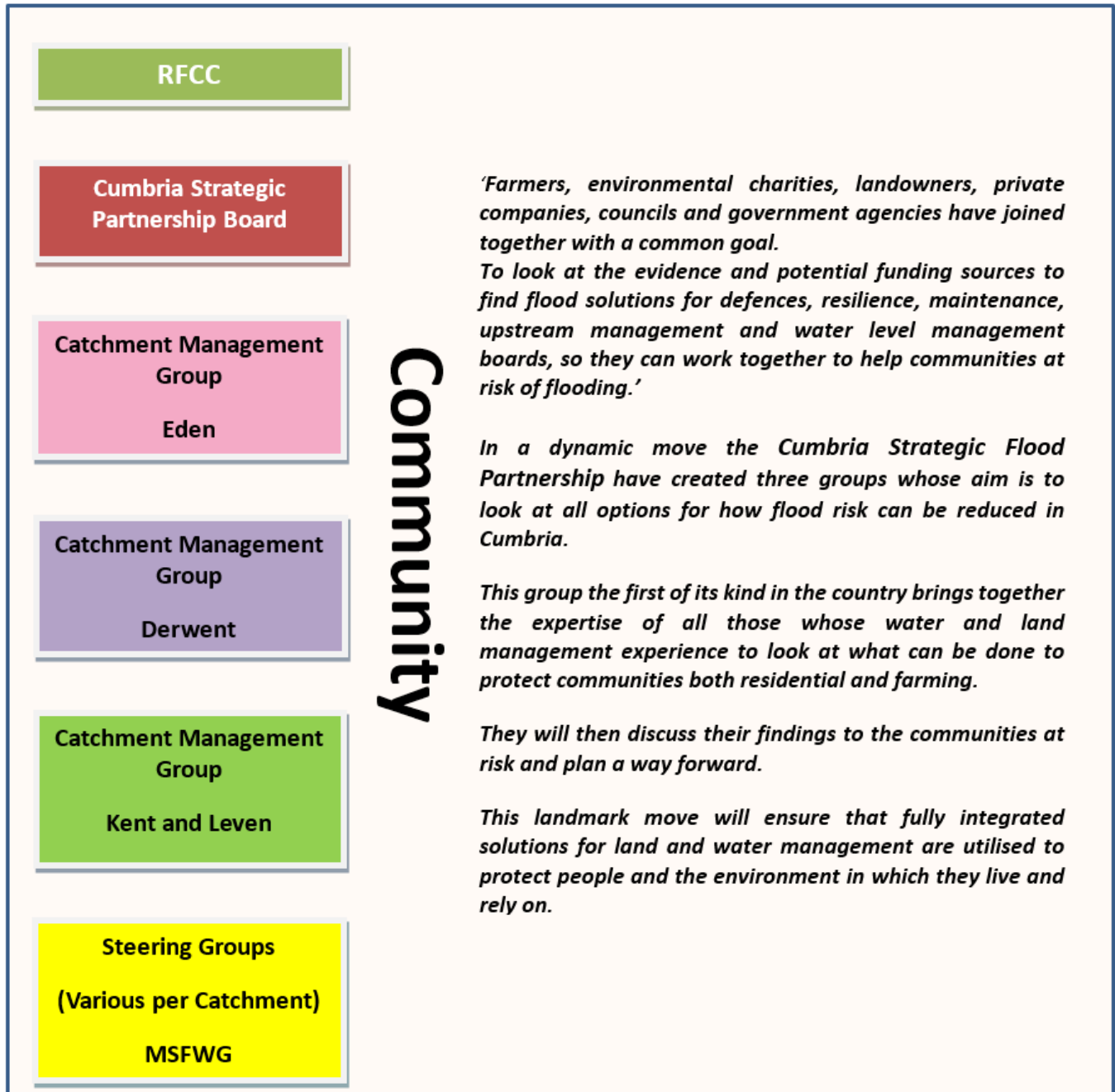
The Cumbria Floods Partnership has brought together a wide range of community representatives and stakeholders from a variety of sectors to plan and take action to reduce flood risk. The Cumbria Floods Partnership, led by the Environment Agency, is producing a 25 year flood action plan for the Cumbrian 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 help demonstrate how the two partnerships have now come together:





Cumbria Strategic Flood Partnership



Appendices

Appendix 1: Acronyms and Glossary

Acronym	Definition
EA	Environment Agency
CCC	Cumbria County Council
SLDC	South Lakeland District Council
LLFA	Lead Local Flood Authority
FLAG	Flood Action Group
LFRMT	Local Flood Risk Management Team
FWMA	Flood and Water Management Act 2010
LDA	Land Drainage Act 1991
WRA	Water Resources Act 1991
UU	United Utilities

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Appendix 3: Links to Other Information on Flooding

Sign up for Flood Warnings

<https://www.gov.uk/sign-up-for-flood-warnings>

Environment Agency – Prepare your property for flooding; a guide for householders and small businesses to prepare for floods

<https://www.gov.uk/government/publications/prepare-your-property-for-flooding>

Environment Agency – What to do before, during and after a flood: Practical advice on what to do to protect you and your property

<https://www.gov.uk/government/publications/flooding-what-to-do-before-during-and-after-a-flood>

Environment Agency – Living on the Edge: A guide of 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

011WAFBR - Rivers Brathay, Rothay and Winster.

Alert issued on Friday 04/12/2015 at 15:22

Alert removed on Tuesday 06/01/2016 at 10:48

Customers in Flood Alert area registered on FWD: 98

Contacts (landline, mobile, email etc) in Flood Alert area registered on FWD: 303

Successful contacts: 267

Unsuccessful contacts: 36

Alert Message:

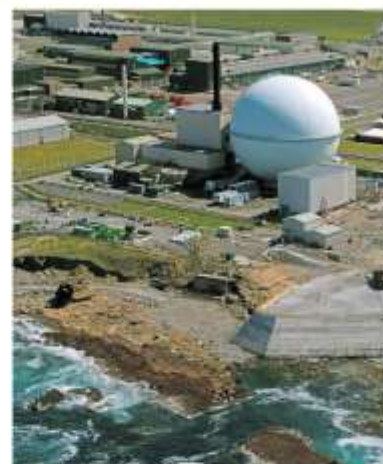
A Flood Alert has been issued by the Environment Agency for the Rivers Brathay, Rothay and Winster. Flooding is possible for Rivers Brathay, Rothay and Winster. Low lying land and roads will be affected first. Be prepared to protect yourself, family, pets and property.

Heavy and persistent rainfall along with strong South-Westerly winds are forecast to continue this evening (Friday 04/12/2015) through until Sunday (06/12/2015). With the ground already saturated the river and lake levels are expected to rise further and we may see some significant impacts. Newby Bridge Sluices remain open (opened 9th November). The forecast is likely to result in Flood Warnings being issued on Saturday (05/12/2015). We advise that you keep an eye on the situation by listening to weather forecasts, checking our web pages or calling Floodline. We are continuing to monitor the situation and have workers on site operating defences and clearing blockages where required.

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

CH2MHILL.

Key Projects in the UK



We partner with your industry

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

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

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

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

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

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Urban Programmes

Key endorsements:

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

– John Armitt, ODA Chairman

"The ODA did a fantastic job in delivering the Olympic venues and infrastructure on time and within budget. They did our nation proud."

– Margaret Hodge MP, Chair of the Public Accounts Select Committee



London 2012 Olympic and Paralympic Games

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

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



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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 £14.88bn rail link will boost London's rail-based network capacity by ten percent—transporting 200 million passengers annually, bolster the capital's position as a world-leading financial center, and significantly reduce journey times across the city.



High Speed 2 (HS2)



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

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

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

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

We provide services for your success

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



Water Resources-Ecosystem Management Services

Flood Risk Management

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

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

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

Sub-technologies

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

Flood mapping and appraisal

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

Capital works delivery

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

O&M and asset management (AM)

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

Challenges, Trends, Opportunities

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

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

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

Did You Know?

- A review by the Organization for Economic Cooperation and Development on 136 coastal cities found that the estimated damage from sea level rise, storm surge and subsidence for 1 in 100 year flood event in 2070 was estimated at \$35,000 billion.
- In 2070 it is estimated that over 150 million people will live in these 136 coastal cities at risk.
- River flooding is the most common type of flood event.
- Floods are the number one natural disaster in the US, and just a few inches of water from a flood can cause tens of thousands of dollars in damage.
- The flooding in Alberta, Canada in 2013 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.