

Glenridding

Flood Investigation Report



Glenridding Village Centre, 6th December

Flood Events 5th-6th, 9th-10th and 21st-22nd 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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Executive Summary

Glenridding experienced flooding on three separate occasions in December 2015. These events were on the 5th, 9th and 21st of December with several properties affected by all three events. Flooding during the first event resulted from the effects of Storm Desmond. Further heavy rainfall continued over the following weeks resulting in two further flooding events. Storm Desmond caused a period of prolonged, intense, rainfall across Northern England, falling on an already saturated catchment, causing substantial surface water runoff and subsequent river flows in Glenridding Beck.

The intense rainfall caused significant erosion and landslips on the steep-sided valley, washing very large quantities of rock, gravel and vegetation into the beck. This material was transported by flood flows in the beck, causing additional erosion to the channel banks and depositing substantial quantities of rock and gravel throughout the beck channel and in flooded areas. This action had the effect of exacerbating the out of channel flows leading to the flooding of businesses and properties along the banks of Glenridding Beck.

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 Glenridding between the 5th and 22nd of December, and has referred to a range of data collected from affected residents, site visits, surveys of the area, and data collected by observers during the flood events.

There are no formal flood defences within Glenridding, although regular inspection and removal of gravel from Glenridding Beck forms part of the flood management strategy for the village. Following the extreme rainfall in December 2015, gravel removal has taken place throughout the channel and in excess of 20,000 tonnes of material have been removed.

Fifteen properties were affected by the first flood event. The second and third events affected fewer properties and were largely caused by the material deposited during the first event increasing peak water levels. The flooding also caused significant disruption to utilities and transport infrastructure.

This report details the flooding that occurred within Glenridding, both from Glenridding Beck and from surface water runoff. It identifies the flow routes and the causes of the flooding as well as the impact of this flooding.

Eight 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. The construction of a flood defence wall within Glenridding Village Centre is currently underway and is expected to be completed in autumn 2016.

In response to the flooding, a number of community meetings have taken place, and these will continue in order to ensure that those affected are given the opportunity to be involved in reducing the flood risk to 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. Any additional information should be provided to;

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

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Introduction

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

- (1) *On becoming aware of a flood in its area, a lead local flood authority must, to the extent that it considers it necessary or appropriate, investigate:*
 - (a) *which risk management authorities have relevant flood risk management functions, and*
 - (b) *whether each of those risk management authorities has exercised, or is proposing to exercise, those functions in response to the flood.*
- (2) *Where an authority carries out an investigation under subsection (1) it must —*
 - (a) *publish the results of its investigation, and*
 - (b) *notify any relevant risk management authorities.*

This section of the Act leaves the determination of the 'extent' of flood investigation to the LLFA. It is not practical or realistic for Cumbria County Council to carry out a detailed investigation into every flood incident that occurs in the County, but every incident with basic details will be recorded by the LLFA.

Only those with 5 or more properties/businesses involved will have investigations published. An investigation will be carried out, and a report prepared and published by the LLFA when the flooding impacts meet the following criteria:

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

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

Scope of this report

This Flood Investigation Report **is**:

- An investigation on the what, when, why, and how the flooding took place resulting from the December 2015 flooding events.
- A means of identifying potential recommendations for actions to minimise the risk or impact of future flooding.

This Flood Investigation Report **does not**:

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

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

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

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

To provide feedback on the report please email LFRM@cumbria.gov.uk and include the report number

Flooding History

Glenridding Beck runs through the centre of Glenridding Village. As such, the village has some history of flooding, including severe floods following heavy rainfall in November 2009.

The catchment for Glenridding Beck rises to over 900 metres with steep slopes resulting in rapid run-off. The mountainous catchment has high rainfall and this results in flash flooding in the village.

There are numerous recorded instances of flooding in Glenridding attributed to Glenridding Beck. Flooding often occurs due to blockage of bridges across the watercourse. More recent flash flooding occurred in November 2009 when 11 properties flooded and on 8th January 2005 when a few properties flooded. Flooding to the village also occurred on 7th February 1997. These events were due to surcharging of the Glenridding Beck and large volumes of runoff from the surrounding fells following periods of prolonged intense rainfall.

The November 2009 event was estimated to be an event with a rarity greater than 0.2% Annual Exceedance Probability (AEP)*. The AEP describes the likelihood of a specified flow rate (or volume of water with specified duration) being exceeded in a given year. There are several ways to express AEP as shown in Table 1. Throughout this report AEP is expressed as a percentage. As such an event having a 1 in 100 chance of occurring in any single year will be described as a 1% AEP event.

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

Table 1-Probabilities of Exceedance

* Estimate taken from CEH briefing note <http://nora.nerc.ac.uk/s510223/1/Nov09Floods-CEH-briefing-note.pdf>

Event background

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

Flooding Incident

Glenridding is a village located within the Lake District National Park with a total population of approximately 450. The village lies above the south west shores of Ullswater, the second largest lake within the Lake District. Glenridding is a popular destination for tourists and is surrounded by mountains including Helvellyn to the west. Glenridding Beck flows through the centre of the village into Ullswater from the mountains west of the village.

Figure 1 shows the location of Glenridding. **Figure 2** shows the route of Glenridding Beck and other watercourses in the area.

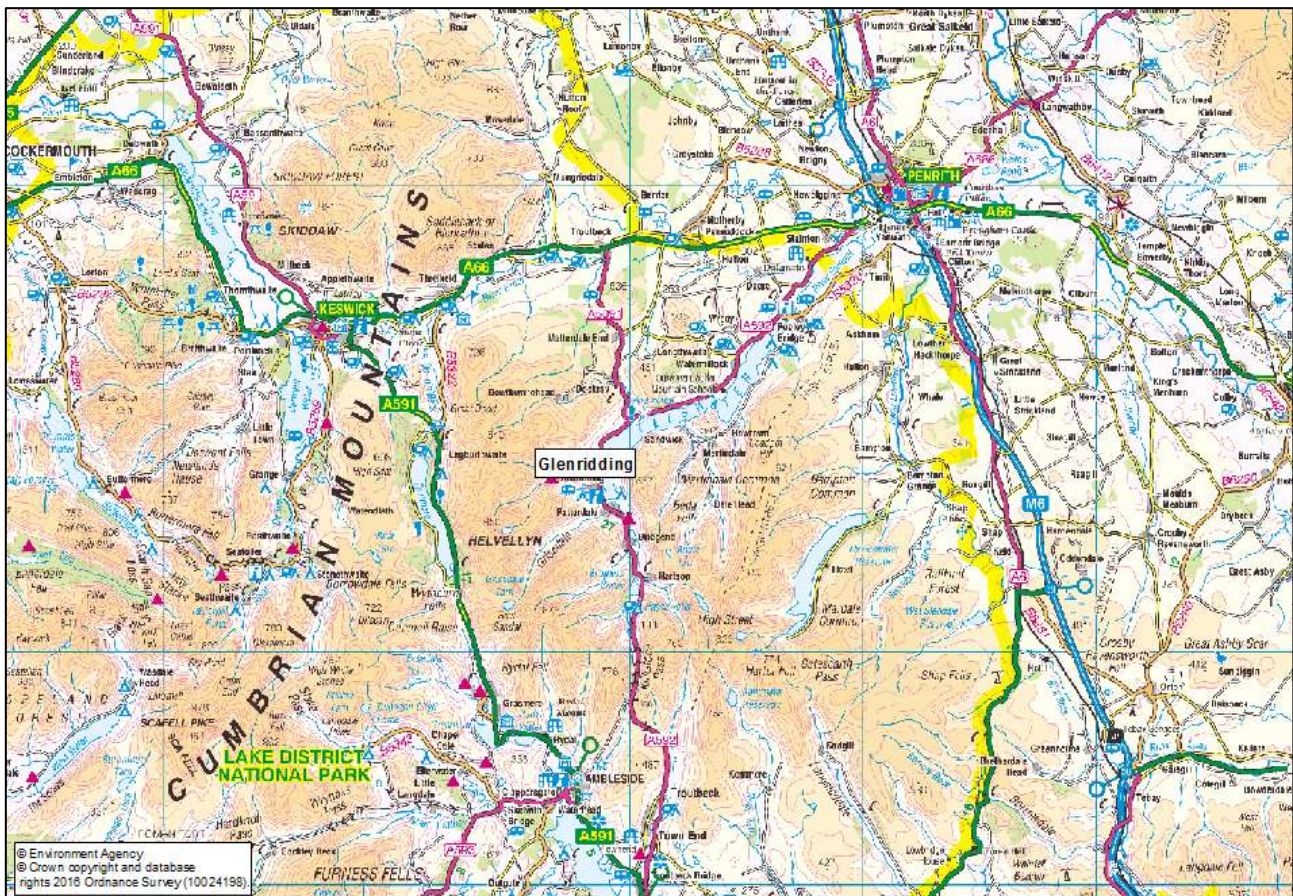


Figure 1-Location of Glenridding within the Lake District National Park



Figure 2-Location of watercourses and water bodies within the catchment

Glenridding experienced flooding on three separate occasions in December 2015. These events were on the 5th, 9th and 21st of December with several properties affected by all three events. On the 5th and 6th December 2015, 15 properties suffered flooding. This flooding can be attributed to a record-breaking rainfall event from Storm Desmond. This was the most severe of the three flooding events and the extent of this is shown in **Figure 3**. This event led to significant deposits of gravel within the village and the channel of Glenridding Beck.

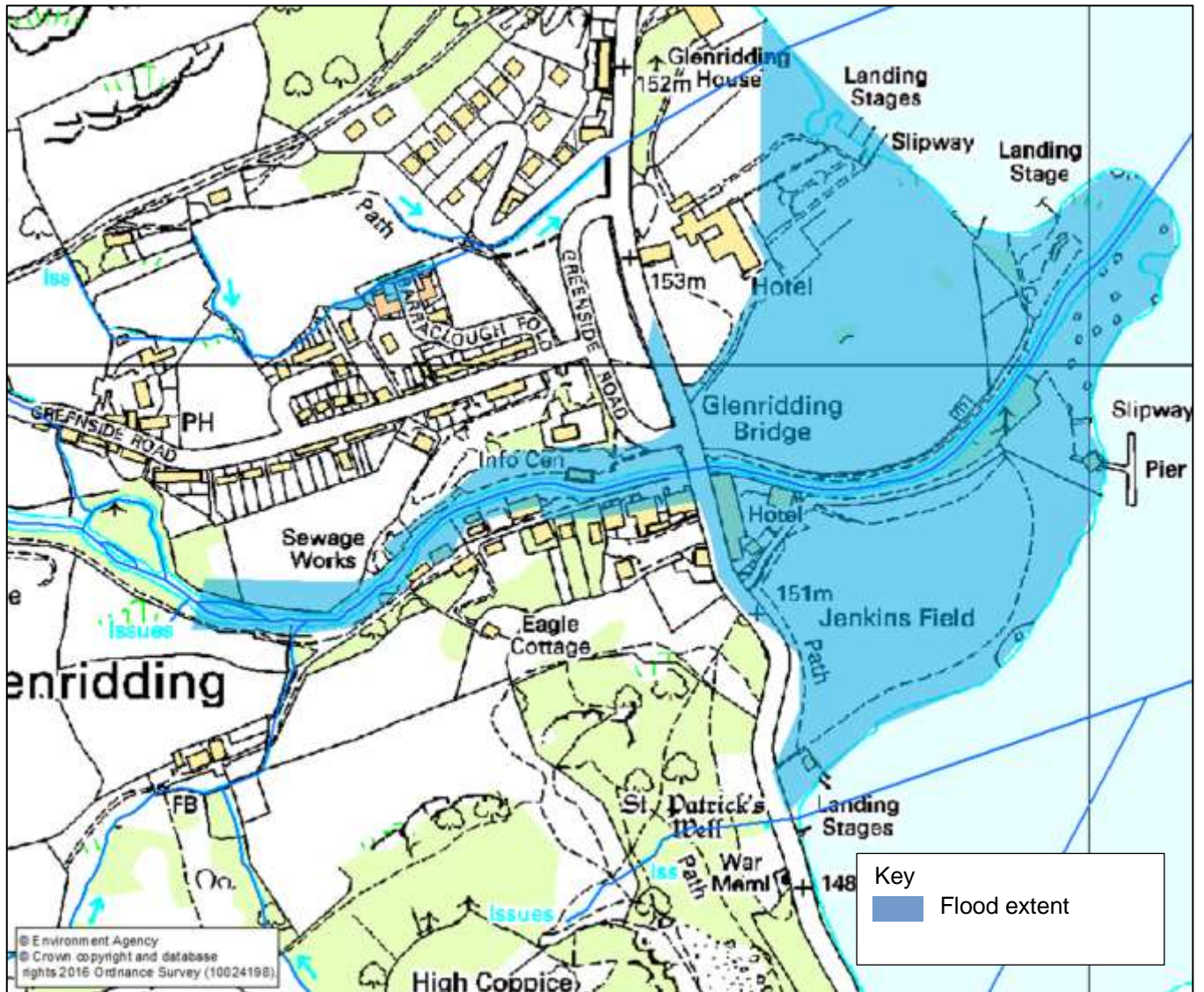


Figure 3-Extent of Flooding* in Glenridding on 5-6th December 2015

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

For this report the flooded area has been divided into 3 sub-areas for investigation. These are shown in **Figure 4**.

- **Village Centre** – The area of the village along Glenridding Beck upstream of Glenridding Bridge.
- **Glenridding Hotel** – The area downstream of Glenridding Bridge, including Glenridding Hotel which was flooded in all three of the December flood events.
- **Barraclough Fold** – A street north of the Village Centre where properties were flooded from surface water.

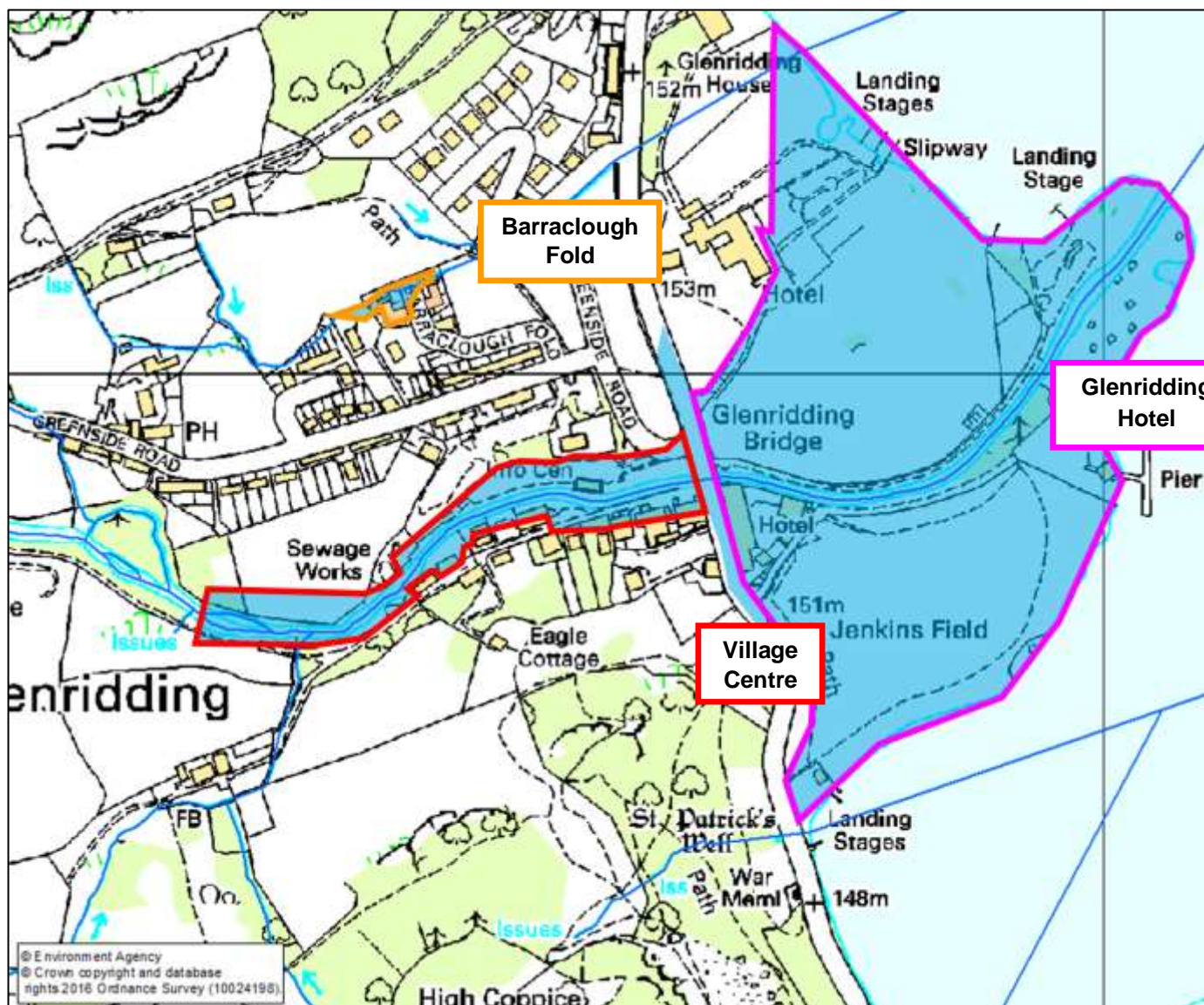


Figure 4-Identification of Flood Sub-areas

Current Flood Risk Management

There are no raised flood defences within Glenridding.

Gravel monitoring and dredging of the channel are undertaken by the Environment Agency in order to manage the risk of flooding from Glenridding Beck. The beck is regularly inspected. When gravel within the channel accumulates to a level where it would cause an increase in flood risk to the village, the gravel is removed.

Gravel removal took place in 2009, 2010 and 2012. The channel was also inspected in April 2015. The level of gravel at this time was identified as being below the pre-determined trigger for removal.

Investigation

This section provides details of the rainfall event and the likely causes of flooding.

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.

Rainfall Event

December 2015 was the wettest calendar month on record for the UK, with much of northern England receiving double the average rainfall for December. This also followed a particularly wet November and as such, much of the ground within the Cumbria catchments was already saturated. Further rainfall could not be absorbed and led to high levels of surface water runoff.

From the 4th to 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. Records for the Ullswater catchment can be seen in **Table 2**. The location of these rain gauges can be seen in **Figure 5**.

Glenridding was affected by the extreme rainfall attributed to Storm Desmond from the 4th to 7th of December causing the first flooding event. The catchment continued to experience heavy rain throughout December, causing the second and third events. However, the rainfall causing these events was less severe than the rainfall from Storm Desmond.

	Previous record			Date	December 2015 Event	
	Date	Location	mm		Location	mm
24hr rainfall	19 th Nov 09	Brotherswater	153.4	5 th Dec 15	Brotherswater	245
		High Row	113.8		High Row	148
48hr rainfall	18 th -19 th Nov 09	Brotherswater	245	4 th -5 th Dec 15	Brotherswater	372
		High Row	171.2		High Row	216

Table 2-Rainfall Records

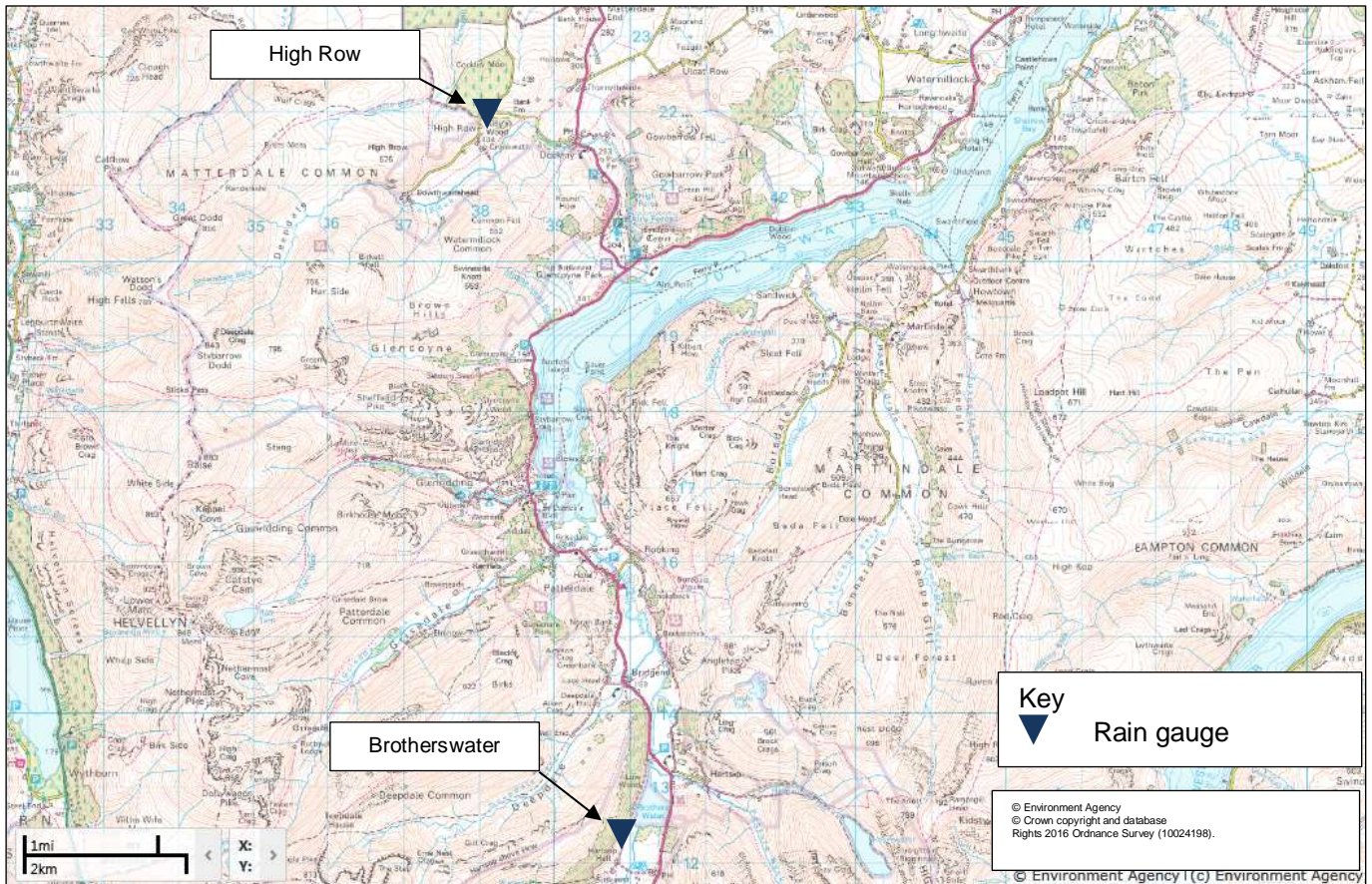


Figure 5-Location of rain gauges

Flooding Flow Routes

There were a number of flood flow routes during the events. For investigation purposes, the flooded areas have been divided into the three sub areas shown in **Figure 4**. The flood flow routes, which were observed to be similar for all three events, are shown in **Figure 6**.

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

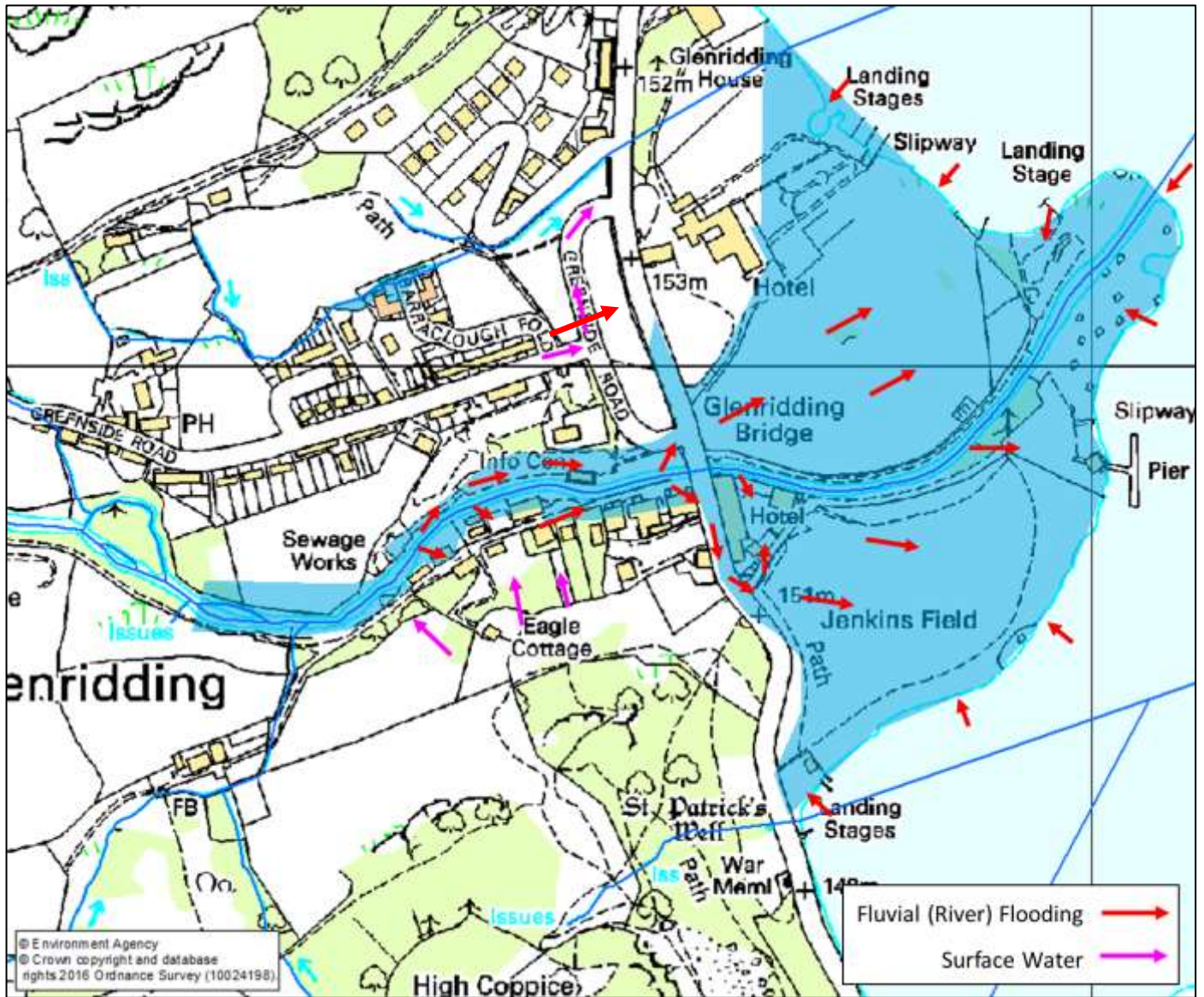


Figure 6-Flood Flow Routes in Glenridding

Impacts and Likely Causes of Flooding

Timeline

Table 3 below shows the times of key events during the Cockermouth flooding in December 2015.

3 rd December	Event
1929	Flood Alert Issued
4 th December	Event
1514	Flood Alert Issued
5 th December	Event
1700	A592 inaccessible due to flooding north and south of Glenridding.
2000	<i>1st Flood Event</i> Glenridding Beck overtops its banks flooding the Village Centre and Glenridding Hotel.
TBC	Properties on Barraclough Fold flooded.
6 th December	Event
0700	A592 accessible from south.
1700	Loss of landline telephones due to collapse of Pooley Bridge.
7 th December	Event
1000	Residents begin debris and gravel removal from Glenridding Beck in the vicinity of the A592 bridge.
1400	Contractor arrives on site and begins to remove gravel and dredge the channel near Village Centre .
TBC	Village water supply cut off due to failure of pumps at Haweswater
8 th December	Event
1500	A592 accessible from the north.
2200	Landline telephone connection restored.
	Estimated 2,000 tonnes of debris removed from river channel between first flooding event and 8 th December.
9 th December	Event
	Dredging of channel stopped due to danger from rising water levels.
1900	<i>2nd Flood Event</i> Glenridding Beck overtops its banks flooding the Village Centre and Glenridding Hotel.
10 th December	Event
1600	Mobile phone coverage restored.
	Dredging of channel resumes.
	Village water supply restored.
21 st December	Event
	<i>3rd Flood Event</i> Flooding to Glenridding Hotel.

Table 3-Flood Incident Timeline

In total, during the three flood events of December 2015, 15 properties were affected by flooding, 6 residential properties and 9 commercial properties. The first event, which began on 5th December, was caused by extreme rainfall as a result of Storm Desmond. This event caused a number of landslips upstream of Glenridding and led to a large quantity of material being deposited within the channel reducing its capacity. All 15 properties were flooded during the Storm Desmond event directly from Glenridding Beck, and/or from surface water flow and overflowing drainage systems.

The village was then flooded four days later on 9th December due to heavy rainfall on the fells, with this rainfall having a greater impact because of the reduced capacity of the channel. The village centre and Glenridding Hotel were flooded from Glenridding Beck. Residents reported that this flooding was to a greater depth than the flooding on the 5th of December.

There was further heavy rain on the 21st of December leading to a third flood event on Glenridding Beck. This event was less severe; partly due to the removal of debris that took place following the second event. The Glenridding Hotel was flooded for a third time.

All three flood events led to large deposits of gravel and debris within the channel. This was caused by landslips in the steep slopes upstream of the village following heavy rain. This debris reduced the capacity of the channel and in particular reduced the clearance under Glenridding Bridge. **Figure 7** shows Glenridding Bridge on 10th December following the second flood event. **Figure 8** shows removal of gravel and blockages on 11th December.

The material deposited in the channel was a contributing factor as to the cause of the second event. Due to the high rainfall prior to the first flood event, a large amount of material was transported downstream from land slips further up the catchment, leading to a rapid build-up of gravel.

Following all three flood events gravel removal took place within the river. More details of this are provided in the 'Environment Agency Flood Incident Response' section of this report.

The flooding caused damage and disruption to Glenridding and the surrounding area, with the main road (A592) flooded during the event. Floodwater, debris, and damage to the road caused this route to be closed for a number of days which left the village isolated.

The water supply to Glenridding was cut off following the flooding. This was due to a damaged United Utilities pumping station at Haweswater. This meant that bottled water had to be supplied to the village by the army. Telephone coverage to the village was also affected with the landline connection lost due to the collapse of Pooley Bridge at the northern end of Ullswater. Mobile phone signal was lost due to power outage to the Vodafone mast located at the flooded Glenridding Hotel.



Figure 7-Glenridding Bridge 10th December 10:49



**Figure 8-Gravel removal and blockage removal,
Glenridding Bridge 11th December 14:47**

There was erosion and landslips along the length of Glenridding Beck upstream of the village. **Figure 9** shows an example of this erosion. The erosion and slope failures led to gravel and fallen trees being deposited in the watercourse. Footpaths and properties close to the river were also damaged. These landslips were the source of both gravel and woody debris within the river.



Figure 9-Bank erosion upstream of Glenridding. Date Taken XX/12/2015

Village Centre

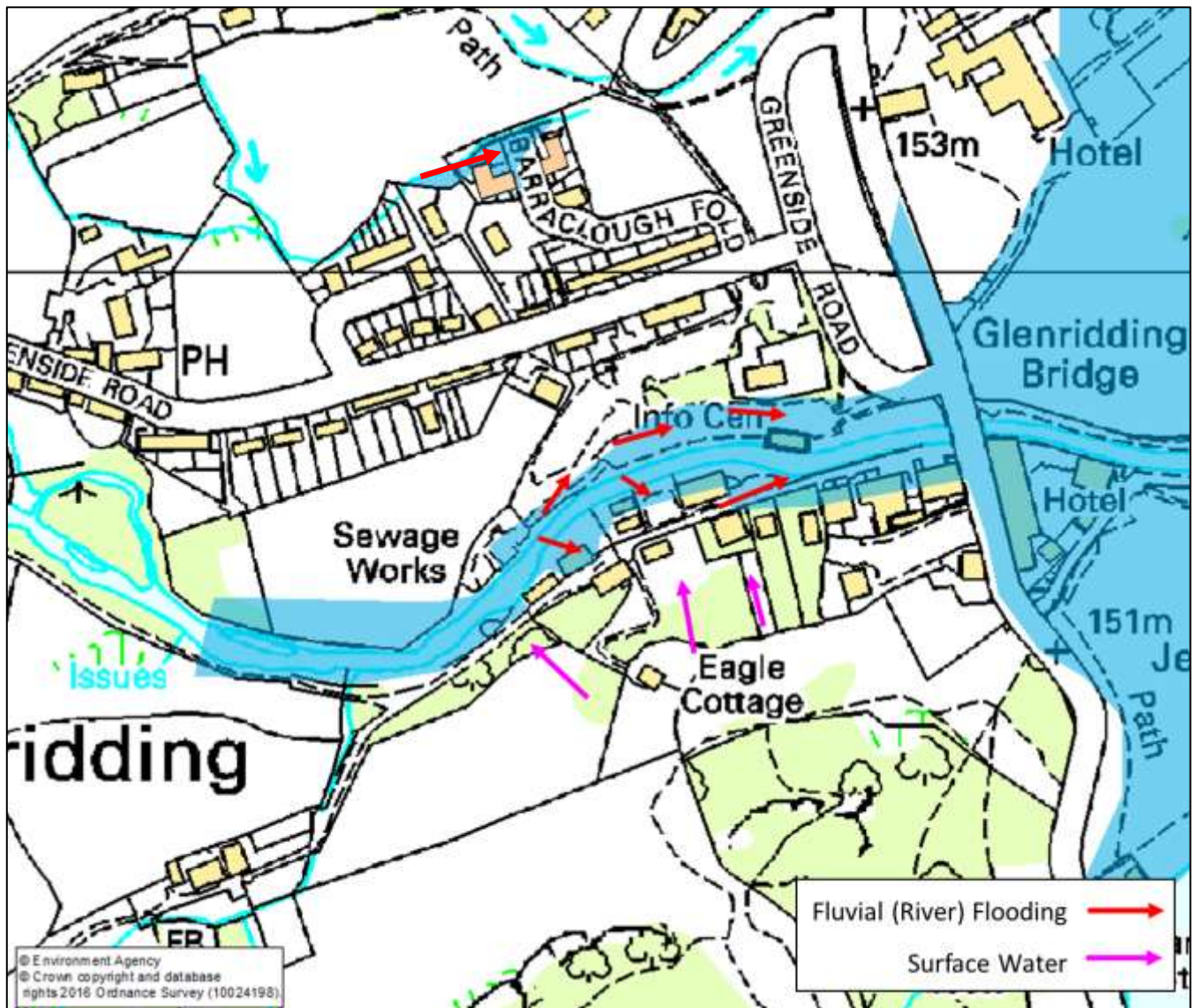


Figure 10-Flood Flow Routes in Glenridding Village Centre

Figure 10 shows the centre of Glenridding where properties on both sides of Glenridding Beck were flooded. This included the Village Hall, Tourist Information Centre and a number of shops and residential properties close to the river. The flood flow routes into this area are also shown in Figure 10.

This area was flooded from Glenridding Beck on 5th December and again on 9th December. The cause of this flooding was high water levels in Glenridding Beck overtopping the banks on both sides. Properties were flooded directly from the beck. There was also flow down the road behind the Village Hall resulting in flooding to properties and damage to the road surface. There was also surface water flow down the slope behind these properties which contributed to the flooding.

There are no flood defences in Glenridding. There is a wall along the river bank in front of properties on the right bank (looking downstream) that protected the properties behind it from flooding. This wall is shown in Figure 11. However, the river levels were greater than the level of this wall. As such, this wall was overtopped and the properties behind it flooded. The wall was also damaged by the flood water. Following the flooding, this wall is to be repaired and reinforced to act as a flood defence. This is discussed in the 'Environment Agency Flood Incident Response' section of this report.



Figure 11-Wall along right bank of Glenridding Beck. Taken 9/12/2015 15:30

The floodwater caused damage to the road surface around the Village Hall. There was also structural damage to the Tourist Information Centre and damage to the recycling centre. Debris and gravel were deposited throughout the areas affected by the flooding.

Huge volumes of gravel and debris were deposited within the river channel following each of the flood events, significantly reducing the channel capacity and increasing the risk of flooding. This was particularly the case following the first flood event. There was significant gravel clearance following this event, with approximately 2000 tonnes of gravel removed from the Beck between the first flood event and the 8th December. However, the channel capacity was still restricted worsening the impact of the second event.

Glenridding Hotel

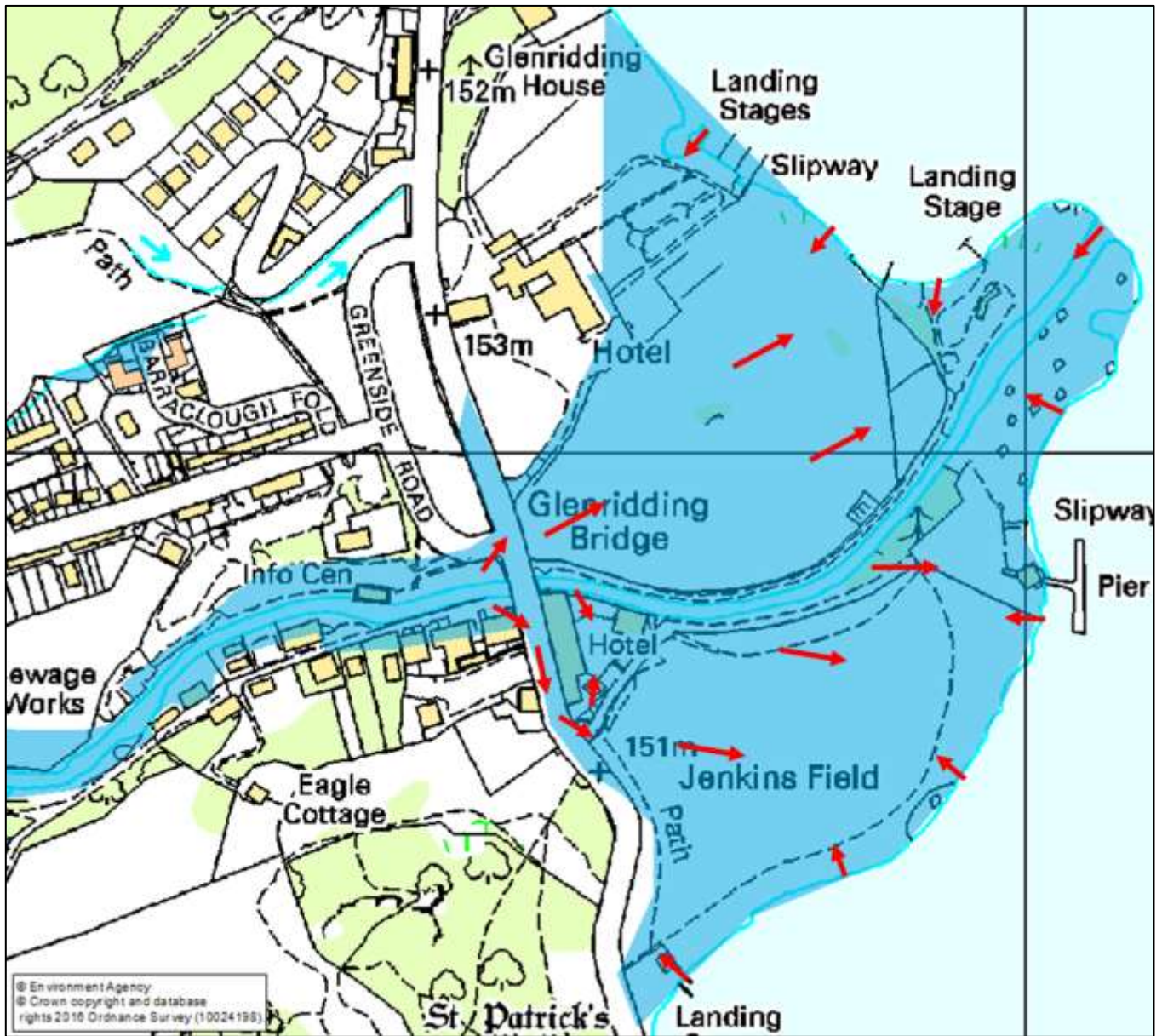


Figure 12-Flood Flow Routes downstream of Glenridding Bridge

Figure 12 shows the area of Glenridding downstream of the bridge. This includes the Glenridding Hotel which was flooded in all three flood events. There are also a number of properties around the Hotel that flooded on 5th and 9th December. Properties further downstream on the shores of Ullswater were also flooded. The flood flow routes into this area are also shown in **Figure 12**.

Properties close to the bridge were flooded from Glenridding Beck. The main cause of this was large amounts of debris and gravel blocking Glenridding Bridge. **Figure 13** shows the bridge partly blocked with debris.

Blockages at the bridge caused water levels to rise on the upstream side of the structure, and water to overtop the river banks and flow onto the A592. From here the floodwater entered the hotel and neighbouring properties from the road. The Glenridding Hotel was also flooded directly from the river where the property backs onto the river bank.



Figure 13-Glenridding Bridge Blocked by debris. Photograph provided by Patterdale Parish Flood Group. Taken **XX/12/2015**

Further downstream, there are a number of properties along the banks of Ullswater that were flooded from high water levels in both Glenridding Beck and Ullswater itself. These include the Ullswater Steamers buildings and Glenridding Activity Centre. The access roads to both these buildings were damaged by overland flow.

Barraclough Fold

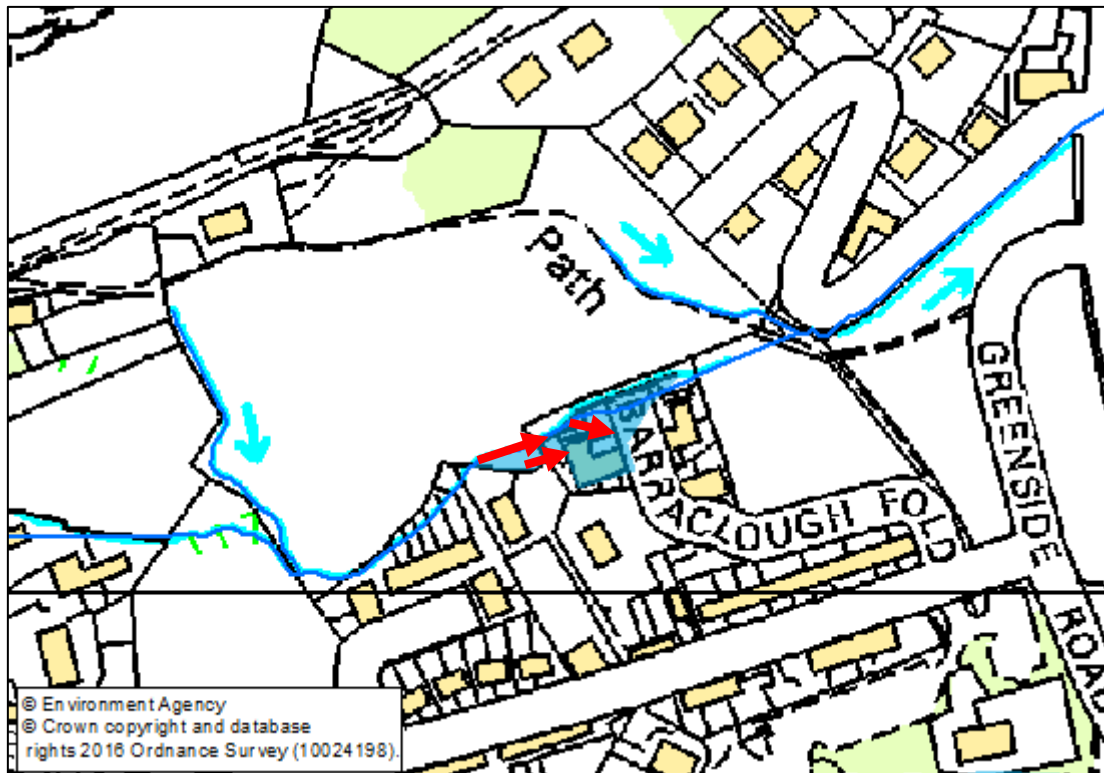


Figure 14-Location of flooded properties on Barraclough Fold

Barraclough Fold is a street in the north of Glenridding. The houses on this street were constructed in 2008. The extent of the flooding on this street is shown in **Figure 14**.

Two of the properties on this street flooded during the event on the 5th-6th of December. The properties flooded were numbers 3 and 7 Barraclough Fold. The watercourse enters a pipe which enables water to pass under a wall. The capacity of this pipe was exceeded resulting in a backing up of water and overtopping of the banks, flooding the two properties.

Environment Agency Flood Incident Response

Immediately after the flood water from the first event had receded local residents began clearing debris from the channel. Private contractor machinery arrived in the village on 7th December consisting of two excavators to assist with removal of gravel from the channel that had been transported during the flood.

The Environment Agency worked with the contractor to continue the removal of material from Glenridding Beck, **Figure 15**. Work was halted on 9th December due to the danger from rising water levels from the second flood event. This event deposited further material within the village, and gravel removal resumed once the flood water had receded. 2,000 tonnes of gravel was removed from Glenridding Beck between the first and second flood event, and it is estimated that in excess of 20,000 tonnes of material has been removed in total.



Figure 15-Gravel being removed from Glenridding Beck. Taken 10/12/2015 11:21

Regular monitoring of gravel accumulation forms a key part of the Environment Agency's maintenance programme in Glenridding. The accumulation of gravel will continue to be closely monitored and removal undertaken when required to manage flood risk. An inspection of Glenridding Beck was undertaken in April 2015 and the trigger level for gravel removal had not been reached.

The Environment Agency has worked closely with the affected communities and attended a number of meetings with residents. Following this flood event, and more widespread flooding in the Patterdale area, the Patterdale Parish Community Flood Group was created. This group has been formed in order to coordinate the recovery from the flooding, and to plan and prepare for future flooding.

There are no flood warning areas for Glenridding. Due to the steep slopes upstream of the village, rapid runoff flooding occurs at such a rate following heavy rainfall that the effectiveness of flood warnings would be severely limited.

The Environment Agency have begun work to replace the damaged wall in front of properties on the right bank of the beck (facing downstream) with a flood defence wall. The wall will be extended and the height increased to protect properties and reduce the risk of future flooding.

This work began on 27th April 2016 and is expected to be completed in autumn 2016. **Figure 16** shows the ongoing construction of this wall.



Figure 16-Construction underway of the new flood defence wall. Taken 14/12/2015

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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 or are ongoing.

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	July 2016
	Environment Agency and Cumbria County Council Highways, United Utilities and Electricity North West.	Review the flood risk and resilience of critical transport and infrastructure.	July 2016
	Cumbria Planning Group, Patterdale Parish Council, Cumbria County Council and Environment Agency	Review Local Development Plans and Strategic Flood Risk Assessment to reflect current understanding of flooding	July 2016
Upstream Management	Cumbria Floods Partnership (CFP)	The Patterdale and Glenridding pilot will be undertaken in a way that agencies and communities work together to reduce and manage flood risk in a way that best suits their community and catchment characteristics.	July 2016
	Cumbria Floods Partnership (CFP)	Gravel management plan including upstream stabilisation works to reduce quantity of material that is washed into Glenridding Beck in heavy rainfall	2016
Maintenance	Environment Agency	An action plan has been developed for Glenridding as a pilot location, produced as part of the Cumbria Floods Partnership.	July 2016
	United Utilities and Cumbria County Council	Complete on-going inspections and repairs to assets which may have been damaged during the flood event	Summer2016

Strengthening Defences	Environment Agency	Complete construction of the flood defence wall on the left bank of Glenridding Beck to protect the properties at this location	Autumn 2016
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* 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.

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Next Steps

The Cumbria Floods Partnership has brought together a wide range of community representatives and stakeholders from a variety of sectors to plan and take action to reduce flood risk. The Cumbria Floods Partnership, led by the Environment Agency, is producing a 25 year flood action plan for the Cumbrian catchments worst affected by the December 2015 flooding.

The plan will consider options to reduce flood risk across the whole length of a river catchment including upstream land management, strengthening flood defences, reviewing maintenance of banks and channels, considering water level management boards and increasing property resilience. The Cumbria Floods Partnership structure below details how these five themes are being delivered in the Flood Action Plans which will be completed in July 2016.

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

Figure 17 below helps demonstrate how the two partnerships are working together:

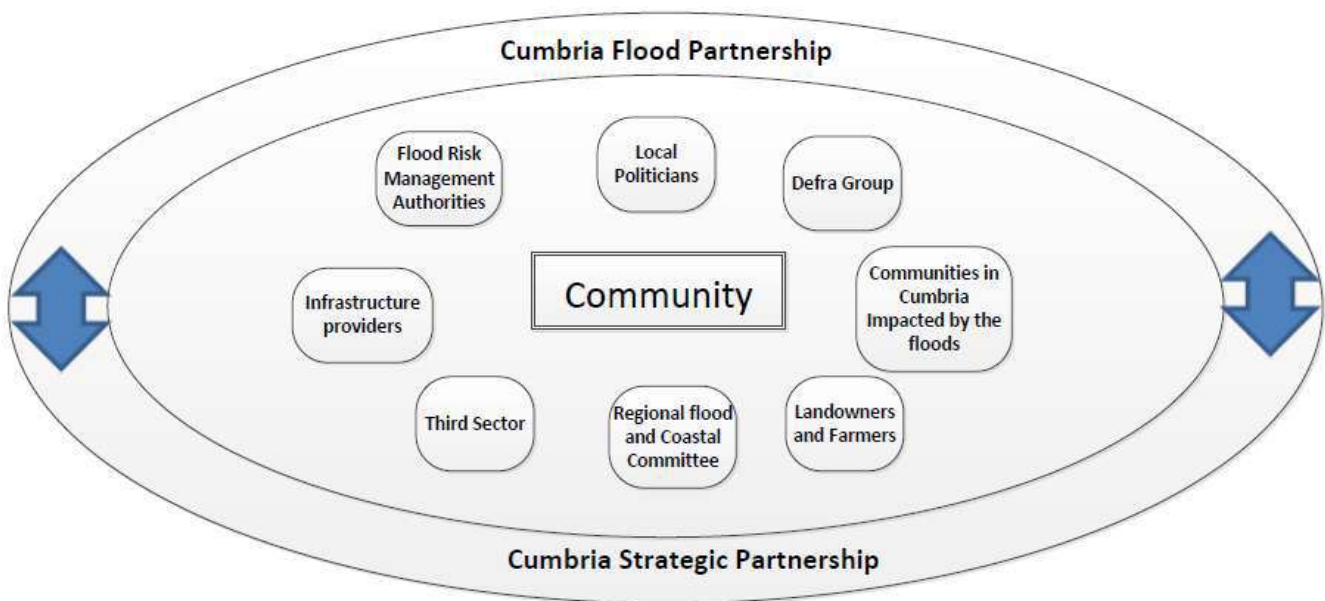


Figure 17-Cumbria Flood Partnership and Cumbria Strategic Partnership

Upstream Management

We are working with farmers, landowners, communities and organisations, such as United Utilities and The Rivers Trust to identify how to use and manage the landscape to slow the flow of water and reduce peak river levels. We will use land-management techniques such as soil aeration, bunds, leaky dams, woodland creation and river restoration to absorb water and slow the flow in locations across Cumbria including Whit Beck, Kentmere, River Gowan and Longsleddale.

We are restoring at least 350 hectares of high priority peatland to absorb water upstream of communities, and we are creating natural flood storage areas upstream of Gamblesby, Cumrew and Stockdalewath. Agri-environmental schemes will help support flood management, and we are exploring the opportunities for upstream engineered water storage. United Utilities is currently reviewing the operation of existing reservoirs such as Thirlmere and Birds Park to manage flood flows.

We are piloting this integrated approach to flood and land management in specific sub-catchments in Patterdale, Glenridding, Stockdalewath, Braithwaite and Staveley. We will share what we find out from these pilots with farmers, landowners and communities across Cumbria, and the lessons we learn will help us in our work in the rest of England.

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Appendices

Appendix 1: Glossary

AEP	Annual Exceedance Probability
ARI	Annual Recurrence Interval
AOD	Above Ordnance Datum
CCC	Cumbria County Council
EA	Environment Agency
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 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>

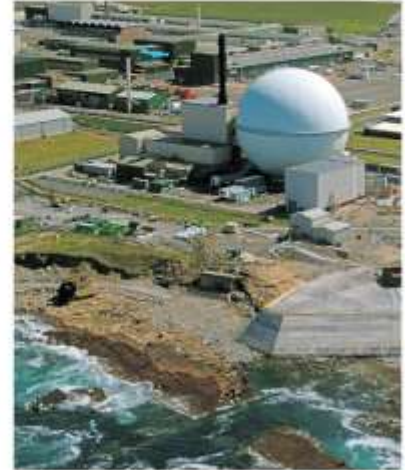
Water Resources Act 1991:

<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: CH2M Hill UK Projects and Flood Risk Management brochure



We partner with your industry

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

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

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

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

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

Urban Programmes

Key endorsements:

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

– John Armitt, ODA Chairman

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

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



London 2012 Olympic and Paralympic Games

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

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



Water

Thames Tideway Tunnel and Lee Tunnel

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

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

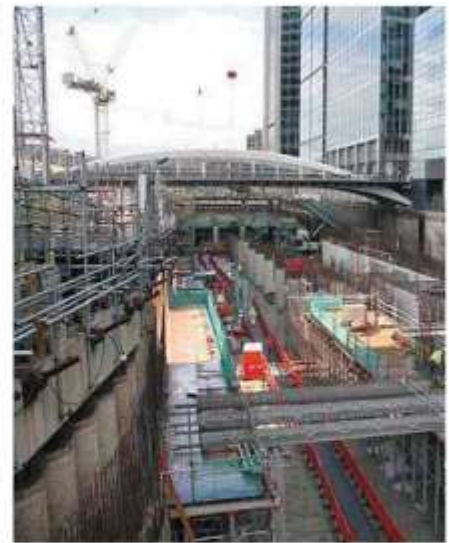
Transport

Crossrail

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

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

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



High Speed 2 (HS2)



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

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

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

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

We provide services for your success

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



Water Resources-Ecosystem Management Services

Flood Risk Management

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

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

A core focus is delivering fully integrated solutions that maximize both direct and indirect benefits for the clients that we serve in WBG, 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 flooded 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.