Patterdale and neighbouring valleys

Flood Investigation Report

Goldrill Bridge on 6th December 2015

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 Eden District Council as Lead Local Flood Authority.

Version	Prepared by	Reviewed by	Approved by	Date
Working Draft for discussion with EA	Sejal Shah	Ian McCall		

Contents

Executive Summary

Patterdale and the neighbouring valleys were flooded on 5th and 6th of December 2015 as a result of Storm Desmond. This storm caused a period of prolonged, intense rainfall across Northern England, falling on an already saturated catchment, and led to high river levels and flooding throughout Cumbria and beyond. Subsequent events occurred on the 5th, 9th and 21st of December with several properties affected by all three events.

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 District 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 Patterdale and the neighbouring valleys on 5th and 6th December and has used a range of data collected from affected residents, site visits, surveys of the area, and data collected by observers and river & rainfall telemetry during the flood event. There are locations that flooded more than once in December 2015 but this report concentrates on the events of 5th and 6th December '15. This data has been compiled by CH2M, specialist consultants in flood risk management who have provided advice in understanding the event and recommendations for future action.

The intense rainfall over a prolonged duration generated a high volume of runoff from the steep mountain catchment which caused significant erosion and landslips, depositing large quantities of gravel and vegetation into the becks draining the valleys above Ullswater. This material was transported by the flood causing additional erosion to the channel banks, and depositing substantial quantities of rock and gravel throughout the channel and in flooded areas.

There are no formal flood defences within Patterdale or the neighbouring valleys. There are some raised embankments and walled channel sides through agricultural land along some sections of watercourses but these are not maintained by the Environment Agency. High ground adjacent to the channels confined the extent of flooding. Following the extreme rainfall in December 2015, localised gravel removal has taken place in the channel and adjacent fields.

According to the Patterdale Parish Communtiy Flood Plan about 70 properties and business were affected by flooding within the Patterdale boundary Parish. Approximately 17 properties were directly affected by the flooding in the area covered by this report. This report details the flooding that occurred from Goldrill Beck and its tributaries and from surface water running off the steep hillsides along the valleys.

The Patterdale Parish Community Flood Plan is a comprehensive review of the flooding within the parish and identifies actions that need to be carried out to help manage future flood risk and to make the community more resilient to flooding in the future. The Flood Incident Report identifies actions to manage future flood risk, which will require the involvement of a number of organisations and the local community and landowners.

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 Patterdale and the neighbouring valleys. Patterdale and Glenridding have been identified as pilot locations in the Cumbria Flood Action Plan.

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

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

Goldrill Beck runs through the Patterdale Valley. The source of Goldrill Beck is Brothers Water to the south of Patterdale and the beck flows into Ullswater to the north. As it flows towards Ullswater, Goldrill Beck collects a number of tributaries from the surrounding hills.

Due to the numerous watercourses and steep mountain slopes around the village there is a risk of flooding.
Patterdale village was flooded twice in 2009; in January 2009 approximately 150mm of rain fell in 36 hours, The village was also flooded in November 2009. Extensive flooding was also experienced in 2005. Flooding to Glenridding occurred on 7th February 1997 but it is not known if this affected the wider area.

Event background

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

Flooding Incident

Patterdale is a small civil parish village, situated south of Ullswater in the eastern part of the Lake District in the Eden District of Cumbria. It is located within the Ullswater valley with a population of approximately 501*. The Patterdale is surrounded by steep fells including Place Fell to the north-east rising to a height of 657m and the Helvellyn range to the north west rising to a height of 950m.

The main water course running through the Patterdale is Goldrill Beck., The source of Goldrill Beck is Brothers Water to the south of the village, and the beck flows north to discharge into Ullswater. Goldrill Beck is fed by many local streams and becks running off the fells including Deepdale Beck and Grisedale Beck. Figure 1 shows the location of Patterdale and these rivers.

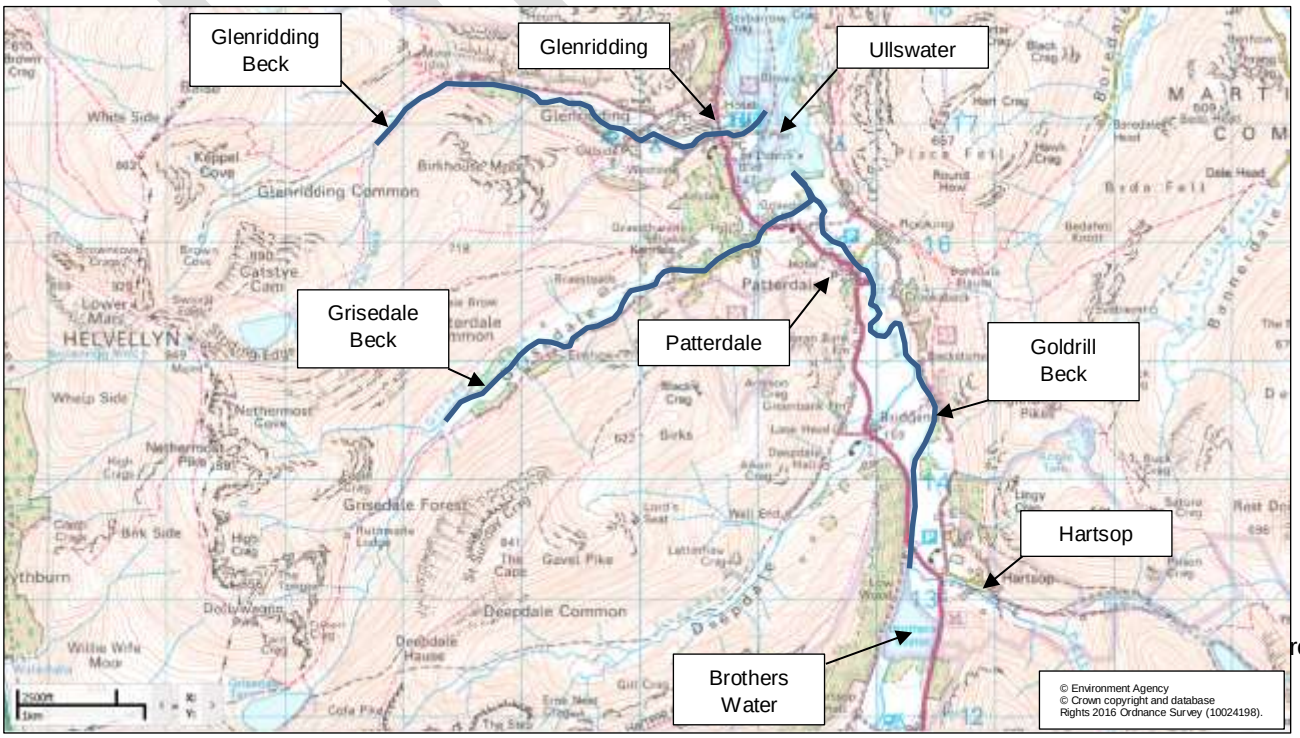

Figure 1- Location of Patterdale and Major

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Rivers

On 5th and 6th December 2015, approximately 17 properties suffered flooding; 13 residential and 4 commercial properties. This flooding is attributed to a record-breaking rainfall event from Storm Desmond. This led to widespread flooding from Goldrill Beck, plus flooding from other watercourses. Figure 2 shows the approximate extent of the flooding.

Flooding was primarily associated with fluvial (river) sources. Patterdale village is located in a valley, and rapid runoff from the steep-sided valley slopes resulted in flooding from the watercourses and directly from runoff from the mountain sides.

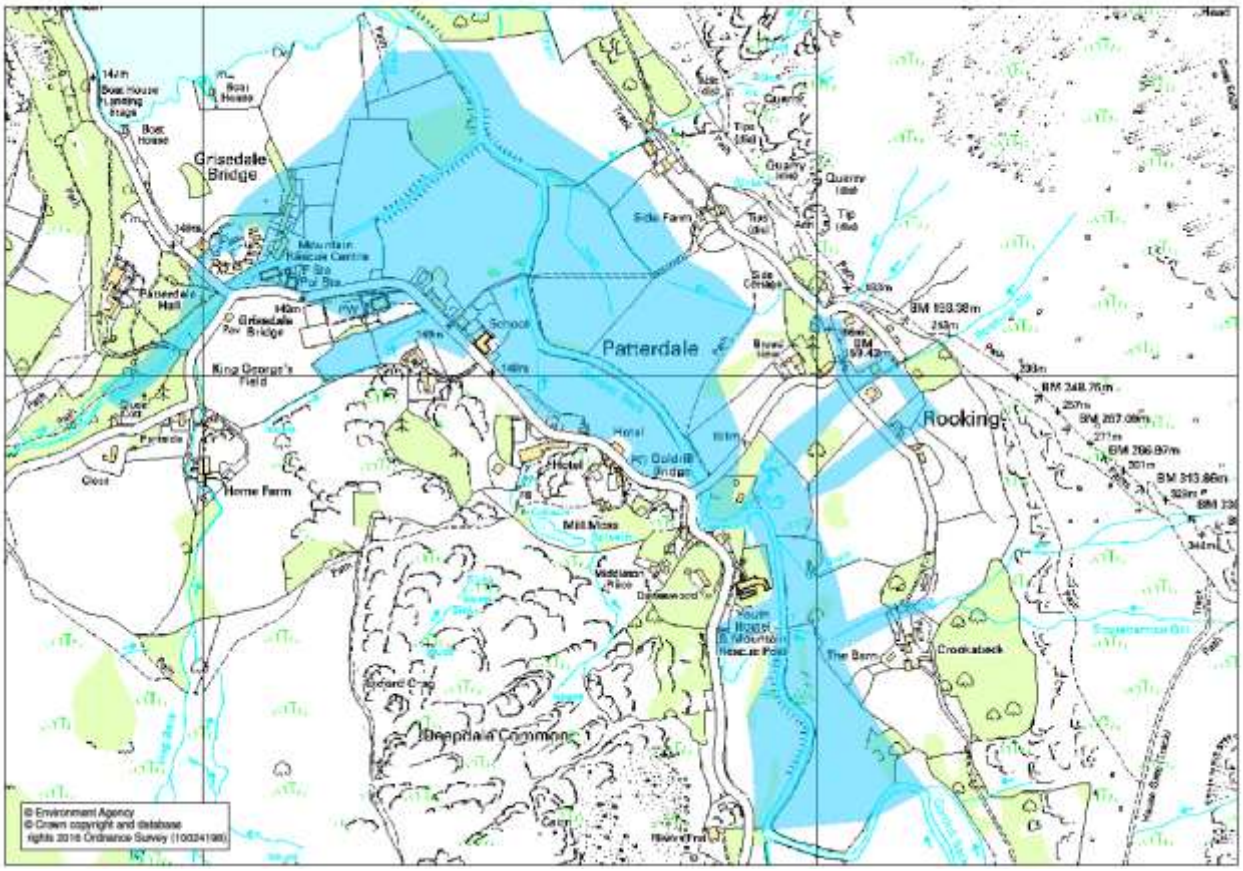


Figure 2-Extent of Fluvial (River) Flooding in Patterdale on 5-6th December 2015

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

- **Deepdale Beck** – The area around Deepdale Bridge, a tributary of Goldrill Beck. This is upstream of the area shown on Figure 3
- **Deepdale Beck to Goldrill Bridge** – the area of Goldrill Beck upstream of Goldrill Bridge
- **Goldrill Bridge –** The area around the bridge and the bridge itself
- **Rooking Gill –** The area along the route of Rooking Gill on the slopes of Place Fell
- **Goldrill Bridge to Grisedale Beck -** the left and the right bank of Goldrill Beck downstream of Goldrill Bridge
- **Grisedale Beck -** The area along Grisedale Beck, a tributary of Goldrill Beck

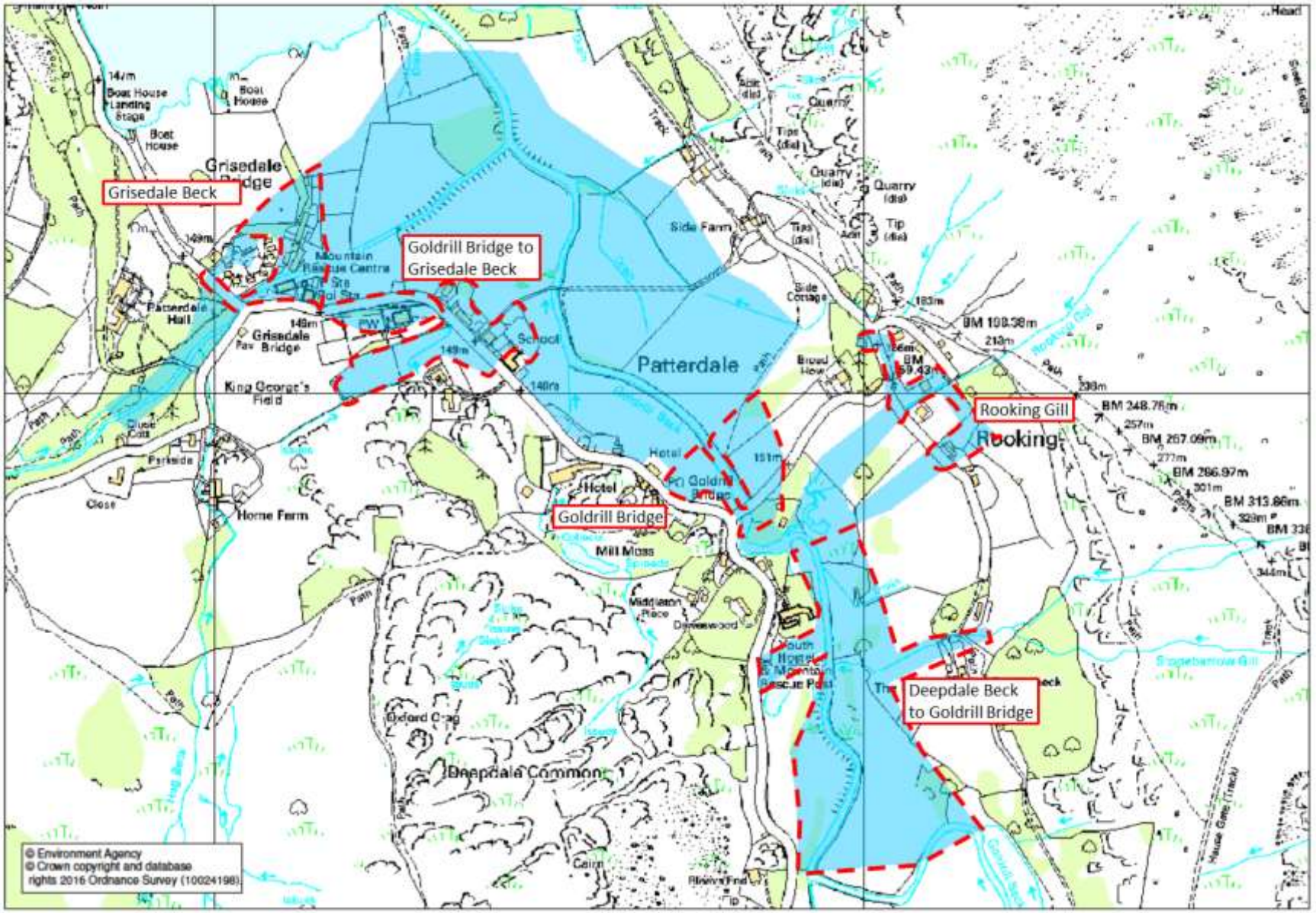


Figure 3-Identification of Areas Flooded

Current Flood Defences

There are no formal flood defence measures present within Patterdale. However, fields on either side of Goldrill Beck act as flood plains, and raised ground or embankments along Goldrill Beck and Grisedale Beck act as the channel banks. The route of the channels and the areas with embankments are shown in Figure 4.

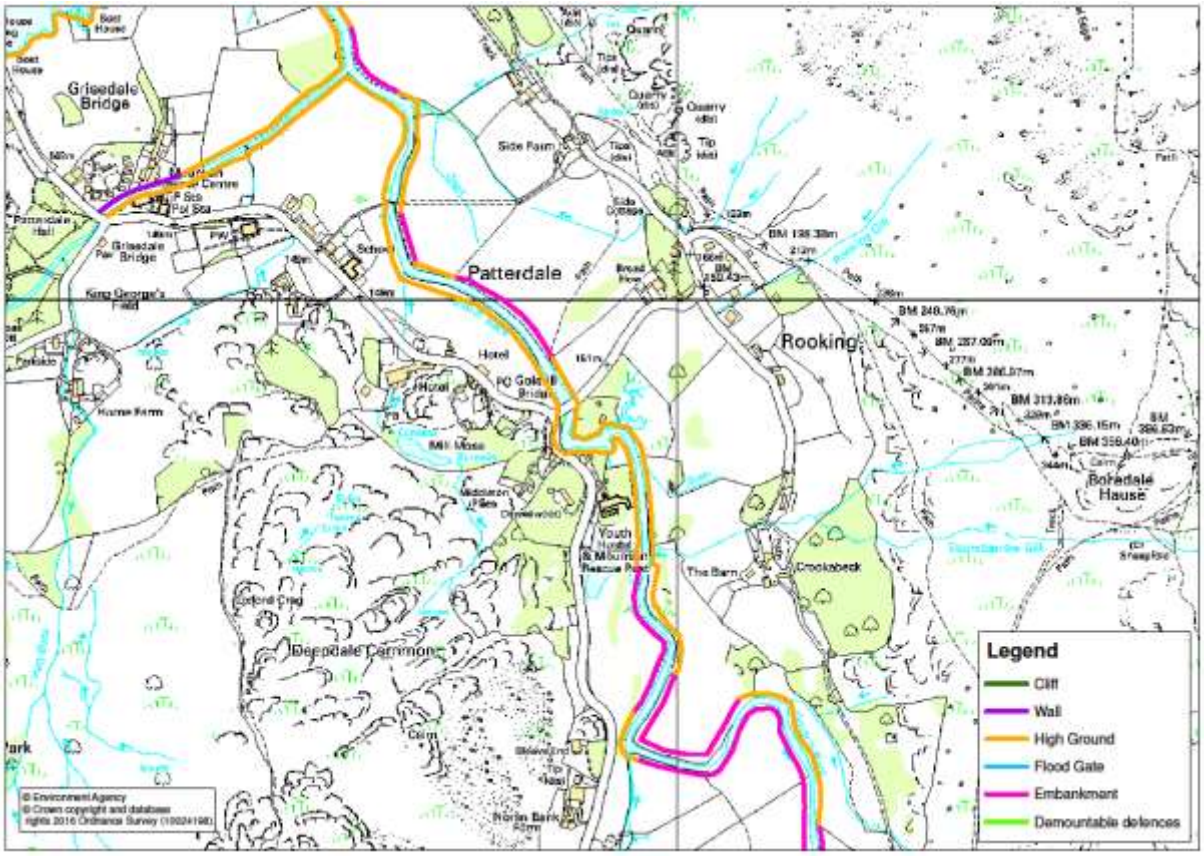


Figure 4-Channel side construction along Goldrill and Grisedale Becks

Investigation

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

This investigation was carried out by the Environment Agency through surveys of the area and data collected from the communities affected with help from Cumbria County Council.

This report has been complied by CH2M from the data collected by the Environment Agency. CH2M are a global civil engineering consultancy providing a full range of flood management consultancy services in the UK and overseas. CH2M's range of experienced specialists have provided input into understanding this event and producing recommendations for future flood management in Patterdale. More details of CH2M's work in the UK is included in Appendix 4.

Rainfall Event

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

From 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.

Location	24-hour Rainfall during November 2009 Event	24-hour Rainfall during December 2015 Event	
	mm	mm	Estimated AEP
Brotherswater	200.8	293.4	<0.1%

Table 1-Rainfall around Patterdale prior to the December 2015 event

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

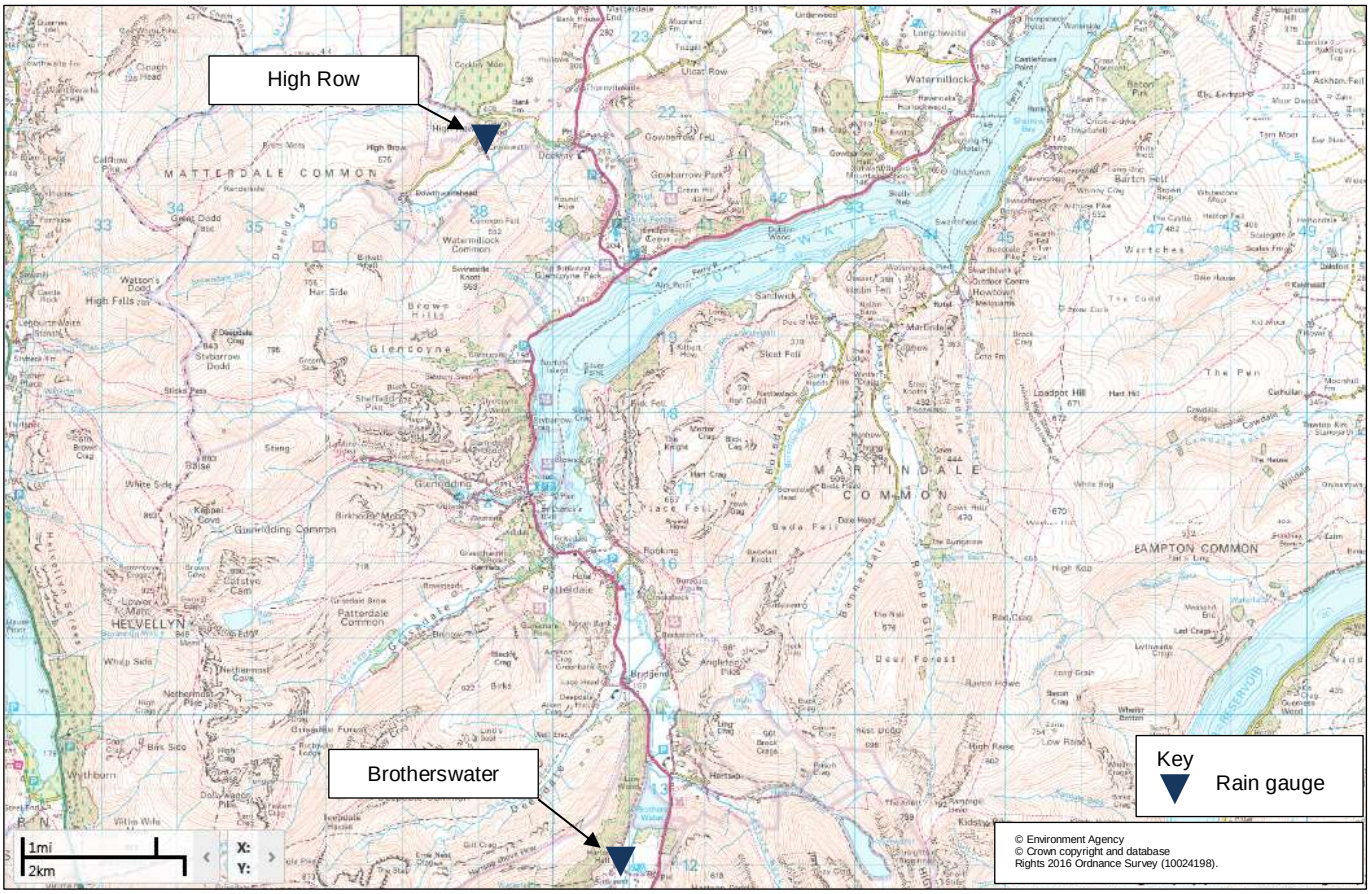


Figure 5-Location of rain gauges in the Goldrill Beck catchment upstream

There are no river level gauges on the watercourses in this area.

Flooding Flow Routes

A number of flood flow routes have been identified. For investigation purposes, the flooded areas have been divided into the six sub- areas outlined previously in this report.

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

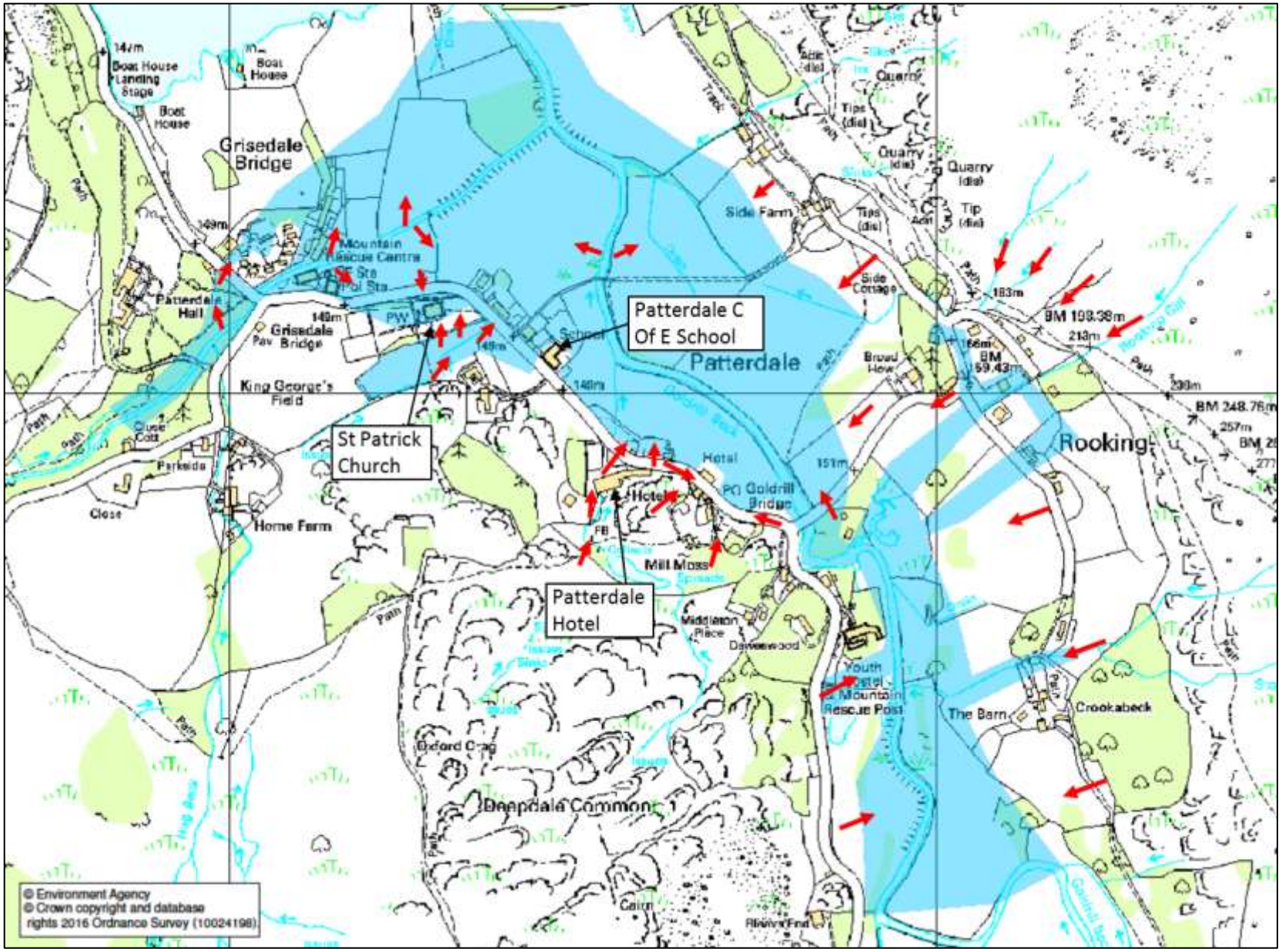
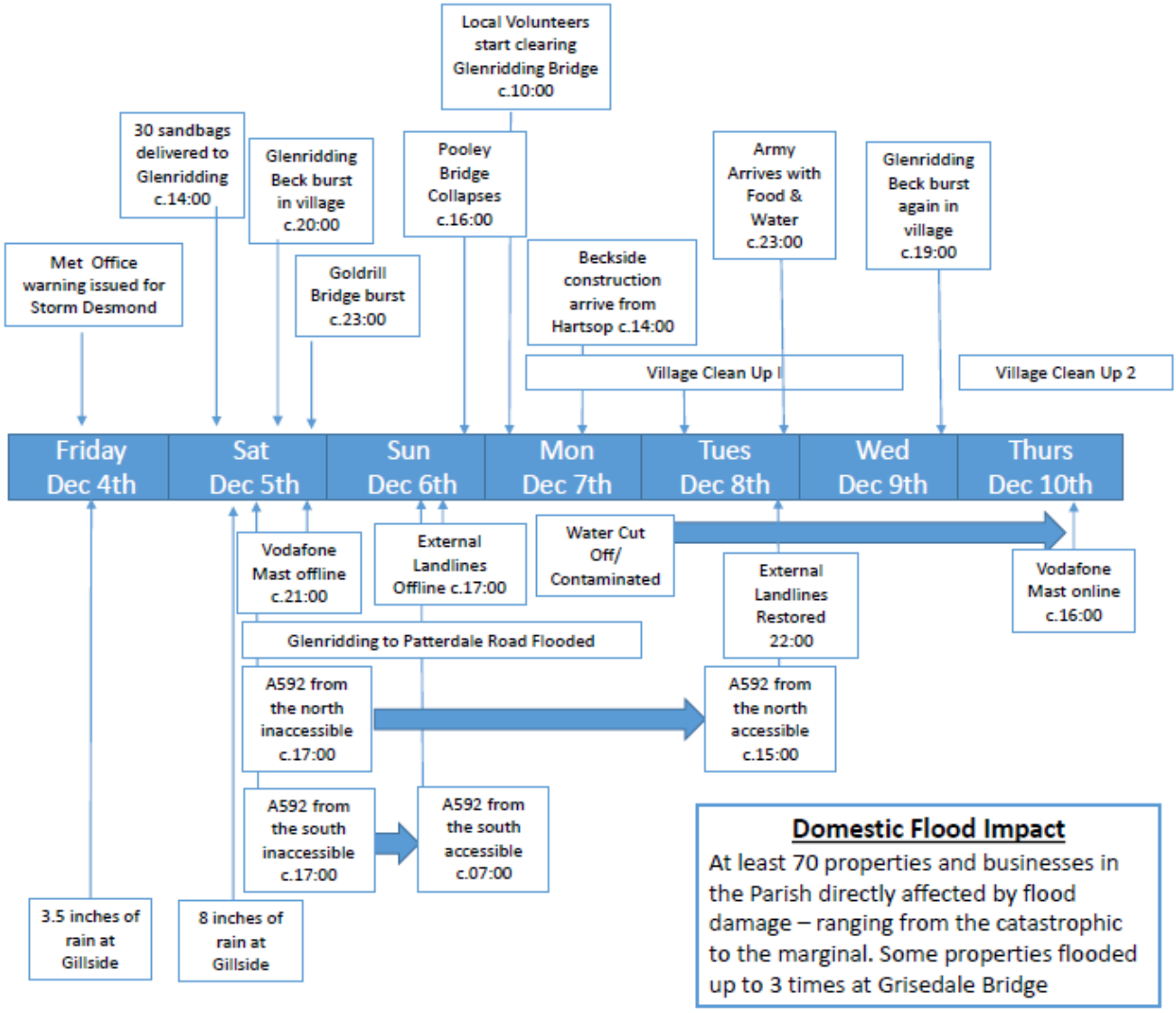


Figure 5-Flood Routes within Patterdale

Impacts and Likely Causes of Flooding

Timeline from Patterdale Parish Community Flood Plan



17 properties were affected by the flooding in the area covered by this report, 13 residential properties, and 4 commercial properties. The flooding event began on the 5th December and was caused by extreme rainfall as a result of Storm Desmond.

High runoff from the hills caused scouring and carried gravel and debris into the beck. There were also two major landslips at Place Fell, behind Rooking, to the north-east leading to a large quantity of material deposited on the road and fields.

Properties were flooded directly from watercourses and from culverts that were overwhelmed by the volume of water. Properties were flooded from Deepdale Beck, Goldrill Beck and Grisedale Beck as well as from surface water flow off mountain sides.

The A592 was flooded during the event. Floodwater, debris and damage to the road surface caused this route to be closed until 8th December. This road is the main route connecting Patterdale to the surrounding villages and as such its closure left the village isolated following the flooding.

Storm Desmond was devastating in its impact on the valley. Such was the impact that the Army arrived in village late on 8th December with food and drinking water for the community. The water supply to Patterdale was cut off following the flooding. This was due to damage to a United Utilities pumping station at Martindale. Communications were severed, telephone coverage to the village was largely lost. Landline signal was lost due to damage to Pooley Bridge at the northern end of Ullswater. Mobile phone signal was lost due to power outage to the Vodafone mast in nearby Glenridding.

Deepdale Beck

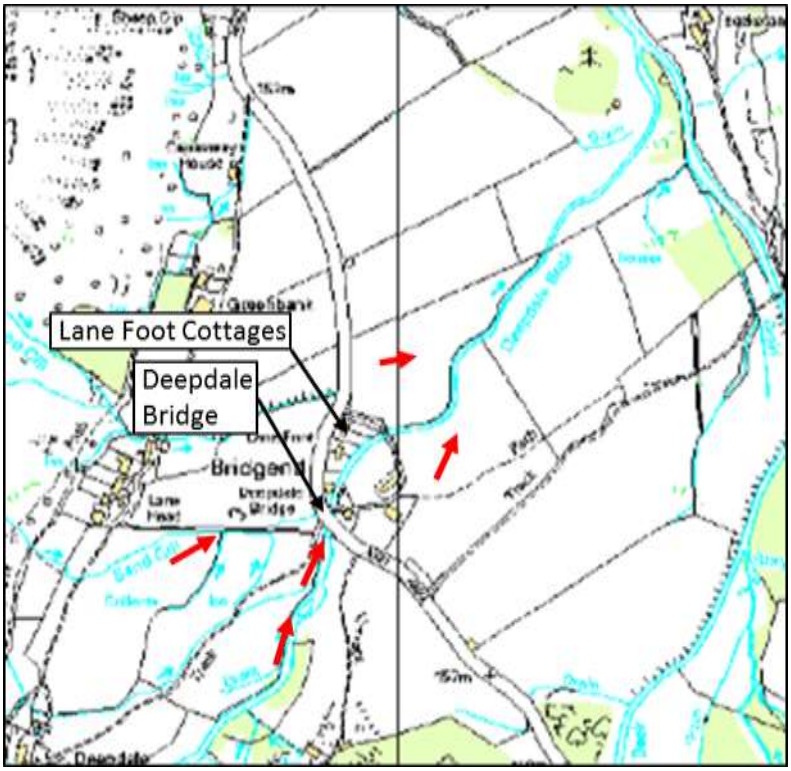


Figure 6-Deepdale Beck flow route

Deepdale Beck is a tributary of Goldrill Beck, located to the south of Patterdale village, this is shown in Figure 6. The A592 crosses the beck at Deepdale Bridge and there are a number of properties along this watercourse around this bridge. The cottages alongside Deepdale Beck were flooded on 5th December due to the beck overtopping its banks. Properties were flooded to a depth of 0.4m.

On the downstream side of Deepdale Bridge, the wall to the rear of Lane Foot Cottages collapsed into the channel. The high flow in the beck caused scouring of the channel banks and damage to garden sheds and garages as shown in the Figure 7.

During the flood event, a large amount of gravel was deposited within the channel and the surrounding fields. There was also woody debris within the channel from fallen trees.

Figure 7-Rear of Lane Foot Cottages

The intense rainfall caused a landslip between Noranbank and Greenbank north of Deepdale Beck. The material from this landslip was deposited on the A592 and blocked the road drainage. The effects of this landslip are shown in Figure 8. Following the event the debris was cleared and CCC Highways have installed new road drainage.

Figure 8-Landslip between Noran Bank and Green Bank

Deepdale Beck to Goldrill Bridge

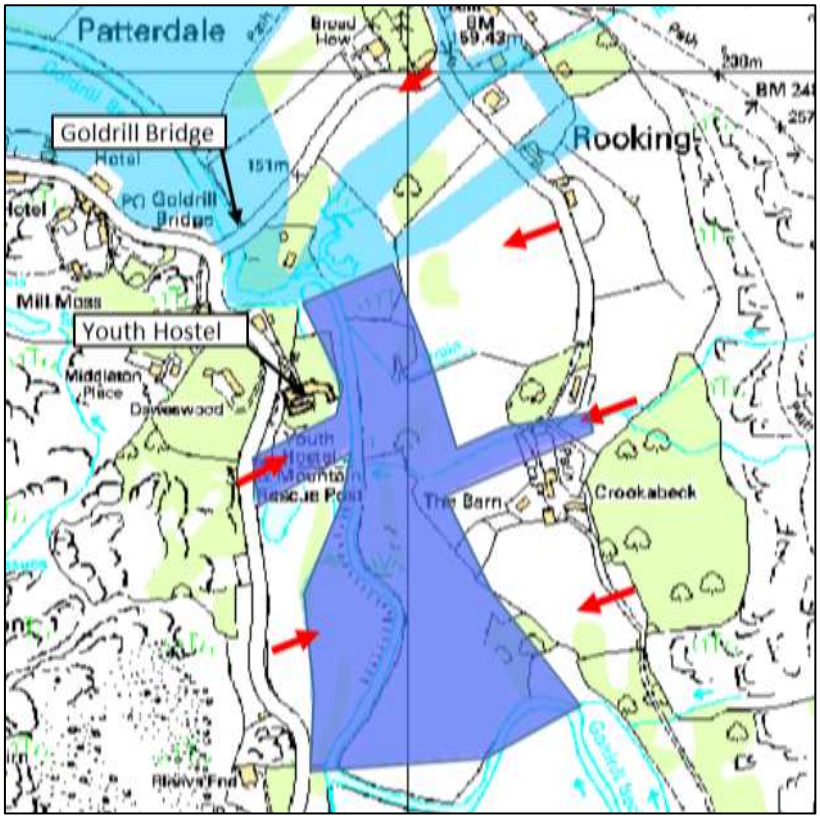


Figure 9- Flood extents and routes upstream of Goldrill Bridge

Figure 9 shows the area along Goldrill Beck between Deepdale Beck and Goldrill Bridge. There are three major tributaries joining Goldrill Beck in this area; Deepdale Beck, Hayeswater Gill, and Angle Tarn Beck. In addition to these tributaries, others minor streams and surface runoff from the fells contribute to the flow in Goldrill Beck.

To the south of the Youth Hostel, surface water runoff flowed over the A592 and towards the fields on the left bank of Goldrill Beck (looking downstream). The Youth Hostel was not flooded. On the right bank, Crookabeck overtopped its banks, but no properties were flooded. This watercourse was carrying gravel from the surrounding hills and this was deposited within the channel and on the surrounding fields as shown in Figure 10.

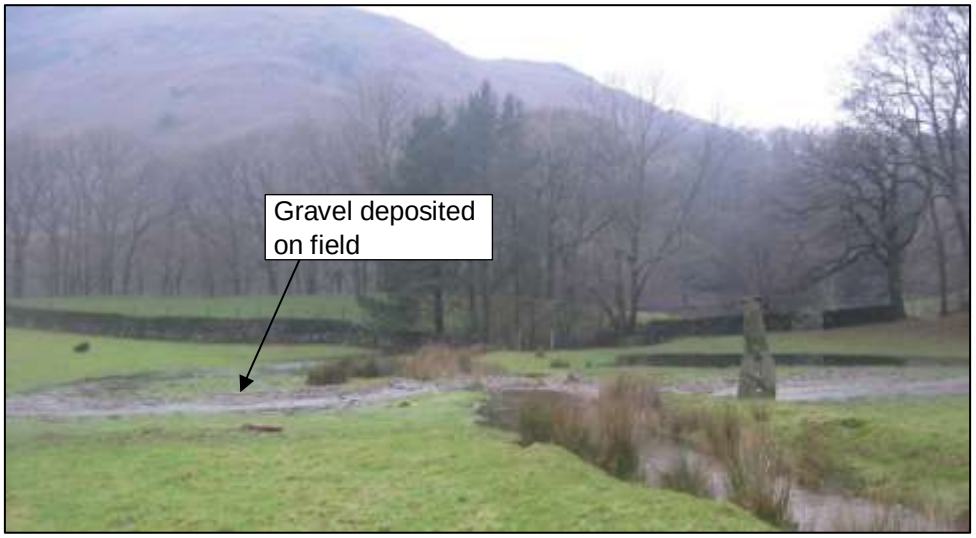


Figure 10-Gravel deposited by Crookabeck

Rooking Gill

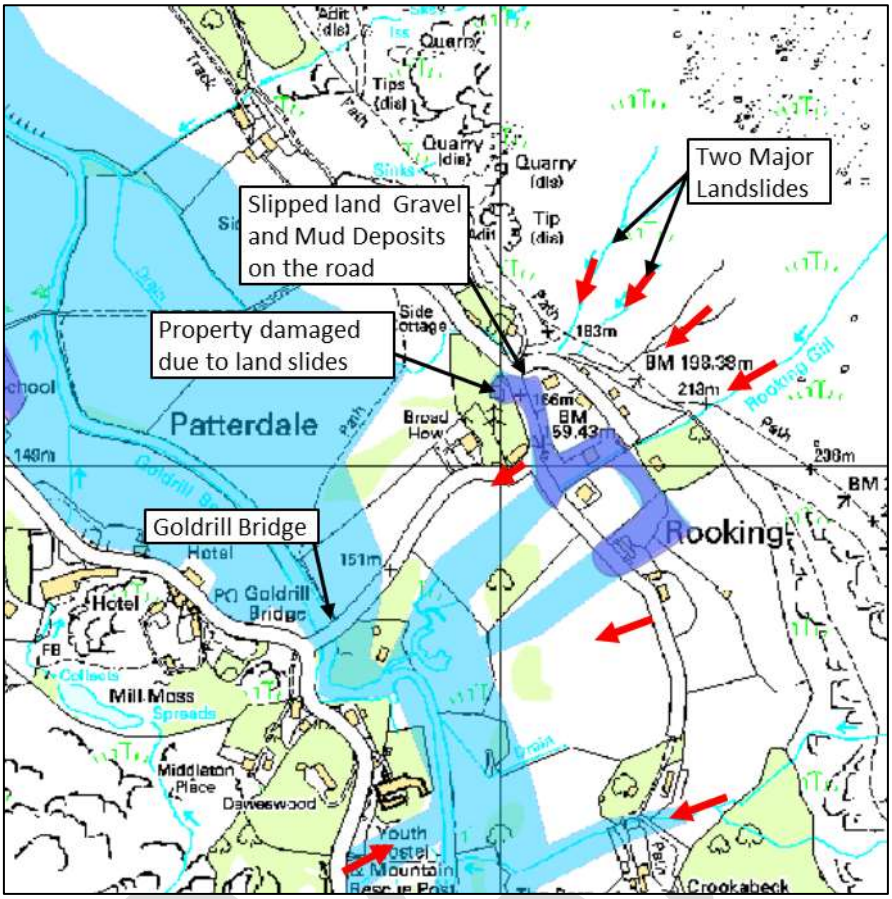


Figure 11-Flood routes in Rooking Gill area

Rooking Gill is a tributary of Goldrill Beck with its source in the steep hills of Place Fell, refer to Figure 11. This watercourse is culverted underneath the gardens and driveway of cottages before flowing through fields to Goldrill Beck. During the flood event the volume of water from upstream exceeded the capacity of this culvert. As such the culvert inlet was overwhelmed and water flowed over driveways and into properties. Two properties in this area were flooded from Rooking Gill. Figure 12 shows flow through these properties, Figure 13 shows the culvert inlet and outlet.

Figure 12-Runoff from fells and Rooking Gill through properties*

* http://www.patterdaletoday.co.uk/gallery/floods-jan-09

Figure 13-Rooking Gill culvert inlet and outlet

Extreme rainfall over a prolonged duration generated high-velocity runoff from the fells. Two major landslides were recorded at Place Fell that caused significant gravel and mud deposition on the road. This material blocked the road to Rooking and access to the gardens of Fell Place Cottage, Green Rigg and Broad How.

Figure 14-Landslides on Place Fell

Figure 15-Debris and Mud Collected on the Road from landslides*

Goldrill Bridge

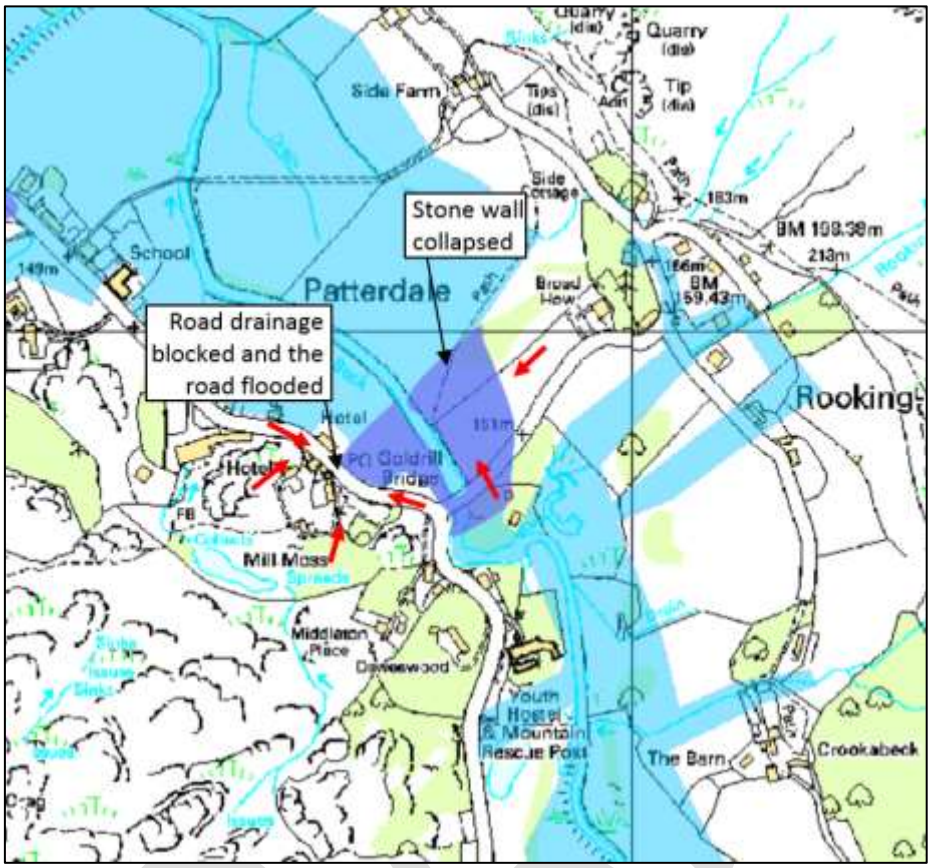


Figure 16-Flood extent at Goldrill Bridge

Figure 16 shows the area around Goldrill Bridge. There are two bridges crossing Goldrill Beck before it flows into Ullswater; namely Cow Bridge and Goldrill Bridge. Goldrill Bridge provides access to the Cottages situated east of the A592. The bridge is a single lane stone bridge with two low arches over Goldrill Beck as shown in Figure 17.

* http://www.patterdaletoday.co.uk/gallery/floods-jan-09

Figure 17-Goldrill Bridge

During the December 2015 flood event due to the intense rainfall there was significant runoff from the nearby mountains transporting a large volume of debris and gravel. This collected within the beck and reduced the capacity of the beck and of Goldrill Bridge leading to the beck overtopping its banks upstream of the bridge.

On the right bank, the level of the beck was above the road level and bypassed the Bridge and flowed towards the downstream field. The stone boundary wall and fence line on the right bank field collapsed due to the flooding. The road surface on the bridge was damaged by the flow. It was reported that Goldrill Bridge was flooded at approximately 23:00hrs on 5th December 2015.

Figure 18-Flood flow bypassed Goldrill Bridge

Figure 19-Goldrill Bridge during flooding- Collapsed stone wall and fence line - Right Bank

The level of the beck was close to the threshold level of Goldrill Cottage situated on the right bank of Goldrill Beck. The flood wrack mark recorded following the flooding was 0.2m below the Cottage's threshold level. There was also flow though the garden of this property causing damage to the garden wall.

Figure 20-Wrack Mark at Goldrill Cottage

Between Goldrill Bridge and the White Lion Inn the A592 is lower than the surrounding ground. As such the road drainage collects the runoff from the road and hills. During the December 2015 flood event, the road drainage was blocked by debris and the road was flooded.

Figure 21-Runoff collecting at low point on the A592

Goldrill Bridge to Grisedale Beck

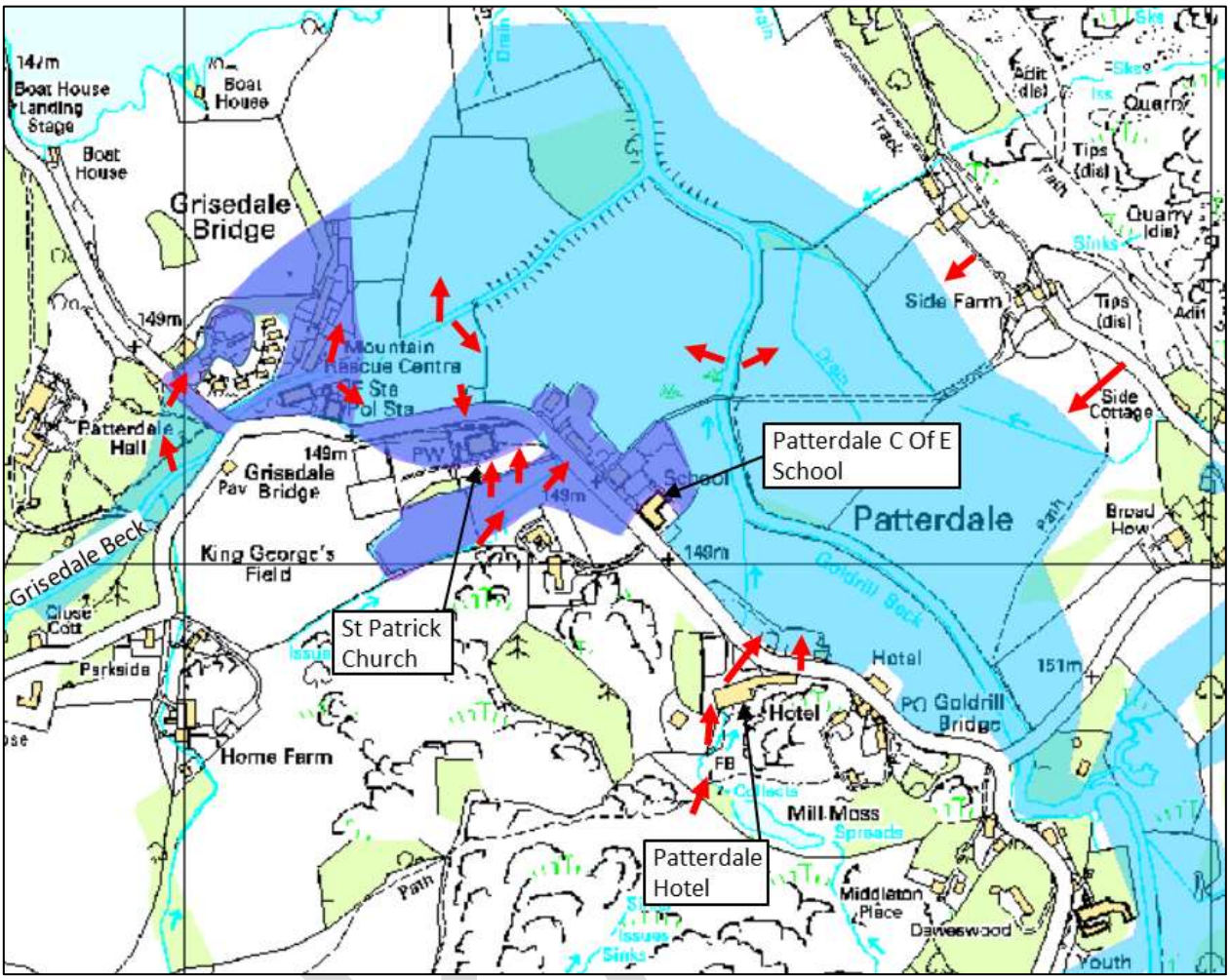


Figure 22-Flood route downstream of Goldrill Bridge

Figure 22 shows Goldrill Beck downstream of Goldrill Bridge and where the beck is joined by Grisedale Beck. There were a number of properties flooded in this area and various flood routes were observed from the hills. On the right bank, a major runoff route was observed from disused quarries, which transported debris which was deposited on the fields and within the beck channel.

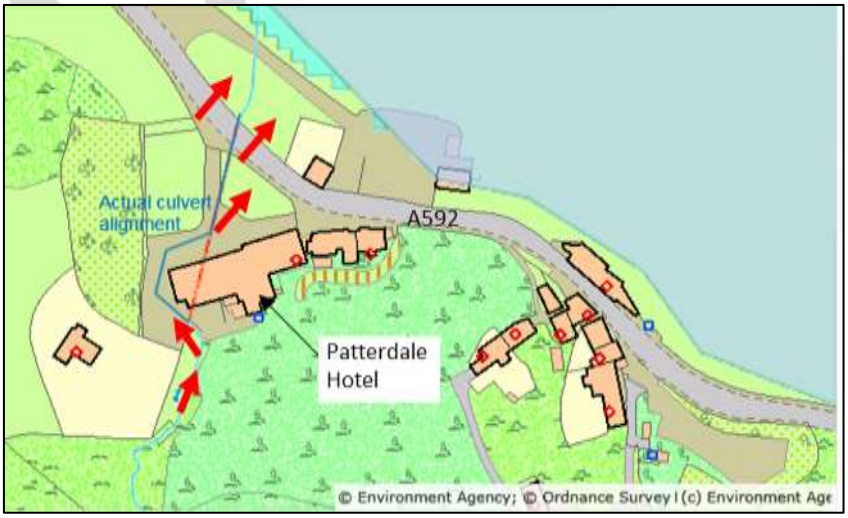


Figure 23-Flow route on the rear of Patterdale Hotel

There is an unnamed watercourse located to the rear of Patterdale Hotel that discharges into Goldrill Beck. This watercourse is culverted underneath the car park and the A592 and outfalls into the field on the left bank of Goldrill Beck as shown in Figure 23 and 24. It was recorded that the inlet to this culvert was surcharging due to the higher volume of water from upstream. This water then flowed through the gap at the rear of the car park and onto the A592 as well as seeping through the stone wall into the field.

Figure 24-Inlet of the culvert and flow route on rear of the Hotel

Figure 25-Culvert inlet on south of St Patricks Church and flow route

An additional flow route was observed from the stream located to the south of St Patrick's Church. This stream is culverted underneath the A592 and outfalls into the field on the left bank of Goldrill Beck as shown in Figure 25. The runoff collected in the field was reported to have seeped through the stone boundary wall and flooded the church (See Figures 26 and 27). The field boundary wall along the road was overtopped and flooded this area of the A592.

Figure 26-Water seeping through stone boundary wall into field

Figure 11-St Patricks Church flooded on 5th Dec 2015

The field to the rear of Patterdale School was flooded from both Goldrill Beck and Grisedale Beck. The water level within the field rose above the boundary wall along the A592 and contributed to the road flooding. High water levels on Ullswater were compounding the problems experienced in Patterdale.

The A592 was flooded from a combination of runoff from the left and right side fields. The flooding on the A592 also contributed to the flood level within the Church.

Figure 28-Flooding on the rear of Patterdale School and around the School

Four properties on the A592 were flooded; three internally, and one property, Patterdale C of E School flooded externally. The flood water was up to the bottom of the school's windows. However, the basement was flooded by water seeping through air bricks.

Grisedale Beck

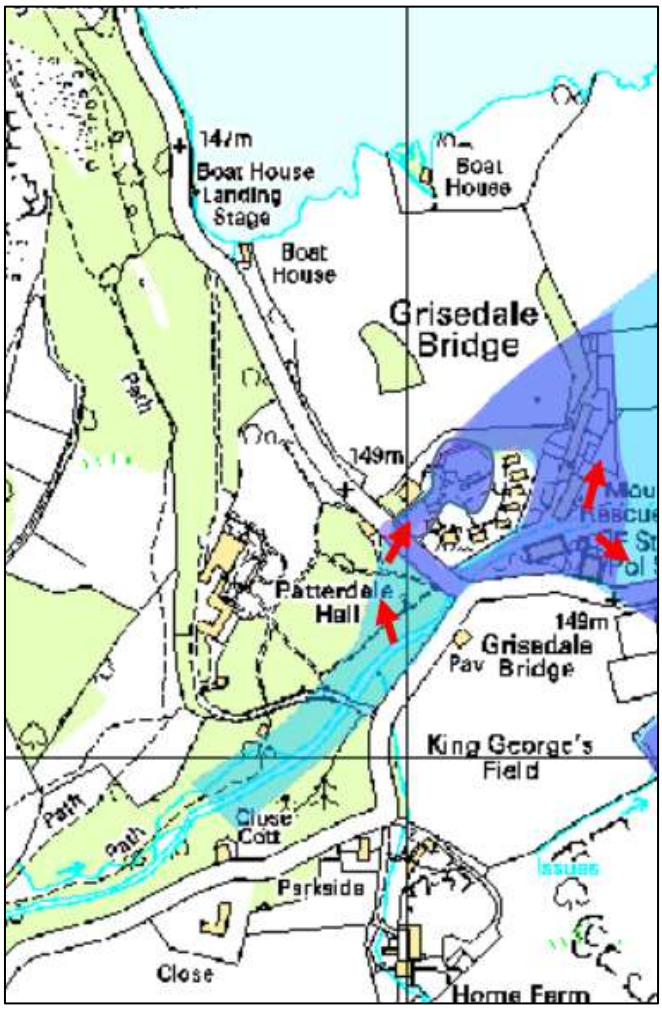


Figure 29-Flow route from Grisedale Beck

Grisedale Beck flows from Grisedale Tarn through the valley of Grisedale and into Goldrill Beck. The A592 crosses the channel at Grisedale Bridge. There are no formal flood defences along this beck. The flood extent and flood flow routes along this river are shown in Figure 29. A number of properties in this vicinity were flooded on more than one occasion during December '15.

The December 2015 flood event caused a number of landslips along the route of Grisedale Beck; near to Eagle Cottage, Kennels, and Close Cottage, and led to a large quantity of material deposited in the stream reducing its capacity.

Grisedale Bridge formed a constriction to the stream flow and caused elevated river levels immediately upstream of the bridge. Also, debris collected on the stream's bed reduced the bridge's capacity. As a result, the beck overtopped its left bank upstream of the bridge and flowed towards the A592 through a stone boundary wall and access gate. This flow flooded the A592 and continued towards Patterdale Hall. The road surface at the entrance of Patterdale Hall was damaged due to the flood flow. Figure 30 shows the route towards Patterdale Hall and the damage to the A592.

The right bank upstream of the bridge was not overtopped. Following the event the Environment Agency have carried out dredging of Grisedale Beck in order to remove debris and increase the bridge capacity.

Figure 30 - Flow route through access gate and stone wall and damage to the A592 road surface

Downstream of Grisedale Bridge Grisedale Beck overtopped and flooded properties on both banks, including the Mountain Rescue Centre, Fire Station and Old Police Station.

Environment Agency Flood Incident Response

The Environment Agency and Eden District 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.

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.

Immediately after the flood event the Environment Agency undertook inspections of the watercourses and worked to clear debris and gravel from the affected rivers to aid conveyance at key locations. Many other organisations, land owners and individuals have been working to repair the damage caused by Storm Desmond. This work continues to date, much of it recorded on the Parish Council's website - http://patterdale-pc.org.uk/

Flood alerts were issued on 3rd and 4th December '15. There are no flood warning areas for Patterdale. Due to the steep slopes surrounding the village heavy rainfall results in rapid runoff hence flooding occurs very quickly limiting the effectiveness of flood warnings.

Recommended Actions

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

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

Cumbria Flood Partnership Theme	Action by	Recommended Action	Timescale
Community Resilience	Cumbria Local Resilience Forum *	Review and update plan to enable homes & business to be better prepared for flooding & reduce the impacts of flooding	2016
	Environment Agency and Eden District Council Highways, Network Rail and Electricity North West.	To review the flood risk and resilience of critical transport and power supply infrastructure.	Autumn 2016
	Cumbria Planning Group, Patterdale Parish Council, Eden District Council and Environment Agency	Review Local Development Plans and Strategic Flood Risk Assessment to reflect current understanding of flooding	2016
	Environment Agency	Ensure all properties at risk can register to receive flood alerts and details are up-to-date.	Summer 2016
Upstream Management	Cumbria Floods Partnership (CFP)	Undertake the Patterdale and Glenridding pilot where agencies and communities are working together to reduce and manage flood risk in a way that best suits their community and catchment characteristics.	Autumn 2016
Maintenance	Cumbria County Council	Complete on-going inspections and repairs to assets which may have been damaged during the flood event.	2016
Strengthening Defences	Environment Agency	Review modelling data to ensure that models for Patterdale and the neighbouring valleys reflect real conditions as accurately	2016

		as possible and use this information to make any improvements to the flood warnings service. This will be used to inform future investment plans.	

* 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

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

The plan will consider options to reduce flood risk across the whole length of a river catchment including upstream land management, strengthening flood defences, reviewing maintenance of banks and channels, considering water level management boards and increasing property resilience. The Cumbria Floods Partnership structure below details how these 5 themes are being delivered in the Flood Action Plans which will be completed in July.

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 31 below helps demonstrate how the two partnerships are working together:

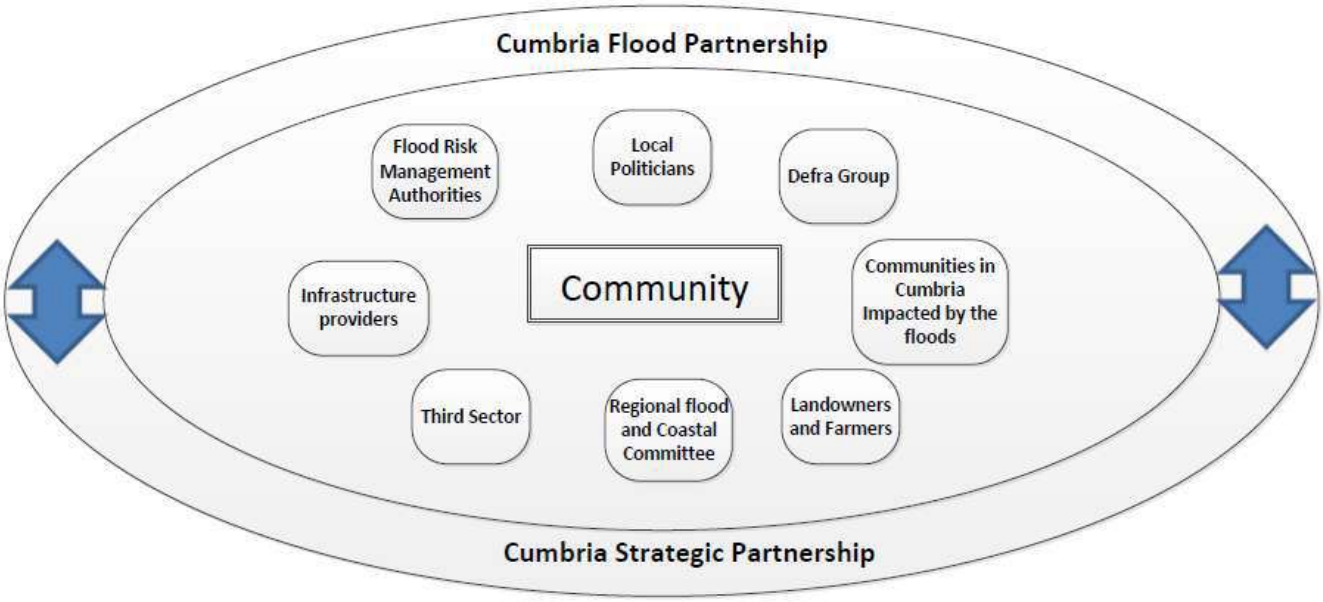


Figure 31: Cumbria Flood Partnership and Cumbria Strategic Partnership

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.

Appendices

Appendix 1: Glossary

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Appendix 3: Links to Other Information on Flooding

Sign up for Flood Warnings
https://www.gov.uk/sign-up-for-flood-warnings

Environment Agency – Prepare your property for flooding; a guide for householders and small businesses to prepare for floods
https://www.gov.uk/government/publications/prepare-your-property-for-flooding

Environment Agency – What to do before, during and after a flood: Practical advice on what to do to protect you and your property
https://www.gov.uk/government/publications/flooding-what-to-do-before-during-and-after-a-flood

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

Flood and Water Management Act 2010:
http://www.legislation.gov.uk/ukpga/2010/29/contents

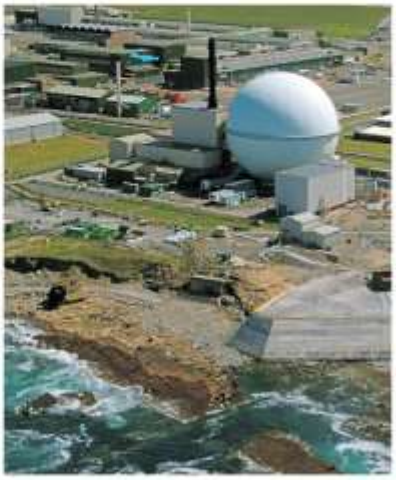
Water Resources Act 1991:
http://www.legislation.gov.uk/all?title=water%20resources%20act

Land Drainage Act:
http://www.legislation.gov.uk/all?title=land%20drainage%20act

Appendix 4: CH2M Hill UK Projects and Flood Risk Management brochure

CH2MHILL.

Key Projects in the UK



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- Municipal Water, Wastewater, and Water Supply
- Aviation, Ports, Transit, and Rail
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- 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 flooding displaced 100,000 people and is estimated to cost $6 billion.
- According to the House of Commons library, £2.34 billion has been spent on new flood defenses in England alone since 2011.