Lyth Valley

Draft Flood Investigation Report

Ulpha Pumping Station, Lyth Valley

Flood Event 5th – 6th December 2015

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

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Executive Summary

The flooding experienced in Cumbria on the 5th and 6th of December 2015 was severe, and was the result of the effects of Storm Desmond. This storm caused a period of prolonged, intense rainfall across Northern England, falling on already saturated catchments, and led to high river levels and flooding throughout Cumbria and beyond.

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 (LLFA), 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 the Lyth Valley on the 5th and 6th December. This flood investigation has used a range of data collected from affected residents, professional partners, site visits, surveys of the area, data collected by observers, and river, tidal & rainfall telemetry during the flood event.

This report details the flooding that occurred across the Lyth Valley. It identifies the flow routes and the likely causes of the flooding, including where river banks were overtopped. In brief, it is concluded that the flooding that occurred in the Lyth Valley was a result of number of different factors identified below.

- Saturated soils in the Lyth Valley and River Kent catchments following intense rainfall throughout November and the first few days in December 2015.
- Heavy rainfall resulted in a smaller flood event on the 10th November that caused a breach in an earth embankment on the Brigsteer Beck / Underbarrow Pool. This did not result in any direct property flooding but had some influence on the subsequent flooding mechanisms on the 5th and 6th December 2015.
- A significant volume of fluvial floodwater was routed through the River Kent catchment on the 5th and 6th December 2015 following the intense rainfall over the surrounding saturated catchments. The floodwater in the River Kent peaked at 20:45 that evening. It was observed that water levels at locations in the lower valley continued to rise until Tuesday 8th December, and did not begin to recede until Thursday 10th December.
- The high tide in the River Kent Estuary restricted the free discharge of the fluvial floodwater in the River Kent into Morecambe Bay and the Irish Sea.
- The volume of floodwater combined with the restriction caused by the high tide, resulted in overtopping of the right bank of the River Kent in the area around Levens Hall and Levens Moss.
- Once out of bank, the fluvial floodwater from the River Kent was routed in a northerly direction up the valley along the flat topographic gradient and initially could only drain back out of the valley via the ‘low level’ system. This resulted in the A590 road being flooded in the vicinity of Levens village and other minor roads being cut off.
- Floodwater present in the high level system near Brigsteer discharged through an existing breach in the embankment on the Brigsteer Beck / Underbarrow Pool, ultimately draining into the low level system and into Levens Main Drain.
- Water present within the Levens Main Drain was pumped back into the River Gilpin at the Sampool Pumping Station. During the peak of the flooding this led to flood water flowing back upstream in the high level system due to the significant fluvial flooding from the River Kent restricting flows into the estuary.

- The A590 road closure at Brettargh Holt was caused by the culverted ordinary watercourse exceeding its capacity and combining with surface water flooding on the public highway.

- The flooding that occurred within the Lyth Valley was not a result of pumping inadequacy; the pumping stations are designed for land drainage purposes and not for flood risk management. Additional pumping capacity is unlikely to have yielded significant betterment during the flood event due to the volumes of floodwater and flat valley topography.

- Following the flooding event the pumping stations, and additional temporary pumps deployed by the Environment Agency, assisted with the speed of the post-event flood recovery by drawing down standing water levels across the flat valley bottom.

Nine actions have been recommended in this report to manage future flood risk in the Lyth Valley, which will require the involvement of a number of organisations and the local community. 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, such as that gathered and collated from the Brigsteer Village Hall community drop-in session held on the 7th January 2016. The scale of this report means that not every piece of information can be incorporated into the document. Any additional information should be provided to:

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

Introduction

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

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

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

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

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

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

Scope of this Report

This Flood Investigation Report **is**:

- an investigation on the what, when, why, and how the flooding took place resulting from the 5th-6th December 2015 flooding event and
- a means of identifying potential recommendations for actions to minimise the risk or impact of future flooding.

This Flood Investigation Report **does not**:

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

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

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

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

To provide feedback on the report please email **LFRM@cumbria.gov.uk**.

Site Background

The Lyth Valley is situated on the edge of the Lake District National Park in south east Cumbria, England, at Ordnance Survey National Grid Reference SD 47225 85593. The flat bottom of the Lyth Valley was originally wetland, but it has been managed for the benefit of agriculture for many decades, with pumped drainage in place for the last 30 years. The Environment Agency currently operates five land drainage pumping stations (PS) within the Lyth Valley and these are as follows:

- Ulpha PS (NGR SD 45586 80723);
- Sampool PS (NGR SD 47244 85540);
- Johnscales PS (NGR SD 46790 86735);
- Pool Bridge PS (NGR SD 46380 88490); and,
- Levens Catchwater PS (NGR SD 48764 84938);

The pumping regime drains the Lyth Valley via an extensive land drainage network which is separated into a 'High Level System' and a 'Low Level System'. The Pool Bridge, Johnscales and Sampool pumping stations discharge into the River Gilpin, whilst the Levens Catchwater and the Ulpha pumping stations discharge into the River Kent Estuary. The Lyth Valley catchment is comprised of a combination of main rivers, ordinary watercourses and an artificial land drainage network.

Since 2005, the Environment Agency's maintenance and operational activities have been assessed using a risk based approach, focusing on areas of greatest flood risk to people and property, in line with Defra guidance. Where the benefit is mainly to land drainage, the Environment Agency has therefore been reducing the extent of watercourse management and reviewing the continued operation of pumping stations in rural areas of Cumbria and elsewhere.

In January 2011, the Environment Agency notified land occupiers that it would cease to operate four land drainage pumping stations at Johnscales, Pool Bridge, Sampool and Ulpha from January 2013, and that funding for channel maintenance would also be reduced. The deadline for withdrawing from the pumping stations has been extended a number of times since then to enable work to be progressed to find an alternative solution. The results of the public consultation undertaken in 2015 showed clear support from affected landowners and occupiers to progress the setting up of a new Water Level Management Board, also known as an Internal Drainage Board. In February 2017 the Notice was extended to 31 December 2020 to provide a realistic timescale to address issues with the relevant legislation.

The Environment Agency will continue to operate the Levens Catchwater pumping station into the future as this asset reduces flood risk to properties in Levens village.

The map (**Figure 1**) on the following page shows the location of the five pumping stations in the Lyth Valley.

Existing Flood Defences

The Environment Agency maintains several flood defence assets and control structures within the Lyth Valley. Both the Rivers Kent and Gilpin are flanked by earth embankments intended to mitigate the risk of fluvial and tidal flooding from Morecambe Bay.

Whilst the primary purpose of the pumping regime in the Lyth Valley is to drain the low-lying topography for agricultural use, the Levens Catchwater pumping station does provide a local reduction in flood risk to the properties in Levens village. The other pumping stations are primarily for agricultural land drainage

and are not designed to accommodate flood flows. A small number of informal earth embankments are also maintained by third parties in the Lyth Valley. A site location map is shown in **Figure 1**.

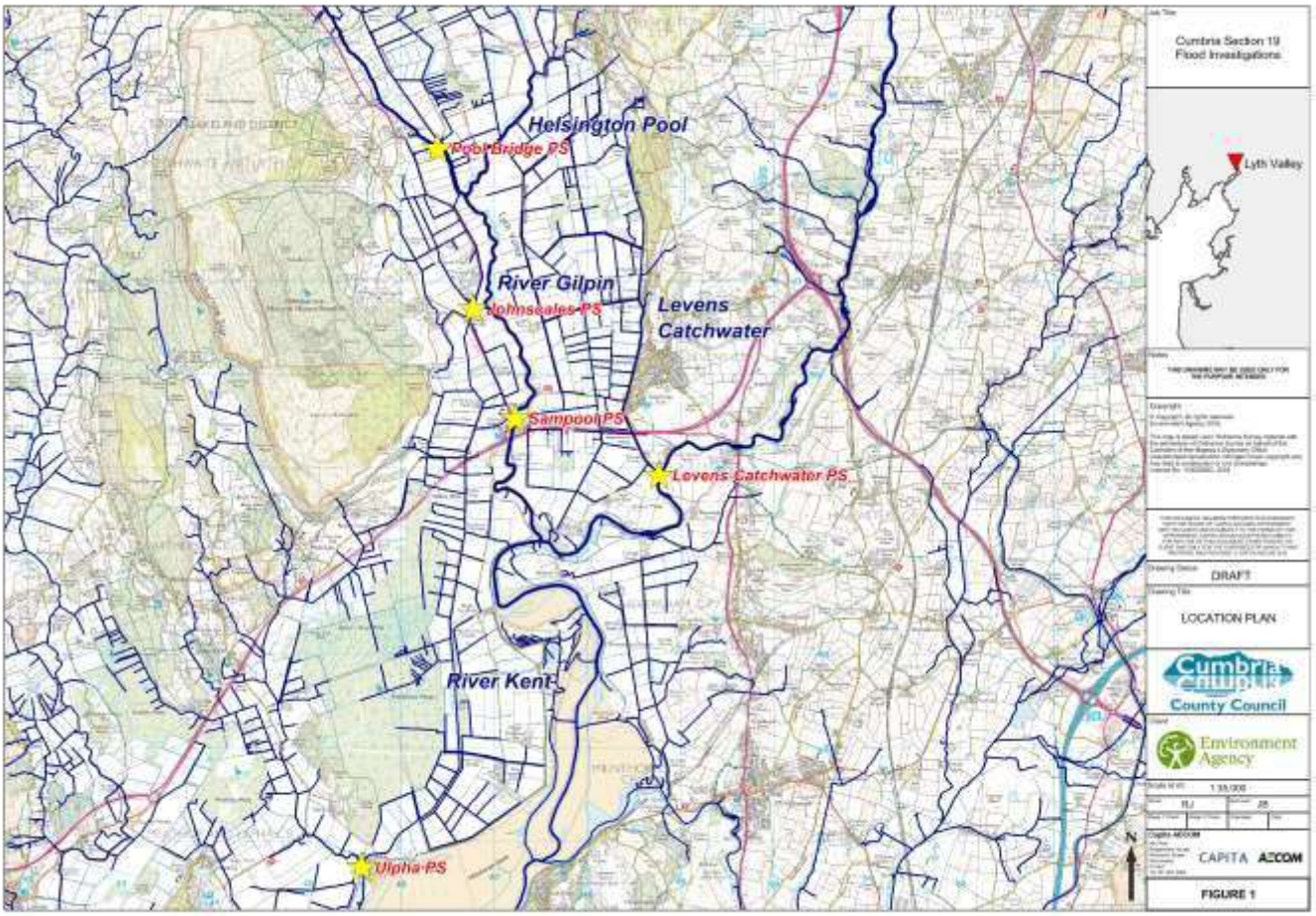


Figure 1: Location Plan

Event Background: December 2015

Flooding Incident

The majority of the flooding that occurred in the Lyth Valley occurred from the 5th December 2015 onwards. This was preceded by a smaller flooding incident on the 10th November 2015.

10th November 2015

On Tuesday 10th November 2015 a section of one of the raised defences on the right hand bank of Brigsteer Beck collapsed. Brigsteer Beck flows through the Lyth valley bottom and the collapse caused the river to flood a number of the adjacent agricultural fields. This collapse did not result in the direct fluvial flooding of any residential properties, but did lead to the closure of the smaller access road from the valley bottom to Brigsteer Village.

5th – 6th December 2015

The flooding that occurred in the Lyth Valley during December 2015 was widespread across the valley floor and remained for an extended period of time due to the flat and low-lying pumped coastal topography. The severity of the flooding was exacerbated by high water levels on the River Kent overtopping the adjacent earth embankments. Further details about the flooding mechanisms are presented in a latter section of this Flood Investigation Report. Strategic photographs of the valley flooding are shown in **Photograph 1** through to **Photograph 4**.

In total approximately 30 properties were impacted by the widespread flooding in the valley floor and a further 20 were marooned by the floodwater. Whilst a number of the flooded properties were isolated and spread out across the valley floor, the following settlements were broadly impacted by the extensive flooding:

- Bellart Howe
- Brigsteer
- Gilpin Bridge
- Lords Plain
- Low Sampool
- Middle Foulshaw (where the majority of the marooned properties were located)
- Summer Hill
- Witherslack

The flooding also resulted in an estimated £100,000 of flood damage at the Levens Hall complex, a historic manor house that is located adjacent to the River Kent and the A6 road (**Photograph 5**).

During the flooding incident the A590 was closed near the junction with the A591 roundabout at Brettargh Holt from 10:00 on the 5th December 2015 until 20:00 the following day, with a number of motorists stranded in their cars for up to 24 hours. The A590 in the Lyth Valley also experienced significant flooding, as indicated by **Photograph 1** below, and was impassable from approximately 17:00 on the 5th December to the afternoon on the 6th December. This resulted in a number of vehicles being stranded in flood water up to a depth of 1m. The flooding of the A590 at a number of locations represented

a loss of the strategic access link to Furness and parts of South Lakeland and also inhibited Environment Agency operational staff from accessing the Bridge End Depot for emergency operations work.

Photograph 1: Lyth Valley, December 2015

Photograph 2: Lyth Valley Flooding, December 2015

(Source: http://www.cumbrianaturally.co.uk/blog/savinhill-farm-flooding-in-the-lyth-valley)

Photograph 3: Lyth Valley from Levens Village, Looking South-West, December 2015

Photograph 4: Flooding near Brigsteer, December 2015

Photograph 5: Receding Floodwater at Levens Hall, December 2015

(Source: https://twitter.com/levensgardener/status/673570209358311424)

Flood Incident Response

November 2015

In response to significant rainfall over the weekend of the 14th November 2015, a decision was made by the Environment Agency Flood Incident Duty Officer to temporarily operate the mothballed land drainage pumping stations at Johnscales and Pool Bridge to help move water from the agricultural land and minor roads in the Lyth Valley on Monday 15th, Tuesday 16th and Wednesday 17th November 2015. Pool Bridge pumping station was damaged during this period and stopped operating. The pumps at the other pumping stations remained in operation throughout the duration of this flood event and into the flooding experience on 5th and 6th December.

December 2015

Heavy rainfall events continued to occur in the first few days of December. During the significant rainfall on the 5th December 2015 four of the five pumping stations were operational in the Lyth Valley, with Pool Bridge pumping station still damaged and not operating. The Environment Agency deployed additional storm water pumps at four of the pumping stations, including Pool Bridge, to assist with draining floodwater from the flat valley bottom. A record of the pumping stations pumps in operation and additional storm water pump deployment is summarised in Table 1 below.

Location	**Pumping station pumps operating in Dec**	Additional storm water pumps put in to draw down flood water						
		7 Dec	**8 Dec**	**9 Dec**	**10 Dec**	**11 Dec**	**12 Dec**	**13 Dec**
Ulpha	X2	1 x 10”		2 x 8”	1 x 6”			1 x 24”
Sampool	X3		1 x 24”		1 x 24”	2 x 6”		
Johnscales	X2	2 x 6”				1 x 4”		
Pool Bridge	None			1 x 8”	1 x 6”			
Levens Catchwater	X2							

Table 1: Operational pumping station and storm water pumps in the Lyth Valley in December 2015

Photograph 6 to **Photograph 9** show some of the additional storm water pumps deployed at the Lyth Valley Pumping Stations during the flooding incident.

Photograph 6: Additional Storm water Pumps Deployed at the Sampool Pumping Station

Photograph 7: Additional 24" Storm water Pumps Deployed at the River Gilpin at Sampool PS

11th December 2015, 08:47, NGR SD 47225 85593

Photograph 8: Additional Storm water Pumps Deployed at the Ulpha Pumping Station

9th December 2015, 12:22, NGR SD 49622 79659

Photograph 9: Additional Storm water Pumps Deployed at the Pool Bridge Pumping Station

9th December 2015, NGR SD 49673 79607

Flood Investigation

This section provides details of the rainfall and fluvial event that impacted the Lyth Valley from the 5th December 2015.

Rainfall, Fluvial and Tidal Events

December 2015 was the wettest calendar month on record, with much of northern England receiving double the average rainfall for that time of year. This also followed a particularly wet November, which resulted in catchments that were already heavily saturated prior to the rainfall event associated with Storm Desmond.

From the 4th to the 7th of December 2015, Storm Desmond resulted in a period of prolonged rainfall across Cumbria, which was particularly intense over 5th- 6th December and caused widespread flooding across the county. Over this period, new 24 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 in the November 2009 flood event, which saw widespread devastation in the towns of Cockermouth, Keswick, and Workington. The record-breaking total rainfall values are presented in Table 2.

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

Table 2: UK Rainfall Records

Within the River Kent catchment, Kentmere Hallow Bank rain gauge recorded a total of 225.8mm of rain between 19:00 on 04/12/2015 and 07:45 on 06/12/2015 and at Fisher Tarn, which is located to the east of Kendal, 139.6mm fell in 48 hours. In the River Mint catchment, the rain gauge at Watchgate recorded 181.8mm of rain in 48 hours. This is the rainfall associated with Storm Desmond and this followed a series of smaller rainfall events in the preceding days, which contributed to the already saturated ground conditions in the catchment due to the prolonged rainfall in November.

Table 3 summarises the rainfall data recorded in the River Kent, Stock Beck, and River Mint catchments during Storm Desmond and illustrates that the data recorded during Storm Desmond far exceeds the previous record gaugings.

Location	Rainfall Period	Storm Desmond		Previous Record	
		Date	Total rainfall (mm)	Date	Total rainfall (mm)
Kentmere Hallow Bank	24 hour rainfall	December 2015	183.4	November 2009	137.6
	48 hour rainfall	December 2015	225.8	November 2009	160.4
Fisher Tarn	24 hour rainfall	December 2015	114.2	October 2008	70.2
	48 hour rainfall	December 2015	139.6	October 2008	74.0
Watchgate	24 hour rainfall	December 2015	147.8	November 2009	89.0
	48 hour rainfall	December 2015	181.8	November 2009	104.8

Table 3: Rainfall data associated with Storm Desmond in the River Kent, Stock Beck and River Mint catchments

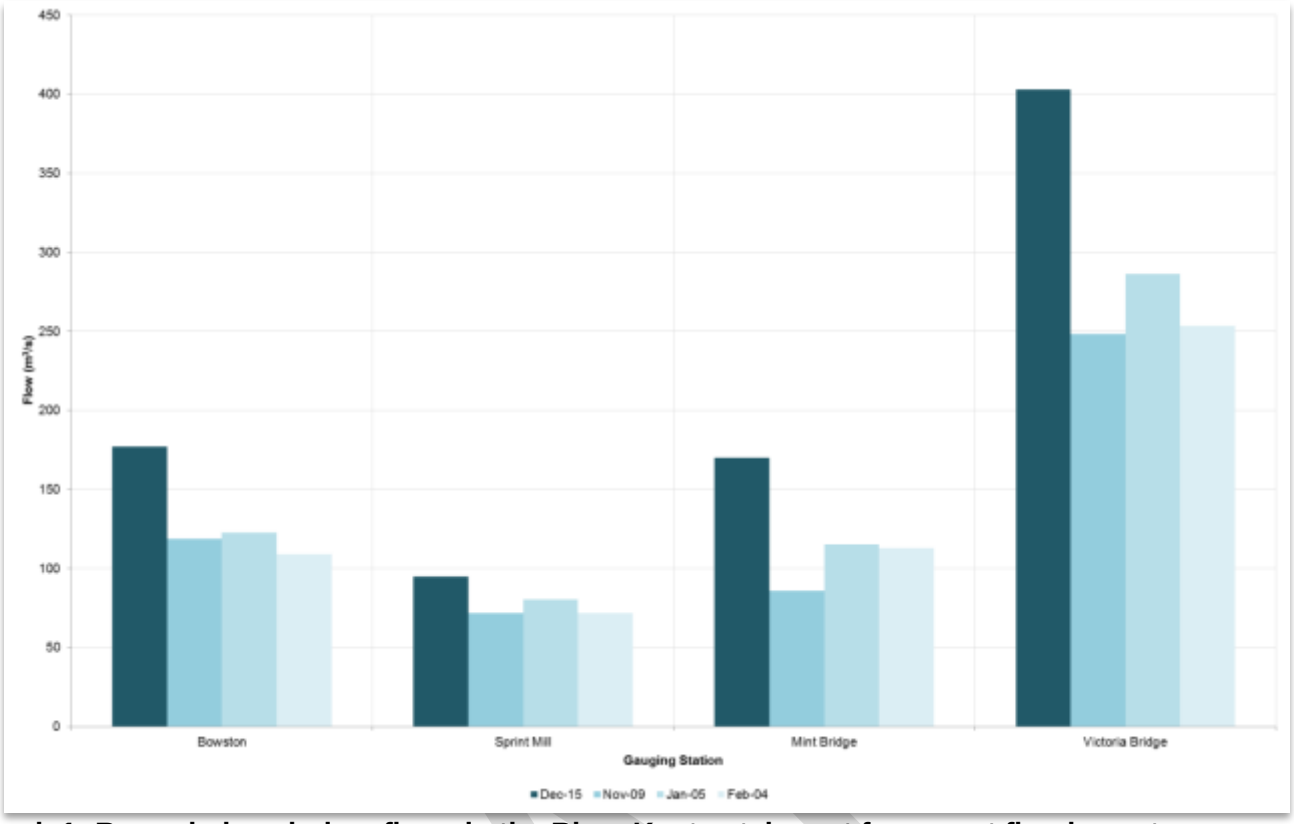
Five principal flow gauging stations are located within the catchment of the River Kent[1]. Three of the stations are located upstream of Kendal, with one on the River Kent (Bowston), one on the River Sprint (Sprint Mill), and one on the River Mint (Mint Bridge). Bowston gauging station replaced Burneside gauging station (now closed) in 1999. Victoria Bridge gauging station is located in the centre of Kendal itself, whilst Sedgwick gauging station is located approximately 3.5km upstream of the Lyth Valley. Together, these stations recorded the fluvial event caused by Storm Desmond, and the recorded data is presented in Table 4, Graph 1 and Graph 2.

Gauging Station	River	Area of upstream catchment (km^2)	Peak flow (m^3/s)			
			Dec 2015	Nov 2009	Jan 2005	Feb 2004
Bowston	Kent	71	177.0	118.9	122.5	109.0
Sprint Mill	Sprint	35	94.8	71.7	80.5	71.9
Mint Bridge	Mint	66	170.0	85.9	115.4	112.8
Victoria Bridge	Kent	183	403.0	248.4	286.5	253.6
Sedgwick	Kent	209	526.8	-	347.0	312.0

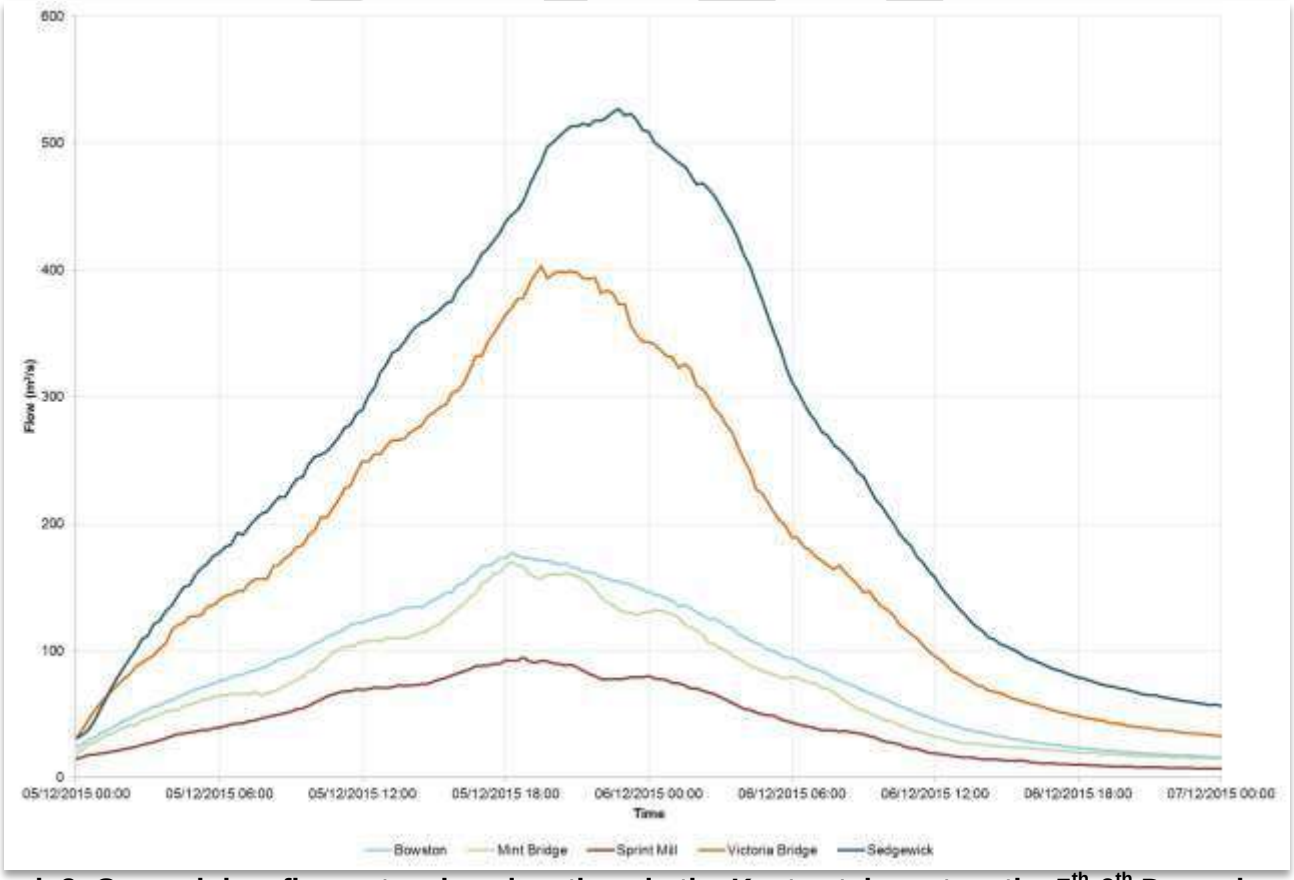
Table 4: Recorded peak river flows in the River Kent catchment for recent flood events

Source: Flow gauging station data obtained from Environment Agency records and the National River Flow Archive (www.nrfa.ceh.ac.uk)

[1] Flow gauging station data obtained from Environment Agency records and the National River Flow Archive (www.nrfa.ceh.ac.uk)

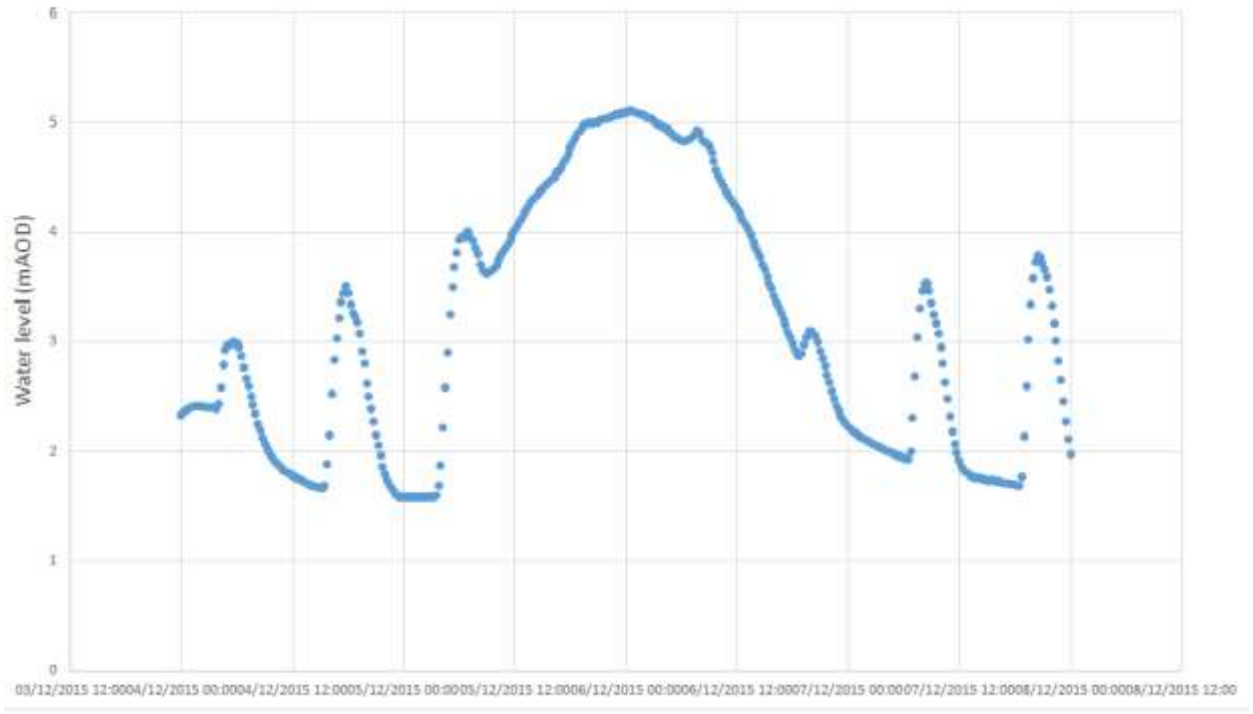


Graph 1: Recorded peak river flows in the River Kent catchment for recent flood events



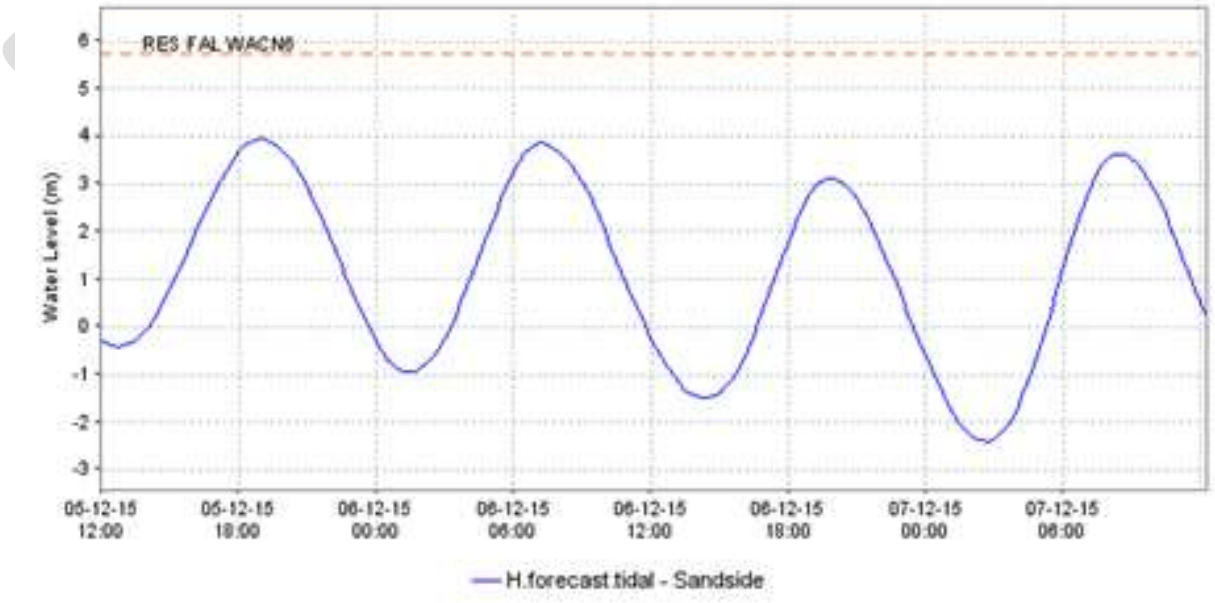
Graph 2: Gauged river flows at various locations in the Kent catchment on the 5th-6th December 2015

The tidal data as recorded at Lancaster Quay on the River Lune is shown in graph 3 below.



Graph 3: Tidal data recorded at Lancas ecember 2015

Storm Desmond occurred at a time of Neap tides, with the forecast tides at Sandside at least 1.5m lower than the Flood Alert level, the level at which roads and car parks begin to flood. The forecast high tide on the evening of the 5th December coincided with the peak fluvial flow recorded in the River Kent. When the recorded data at Lancaster Quay is compared to the tidal forecast at Sandside (shown below in graph 4), the recorded data shows a raised peak through the 5th December. This is indicative of the significantly higher fluvial outflow from the flooded river systems overriding the tidal effect in estuarine areas of Morecambe Bay during this period, combining to produce much higher water levels.



Graph 4: Tidal forecast at Sandside 5th- 7th December 2015

Site Observations

A site visit was undertaken on the 7th June 2016 by the Capita AECOM survey team. The site visit included a walkover of key locations within the Lyth Valley. Key features, observations and photographs from the site visit are presented in **Figure 2**.

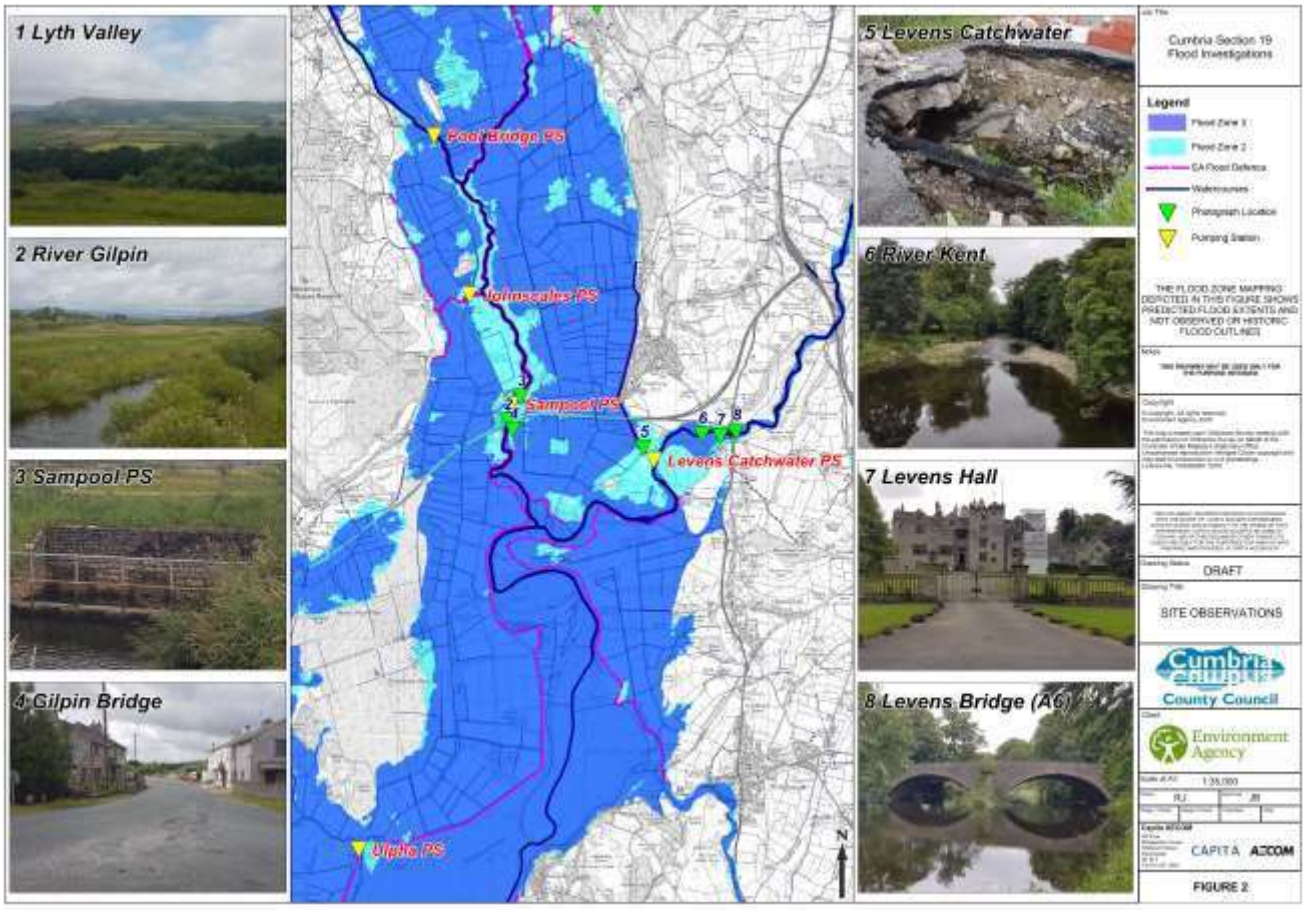
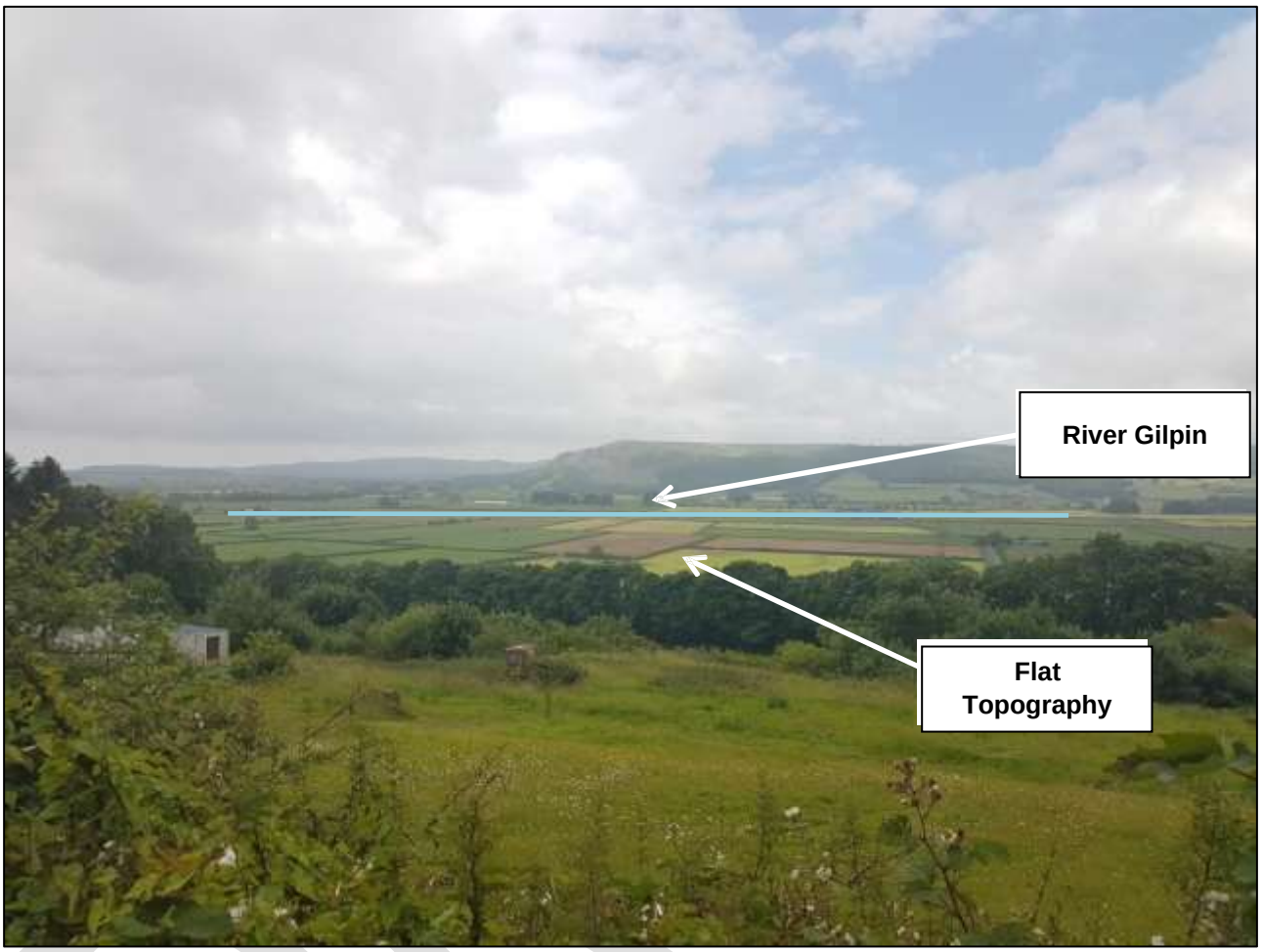


Figure 2: Key Observations

The Capita AECOM survey team commenced the site visit of the Lyth Valley at Levens Village. This settlement is located on the steep valley sides of the Sizergh Fell and as a result of the siting is elevated above the areas of historic flooding and areas of risk of flooding in the future. The flat topography of the Lyth Valley bottom is the primary pathway of the flooding that occurred in December 2015 (**Photograph 10**).



Photograph 10: Overlooking the Flat Topography of the Lyth Valley from Levens Village

July 7th 2016, NGR SD 48854 86836

The survey team undertook a visual inspection of the A6 Road Bridge over the River Kent at Levens Hall (**Photograph 11**). The A6 Road Bridge is located between Levens Hall and the associated Deer Park. This is a substantial twin arch structure with significant capacity for dry-weather flows on the River Kent. At the time of writing the hydraulic modelling project of the River Kent has not been completed; it is therefore not possible to quantifiably determine whether the structure throttled flood flows on the River Kent during the December 2015 flooding. Anecdotal reports from local observers indicate that it may have constrained flows and resulted in a 'backing up' of floodwater within the Levens Hall Deer Park during the incident. Flows also reportedly overtopped the structure during the flooding incident.

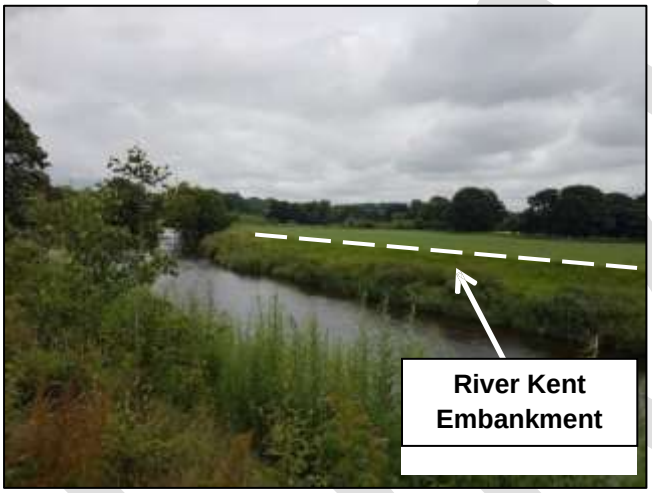
At the time of the site visit, refurbishment works were being undertaken at Levens Hall (**Photograph 12**). The gardens and the complex's car park are immediately adjacent to the River Kent with relatively little freeboard above the river banks on the River Kent. Levens Hall itself is slightly elevated above the surrounding land but is still located within an area at risk of an extreme flood (i.e. the Environment Agency's Flood Zone 2).

Photograph 11: A6 Road Bridge at Levens Hall

July 7th 2016
NGR SD 49608 85229

Photograph 12: Refurbishment Works at Levens Hall

July 7th 2016
NGR SD 49537 85186



Photograph 13: River Kent Embankments

July 7th 2016
NGR SD 48829 85066

Photograph 14: River Kent Embankments

July 7th 2016
NGR SD 48829 85066

There is a raised embankment on the left bank of the River Kent downstream of Levens Hall, which provides protection to farmland belonging to Ninezergh Farm (as shown in **Photograph 13** and **Photograph 14**). The flooding mechanisms observed locally during the flood event, as well as the impacts of the flooding to the local area in the proximity of the embankment, have resulted in local residents concluding that the embankment has a detrimental impact on flood risk to their property.

Further downstream of the Ninezergh farmland, the River Kent is flanked by formal Environment Agency maintained embankments. These assets serve to reduce the risk of fluvial and tidal flooding to agricultural land and properties. During the December 2015 flooding incident elevated water levels in the River Kent resulted in overtopping of embankments on the right bank of the River Kent.

The Levens Catchwater near Low Levens also overtopped during the flood incident and this resulted in local damage to an access bridge and surrounding properties (**Photograph 15** and **Photograph 16**).

Photograph 15: Flood Damage on an Access Bridge over the Levens Catchwater

July 7th 2016
NGR SD 48655 85036

Photograph 16: Levens Catchwater Drain

July 7th 2016
NGR SD 48655 85036

The River Gilpin discharges into the River Kent at NGR SD 47473 84210. Approximately 550m upstream of the confluence the River Gilpin passes beneath the A590 road bridge (**Photograph 17**), fitted with tidal flaps. Another 50m further upstream it also passes beneath the A5074 at Gilpin Bridge (**Photograph 18**).

Photograph 17: A590 Box Culvert at Gilpin Bridge, Looking Downstream

April 28th 2016
NGR SD 49629 79995

Photograph 18: Arch Bridge over the A5074, Looking Downstream

July 7th 2016
SD 49627 79945

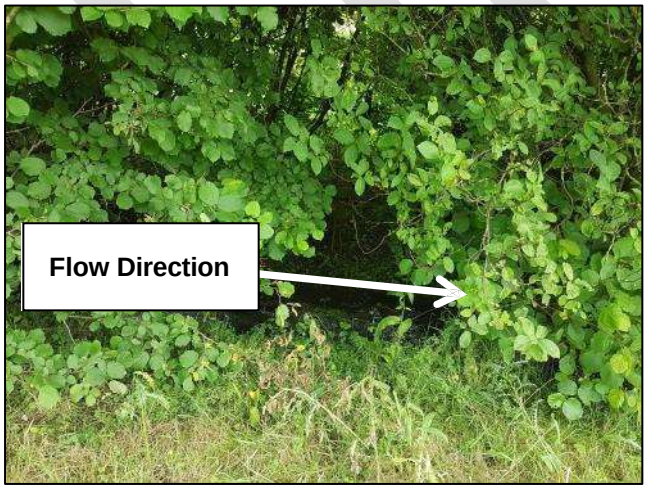
The Sampool Pumping Station is located just upstream of the A5074 road bridge over the River Gilpin. This Environment Agency asset pumps water from the Levens Main Drain into the fluvial river system and was functional during the flooding incident. There is also a siphon culvert to allow water in Levens Main Drain to flow by gravity under the River Gilpin.

Photograph 19: Sampool Pumping Station at the River Gilpin

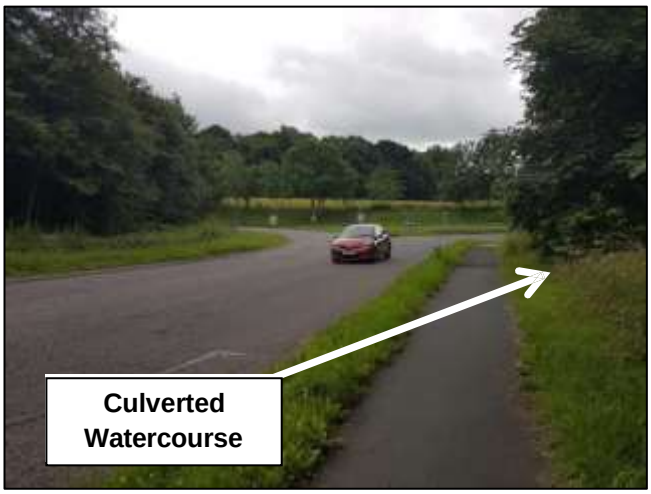
July 7th 2016, NGR SD 47221 85544

The Lyth Valley 'Low Level' system converges with the Witherslack Main Drain at the Ulpha Pumping Station at NGR SD 45586 80723. This is a flapped outfall which discharges via gravity into the River Kent Estuary during low tides. The pumping system pumps water from the Levens Main Drain into the estuary when the outfall is unable to drain via gravity. The efficiency of the gravity outfall is frequently impacted by the natural build-up of silt and sediment within the estuary.

The survey team completed the site visits with a visual inspection of the land around the Brettargh Holt roundabout. An unnamed ordinary watercourse drains the catchment immediately north-west of the roundabout, near Sizergh Castle (**Photographs 20 & 21**). This watercourse passes beneath the roundabout via a culvert and ultimately discharges into the River Kent at OS NGR 350700 486860. It is likely that the flooding which occurred and resulted in the road closure of the A590 was attributable to a combination of this watercourse exceeding the capacity of the culvert and surface water flooding on the public highway.



Photograph 20: Unnamed Watercourse near the Brettargh Holt Roundabout on the A591
April 28th 2016
NGR SD 49629 79995



Photograph 21: Brettargh Holt Roundabout on the A590
July 7th 2016
SD 49627 79945

Likely Causes of Flooding

The flooding which occurred across the Lyth Valley in December 2015 can be attributed to a number of complex flooding mechanisms interacting throughout the course of the flood event. This can be effectively summarised as below.

- Saturated soils in the Lyth Valley and River Kent catchments following intense rainfall throughout November and the first few days of December 2015. Heavy rainfall resulted in a smaller flood event on the 10th November that caused a breach in an earth embankment on Brigsteer Beck. This did not result in any direct property flooding but later had some influence on the subsequent flooding mechanisms on the 5th December 2015.

- A significant volume of fluvial floodwater was routed through the River Kent catchment during the 5th December 2015 following the intense rainfall. The floodwater peaked at 20:45 that evening. It was observed that water levels at locations in the lower valley continued to rise until Tuesday 8th December, and did not start to drop until Thursday 10th December.

- The high tide in the River Kent Estuary restricted the free discharge of the fluvial floodwater in the River Kent into Morecambe Bay.

- The volume of floodwater combined with the restriction of the high tide, resulted in overtopping of the right bank in the area around Levens Hall and Levens Moss.

- Once out of bank, the fluvial floodwater from the River Kent was routed in a northerly direction up-valley along the flat topographic gradient, which initially could only drain back out of the valley via the low level system. The extent of this primary flooding mechanism is apparent in **Photographs 1-3**. This resulted in the A590 road being flooded in the vicinity of Levens village and other minor roads being cut off.

- Floodwater present in the high level system near Brigsteer discharged through the existing breach in the embankment on Brigsteer Beck / Underbarrow Pool, ultimately draining into the low level system and into Levens Main Drain.

- Water present within the Levens Main Drain was pumped back into the River Gilpin at Sampool Pumping Station. During the peak of the flooding this led to flood water flowing back upstream in the high level system due to the significant fluvial flooding from the River Kent restricting flows into the estuary.

- The A590 road closure at Brettargh Holt was caused by the culverted ordinary watercourse exceeding its capacity and combining with surface water flooding on the public highway.

- The flooding that occurred within the Lyth Valley was not a result of pumping inadequacy; the pumping stations are designed for land drainage purposes and not for flood risk management. Additional pumping capacity is unlikely to have yielded significant betterment during the flood event due to the volumes of floodwater and flat valley topography.

- Following the flooding event the pumping stations, and additional temporary pumps deployed by the Environment Agency, assisted with the speed of the post-event flood recovery by drawing down standing water levels across the flat valley bottom.

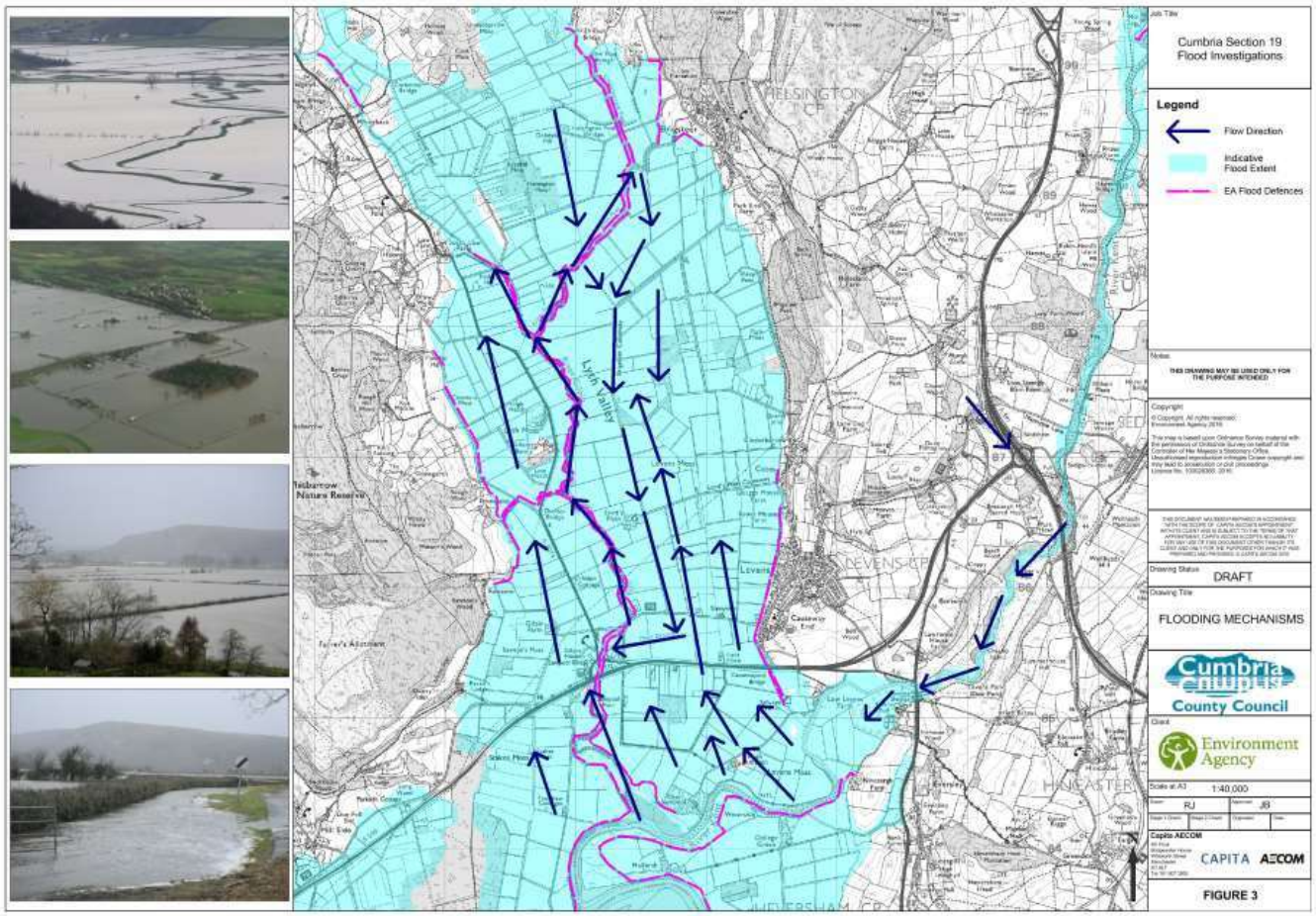


Figure 3: Flooding Mechanisms

Recommended Actions

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

Cumbria Flood Partnership Theme	Action by	Recommended Action	Timescale
Maintenance	Environment Agency	Carry out inspections and repairs to assets which may have been damaged during the flood event.	Asset inspections and any repairs required completed 2016
	Environment Agency	A new Environment Agency system is being developed to make it easier for communities to understand what maintenance work is being carried out in their area. Improvements will show exactly when, where and what maintenance is being planned each year. Make sure that communities understand how they can access information on planned maintenance at: https://www.gov.uk/government/publications/river-andcoastal-maintenance-programme	2017
Resilience	Environment Agency	Complete the hydraulic modelling project for the River Kent catchment in order to inform a better understanding of the level of flood risk and key flooding mechanisms.	Modelling due for completion Autumn 2017
	Residents and South Lakeland District Council	Implement flood resilience measures within flooded properties to reduce the impacts of future flooding. South Lakeland District Council administered the Flood Recovery and Resilience Grants of up to £5000 per property to help people better protect their homes; the grant applications window is now closed. Work to encourage increased resilience will be an ongoing process.	Ongoing
	South Lakeland District Council, Cumbria County Council and Environment Agency	Review Local Development Plans and Strategic Flood Risk Assessment to reflect current understanding of flooding.	2016 - 2017

Resilience	Cumbria Local Resilience Forum*	Review and update plans to enable homes and business to be better prepared for flooding and reduce the impacts of flooding. For example, review of evacuation procedures / emergency response.	Completed in 2016
Water Level Management	Environment Agency, Water Level Management Advisory Group, Landowners & Occupiers, Local community	Work is progressing to create a new Water Level Management Board (WLMB) to take on operation of 4 land drainage pumping stations in the Lyth Valley. This will give responsibility for managing water levels in the valley to those that are most affected.	2017-2020
	Cumbria Floods Partnership (CFP)	The CFP Action Plan considers natural flood management options to reduce flood risk across the catchment. This may include land use changes and/or flood storage.	CFP Action Plan published June 2016
	CFP, Farmers, Landowners, Community Groups, Trusts.	Explore opportunities for natural flood management solutions to be used upstream of the Lyth Valley in order to 'slow the flow' and manage peak river levels.	Medium term (over next 5 years)

Table 5: Recommended Actions for the Lyth Valley

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

Next Steps – Community & Catchment Action Plan

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

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

Defra 25 Year Environment Plan
Cumbria Flood Action Plan
Local Flood Risk Management Strategy

2016 – Cumbria Pioneer	January 2016 - Cumbria Flood Partnership	2013 – LLFA Cumbria Strategic Partnership
DEFRA 25 Year Environment Plan and vision	Created following December 2015 floods	Flood and Water Management Act (2010)
New and innovative ways of working	Local knowledge and expertise	Professional partnership providing strategic leadership for flood risk management
Making best use of resources	Integrated catchment management	Reporting to RFCC
Working at Catchment scale through engagement and commitment	Community focus	Coordination and cooperation between Risk Management Authorities (RMA's)
Place based decision making within DEFRA vision	25 year Cumbria Flood Action Plan	**Lead – CCC as LLFA**
Lead – Jez Westgarth, Environment Agency	**Lead– Rory Stewart MP, Environment Agency and 3 Catchment Directors**	

Communities

Communities working together across Cumbria

Appendices

Appendix 1: Acronyms and Glossary

Acronym	Definition
EA	Environment Agency
CCC	Cumbria County Council
IDB	Internal Drainage Board
LLFA	Lead Local Flood Authority
LFRMT	Local Flood Risk Management Team
FWMA	Flood and Water Management Act 2010
LDA	Land Drainage Act 1991
UU	United Utilities
WRA	Water Resources Act 1991
WLMB	Water Level Management Board

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

Term	Definition
Flood and Water Management Act	Part of the UK Government's response to Sir Michael Pitt's Report on the summer 2007 floods, the aim of which is to clarify the legislative framework for managing surface water flood risk in England.
Flood Storage	A temporary area that stores excess runoff or river flow often ponds or reservoirs.
Flood Zone	Flood Zones are defined in the NPPF Technical Guidance based on the probability of river and sea flooding, ignoring the presence of existing defences.
Flood Zone 1	Low probability of fluvial flooding. Probability of fluvial flooding is < 0.1%
Flood Zone 2	Medium probability of fluvial flooding. Probability of fluvial flooding is 0.1 – 1%. Probability of tidal flooding is 0.1 – 0.5 %
Flood Zone 3a	High probability of fluvial flooding. Probability of fluvial flooding is 1% (1 in 100 years) or greater. Probability of tidal flooding is 0.5% (1 in 200 years)
Flood Zone 3b	Functional floodplain. High probability of fluvial flooding. Probability of fluvial flooding is >5%
Fluvial	Relating to the actions, processes and behaviour of a water course (river or stream)
Fluvial flooding	Flooding by a river or a watercourse.
Freeboard	Height of flood defence crest level (or building level) above designed water level
Functional Floodplain	Land where water has to flow or be stored in times of flood.
Groundwater	Water that is in the ground, this is usually referring to water in the saturated zone below the water table.
Inundation	Flooding.
Internal Drainage Board (now Water Level Management Boards)	Internal Drainage Boards are an integral part of water level management in the UK. Each IDB is a local public authority established in areas of special drainage need in England and Wales. They have permissive powers to manage water levels within their respective drainage districts. They undertake works to reduce flood risk to people and property and manage water levels to meet local needs.
Lead Local Flood Authority	As defined by the FWMA, in relation to an area in England, this means the unitary authority or where there is no unitary authority, the county council for the area, in this case Lancashire County Council.
Main River	Watercourse defined on a 'Main River Map' designated by DEFRA. The EA has permissive powers to carry out flood defence works, maintenance and operational activities for Main Rivers only.
Mitigation measure	An element of development design which may be used to manage flood risk or avoid an increase in flood risk elsewhere.
Overland Flow	Flooding caused when intense rainfall exceeds the capacity of the drainage systems or when, during prolonged periods of wet weather, the soil is so saturated such that it cannot accept any more water.

Term	Definition
Residual Flood Risk	The remaining flood risk after risk reduction measures have been taken into account.
Return Period	The average time period between rainfall or flood events with the same intensity and effect.
River Catchment	The areas drained by a river.
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
Sustainability	To preserve /maintain a state or process for future generations
Sustainable drainage system	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.
Sustainable development	Development that meets the needs of the present without compromising the ability of future generations meeting their own needs.
Sustainable Flood Risk Management	Sustainable Flood Risk Management promotes a catchment wide approach to flooding that uses natural processes and systems (such as floodplains and wetlands) to slow down and store water.
Topographic survey	A survey of ground levels.
Tributary	A body of water, flowing into a larger body of water, such as a smaller stream joining a larger stream.
Watercourse	All rivers, streams, drainage ditches (i.e. ditches with outfalls and capacity to convey flow), drains, cuts, culverts and dykes that carry water.
Water Level Management	Water level management is the general term for any human actions that are used to alter the physical levels of watercourses in order to help manage the area's drainage. Actions may include: dredging, use of pumping stations, excavation of banks etc.
Water Level Management Boards	Internal Drainage Boards are an integral part of water level management in the UK. Each IDB is a local public authority established in areas of special drainage need in England and Wales. They have permissive powers to manage water levels within their respective drainage districts. They undertake works to reduce flood risk to people and property and manage water levels to meet local needs.
Wrack Marks	An accumulation of debris usually marking the high water line.
1 in 100 year event	Event that on average will occur once every 100 years. Also expressed as an event, which has a 1% probability of occurring in any one year.
1 in 100 year design standard	Flood defence that is designed for an event, which has an annual probability of 1%. In events more severe than this the defence would be expected to fail or to allow flooding.

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

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

Flood Source	Environment Agency	Lead Local Flood Authority	District Council	Water Company	WLMBs	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 are the LLFA for Cumbria. 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 Local Flood Risk 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

Internal Drainage Boards also known as Water Level Management Boards are an integral part of water level management in the UK. Each one is a local public authority established in areas of special drainage need in England and Wales. They have permissive powers to manage water levels within their respective drainage districts. They undertake works to reduce flood risk to people and property and manage water levels to meet local needs.

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 Making Space for Water Groups 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 (FlAGs) are usually formed by local residents who wish to work together to resolve flooding in their area. The FlAGs are often supported by either CCC or the EA and provide a useful mechanism for residents to forward information to the Making Space for Water Group.

Appendix 3: Useful contacts and links

Sign up for Flood Warnings

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

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

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

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

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

Environment Agency – Living on the Edge: A guide to the rights and responsibilities of riverside occupiers

https://www.gov.uk/government/publications/riverside-ownership-rights-and-responsibilities

Flood and Water Management Act 2010:

http://www.legislation.gov.uk/ukpga/2010/29/contents

Water Resources Act 1991:

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

Land Drainage Act:

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

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