

# Sedbergh

## Flood Investigation Report



**Flood Event 5-6<sup>th</sup> December 2015**

This Flood Investigation Report has been produced by Cumbria County Council 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.

<b>Version</b>	<b>Undertaken by</b>	<b>Reviewed by</b>	<b>Approved by</b>	<b>Date</b>
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# Executive Summary

The flooding experienced in Sedbergh on the 5<sup>th</sup> and 6<sup>th</sup> of December 2015 was one of the most significant flood events in the history of the town, and was the result of the effects of Storm Desmond. This storm caused a period of prolonged, intense rainfall across Northern England, falling on an already saturated catchment and led to high river levels and flooding throughout Cumbria. Sedbergh was affected by flooding from several ordinary watercourses that feed into the main watercourse through the town. Due to the steep nature of the local topography in Sedbergh, there were also flooding impacts from surface water runoff.

In response to the flood event, this *Section 19 – Flood Investigation Report* has been completed by the Cumbria County Council as the Lead Local Flood Authority, under the duties as set out in Section 19 of the Flood and Water Management Act 2010. This report provides details on the flooding that occurred in Sedbergh on the 5<sup>th</sup> and 6<sup>th</sup> of December, and has used a range of data collected from affected residents, professional partners, site visits, surveys of the area, data collected by observers, and river & rainfall telemetry recorded during the flood event.

This report examines the flooding that occurred in Sedbergh from the various sinks in the area that feed the ordinary watercourses and from surface water. It identifies the likely causes of flooding in the following investigated areas:

- Maple Close/Recreation ground
- Rehearsal Hall/Supermarket
- Guldrey Terrace
- Guldrey Lane/Guldrey Fold
- Loftus Hill
- Main Street area

A total of 9 actions have been recommended in this report to manage future flood risk, which will require the involvement of a number of organisations and the local community. These actions include investigating potential improvements to the existing flood warning service and reviewing the catchment gravel management programme.

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

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

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

## Flooding History

Due to the steep nature of the local watercourse catchments that drain into Sedbergh, the various watercourses that flow through the town respond very rapidly to heavy rainfall. The rapid response of the local watercourses to heavy rainfall means that Sedbergh is classified as being at high risk of flash flooding.

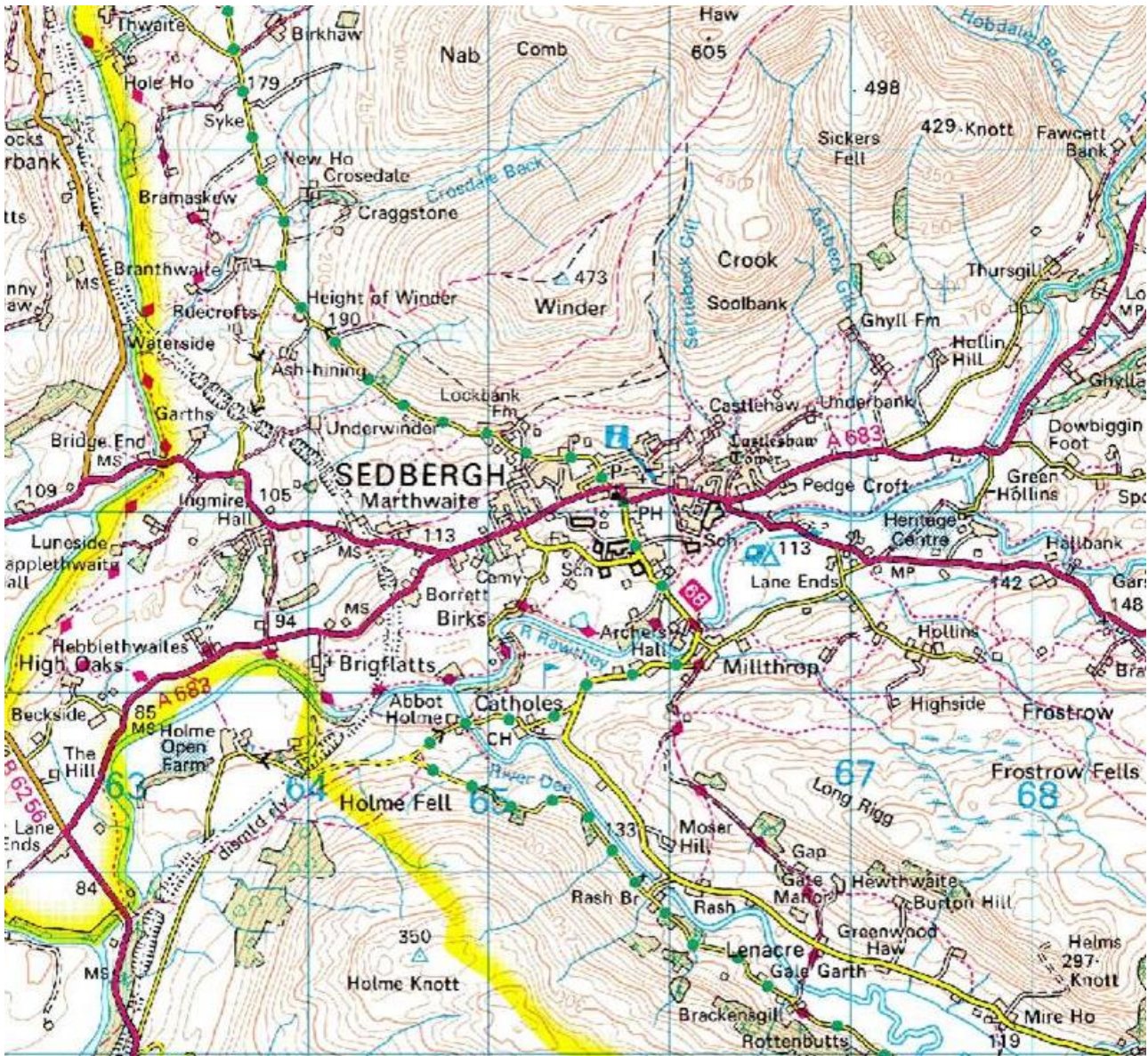
There are records of flooding in Guldrey Lane in 200.2005.2009 and 5<sup>th</sup> Dec 2015.

# Event background

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

## Flooding Incident

Sedbergh is a small town situated in the county of Cumbria in the north west of England, with a population of approximately 2800. The town is located on the A684 east of Kendal. Due to the steep nature of the local watercourse's they react very quickly to heavy rainfall.



**Figure 1 - Location of Sedbergh**

On the 5<sup>th</sup> and the 6<sup>th</sup> of December 2015, approximately 5 properties in Sedbergh were affected by flooding. This flooding can be attributed to a record-breaking rainfall event from Storm Desmond. This led to flooding from the nearby ordinary watercourses indicated with in figure 2 below.



Figure 2 – Ordinary watercourses.

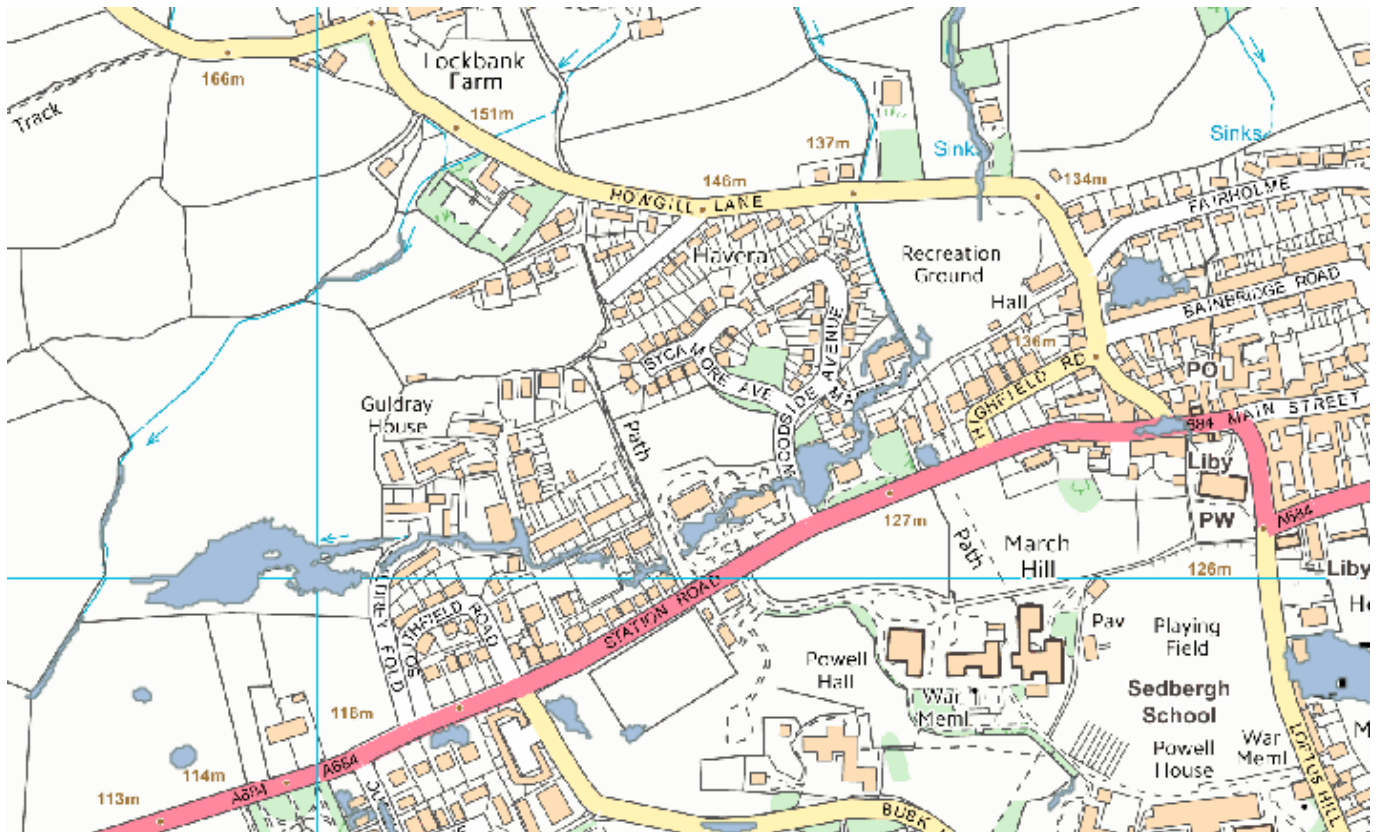


Figure 3 1 in 100 risk of surface water flooding





**Figure 4 - Identification of Areas Flooded**

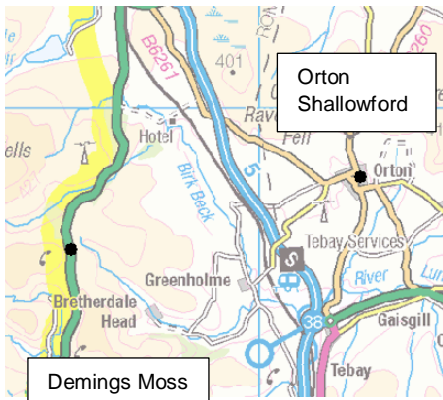
# Investigation

This section describes the rainfall and fluvial events that occurred in the local of Sedbergh, and the likely causes of flooding.

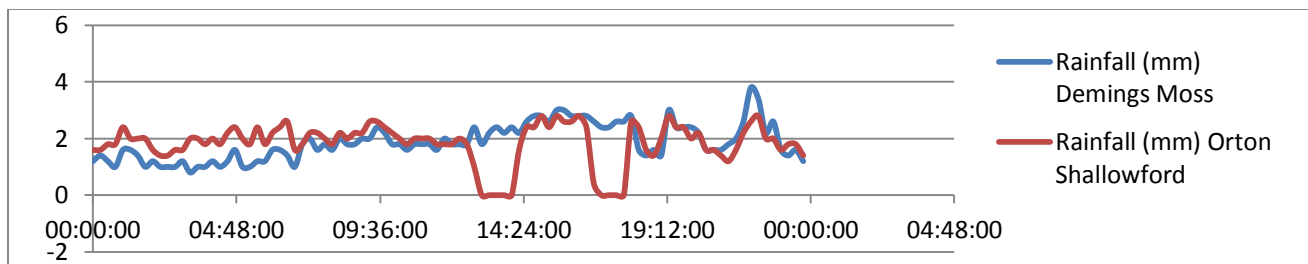
This investigation was carried out by Cumbria County Council and the data was collected from surveys of the area

## Rainfall Event

In November to December 2015 slow-moving low pressure systems driven by a sustained moist south-westerly airflow brought prolonged heavy rainfall to northern and western areas with the persistent unsettled weather (including the named storms 'Desmond', 'Eva' and 'Frank') causing widespread and repeated flooding. Based on data released by the Met Office, December 2015 was the wettest calendar month on record (in a series from 1910) with new 24-hour and 48-hour rainfall totals of 341.4mm (Honister Pass, Cumbria) and 405.0mm (Thirlmere, Cumbria), respectively, delivered by Storm 'Desmond'.

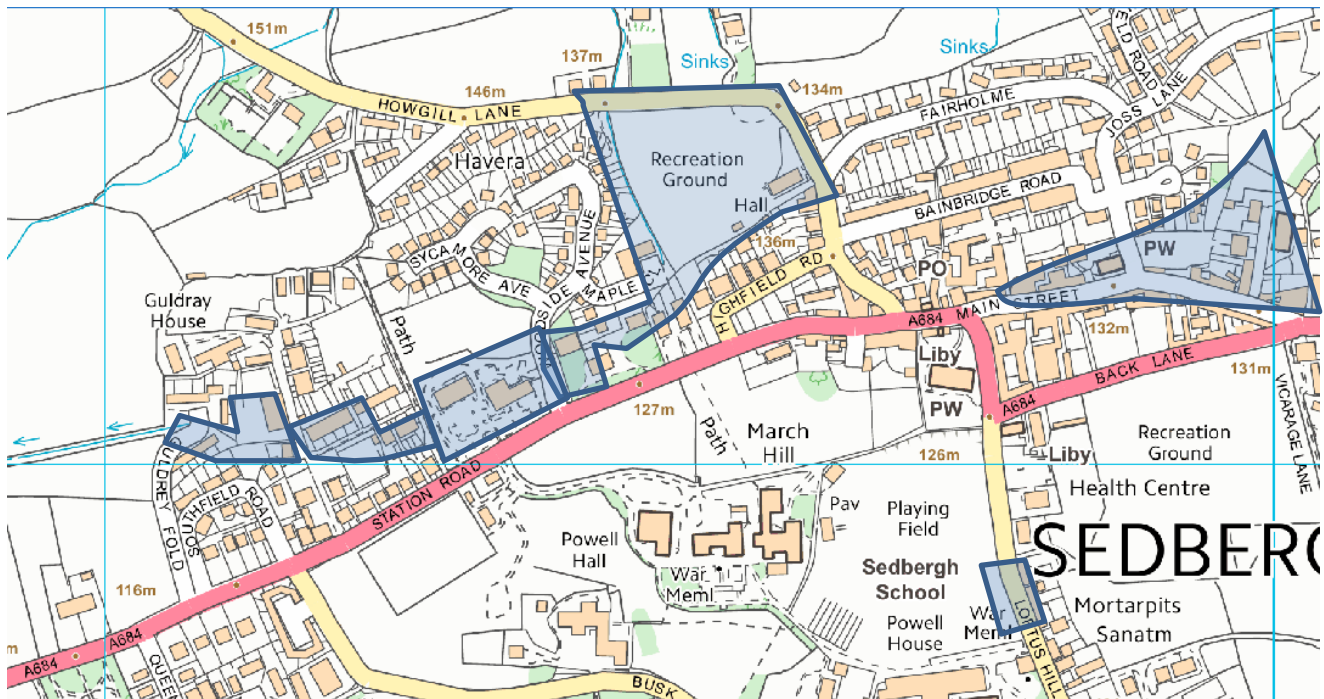


Specifically for Sedbergh, the two nearest rainfall gauging stations are Orton Shallowford (NY 62465 08323) and (NY 55452 06553) which recorded rainfall totals of 174.8mm and 179.8mm on 5 December 2015. The rainfall levels experienced throughout the 5 December 2015 at the two rainfall gauging stations are illustrated in Figure 3 below.



## Sources of Flooding, Flood Flow Routes

There were a number of different flood flow routes during this event. For this report, the flooded area has been divided into 6 sub-areas, as shown below.

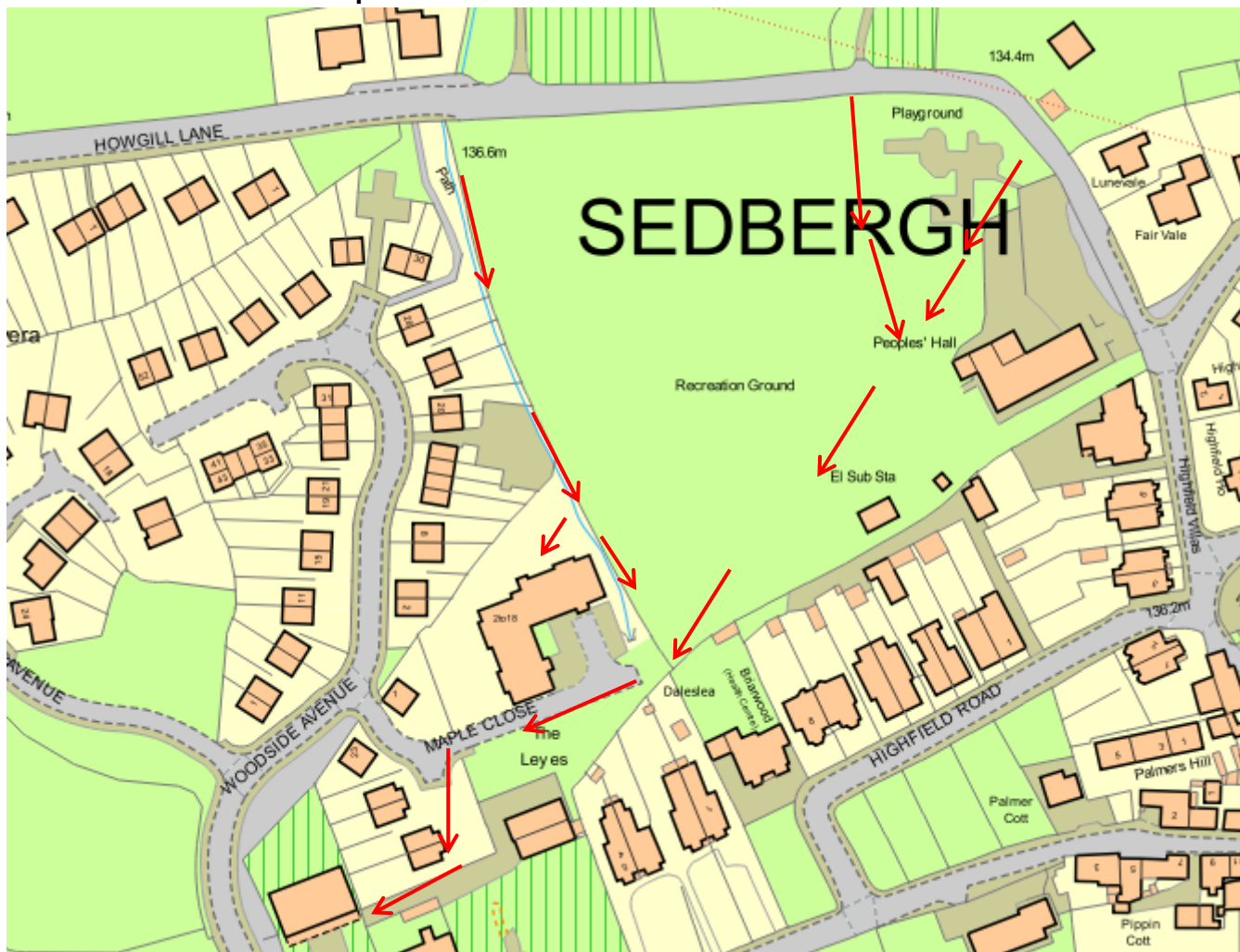


**Figure 5- Indicates the location of the 6 sub-areas**

The details of the flow routes into the 6 sub-areas, the likely causes, and the properties affected are discussed in the 'Impacts and Likely Causes of Flooding' section. Although every effort has been made to accurately identify the likely flooding mechanisms, there are other sections of Sedbergh which have identified flooding and overland flows and are currently under investigation see figure 6 and 7 below.

# Impacts and Likely Causes of Flooding

## Recreation Ground and Maple Close/Nook Lane



**Figure 8- Flows across Recreation Ground exceeded across Howgill road**

Fell side flood water was channelled into 3 sections of open watercourse to the North of Howgill Lane in Sedbergh. The watercourse carried a vast amount of debris and sediment which led to the clogging up of the culvert entrances and blocking of the catcher screens see image 1 below.



**Image 1: Shows the amount of debris trapped on debris screens upstream of Howgill Road**

The culverts were unable to take the volume of water and as a result the watercourse overtopped and continued across the play areas and across Sedbergh Football field towards Maple Close. Once the

flood water made it into the south east corner of the football field the flood water was unable to re-join the due to capacity and some flood water due to the levels passed the culvert catcher shown in image 2 below.



**Image 2: Shows the debris screen on the east boundary in Maple Close.**

Flood waters containing overland surface water and watercourse exceedance continued to flow in a westerly direction through gardens towards a section of Sedbergh School and the music hall.

### Rehearsal Hall/Supermarket



**Figure 9- Shows the flow route through the new build development**

Rehearsal Hall was flooded as the watercourse exceedance was unable to re-enter the culvert. The flood water built up against the side of the public highway which is higher than the ground levels around the music hall. The School made efforts to prevent flood water ingress by placing sandbags against the music hall doors and windows. Once the flood water built up it then flowed over the top of the public highway and then down the access road to rear of the Sedbergh medical centre and towards the rear of the Spar where the flows where met with surface water runoff from the fell which had travelled overland and came down the path from Howgill Lane.

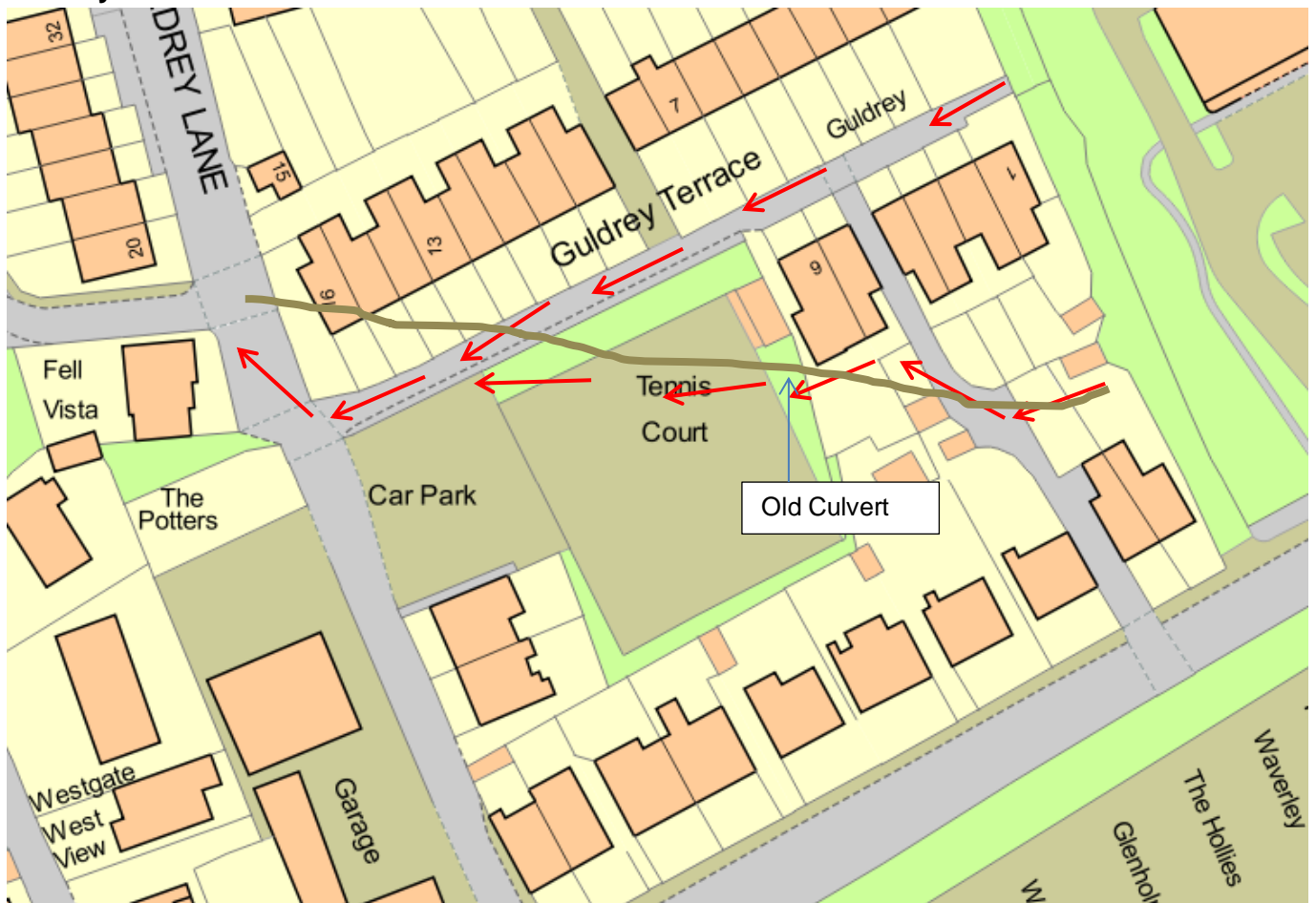


**Image 3 – Shows the ditch at the side of the music Hall where the watercourse exceedence built up, Image was taken from the public Highway and indicate the change in levels**



**Image 4 – Shows the footpath which overland flow channelled down from Howgill Lane and converged on the watercourse exceedence route**

## Guldrey Terrace



**Figure 10– Shows an overlay of the surface water exceedance rout in relation to the old stone culvert**

Old culvert exceeded in the back garden of the Nook house the flows then passed through a number of gardens and across on to the tennis courts. The flood water then joined with flow routes coming down the footway/ access track at the front of Guldrey Terrace. The two flow routes then joined and flooded the lane and then flowing west down Guldrey Terrace and towards Guldrey Lane.

The surface water and watercourse exceedance almost entered the properties of Guldrey Terrace however the residents had taken action to prevent water entering the properties. During the peak of the storm the flood water was up against the front door steps of the properties on Guldrey Terrace.



**Image 5 – Shows the location where the watercourse exceedance from The Nook joins the overland flows from the footpath.**



**Image 6 – Indicates the location in the rear of The Nook where the watercourse had forced its way out of the old stone culvert. The image was taken by residents after the event and after works had been done to repair the culvert wall collapse.**

Once the surface water had left Guldrey Terrace it continued to flow west towards Guldrey lane and the new build development on the former builder's yard and former Cumbria County Council Depot.



The flood water ponded outside the properties and the into a number of properties on Guldrey Lane, residents took action to further protect the properties by placing a temporary barrier in the highway to direct the flooding onto the car park area at the rear of the development see image 7 below.



**Image 7 – Temporary barrier to protect properties on Guldrey Lane**

The drains were unable to bring down the flood water levels in the car park area and the boundary wall to the rear of No 7 Guldrey Fold created a barrier which the flood water built up behind. Some of the water passed through and later over the wall controlling the discharge and protecting potential flooding to No7 Guldrey Fold. See image 8 below shows the open channel of the watercourse, image was taken from the carpark to the rear of the flooded properties on Guldrey Lane and look across the rear garden of No 7 Guldrey Fold.



**Image 8 – Shows the location of the open watercourse**

## Main Street and Loftus Hill area



Figure 6- Indicates the location of flooding reported in the Draft flood forum which had an impact on Main Street Sedburgh



Figure 7- Loftus Hill, Sedburgh and investigation into Cumbria County Council and United Utilities surface water system

- A. Catch pit in the public footpath
- B. Underground catch pit which lifted in a flash flood in June 2016
- C. Overland flows which channelled through gardens and onto the Joss Lane pay and display car park

- D. Cellar flooding to properties at the bottom of New Street in Sedbergh
- E. Overland flows which has channelled down the public highway Castlehaw Lane in Sedbergh. The flows carried significant amounts of debris from the fell which was deposited on the public highway.
- F. Loftus Hill in Sedbergh, this location has been under investigation with United Utilities as the system is combined. UU have undertaken works to clear gullies and manholes in the area and have discovered a potentially separate surface water system which is under investigation with Cumbria County Council highways department. Loftus hill resulted in internal flooding to No 3, 4, 5 and 6 in December 2015 and unfortunately No 7 was flooded internally in June 2016.

The above locations have been discussed with Cumbria County Council Highways Department and United Utilities and will be further investigated by both organisations.

# 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 (WLMB's). Some of these recommendations may have already been carried out or are ongoing.

Cumbria Flood Partnership Theme	Action by	Recommended Action	Timescale
Resilience	Cumbria Local Resilience Forum <sup>1</sup>	Review and update plans to enable homes & business to be better prepared for flooding & reduce the impacts of flooding. For example, review of evacuation procedures / emergency response.	2016
	Residents & South Lakeland District Council	Implement flood resilience measures within flooded properties to reduce the impacts of future flooding. South Lakeland District Council is administering the Flood Recovery and Resilience Grants of up to £5000 per property to help people better protect their homes. A further £2,000 top up grant can also be applied for from the Cumbria Flood Recovery Fund.	Closing date for grant applications is end of December 2016
	South Lakeland District Council, Yorkshire Dales National Park Authority, Cumbria County Council and Environment Agency	Review Local Development Plans and Strategic Flood Risk Assessment to reflect current understanding of flooding.	2016
	Cumbria County Council United Utilities, Environment Agency and Electricity North West.	Review the resilience of critical transport, utility and power supply infrastructure in relation to flood risk.	2016
Upstream Management	Cumbria Floods Partnership (CFP)	The CFP action plan will consider natural flood management options to reduce flood risk across the catchment. This may also include land use changes and/or flood storage.	Summer 2016
	Cumbria Floods Partnership (CFP), Farmers,	Explore opportunities for natural flood management solutions to be used upstream of Sedbergh in order to 'slow the flow' and manage peak river levels.	Medium term (over next 5 years)

<sup>1</sup> 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.

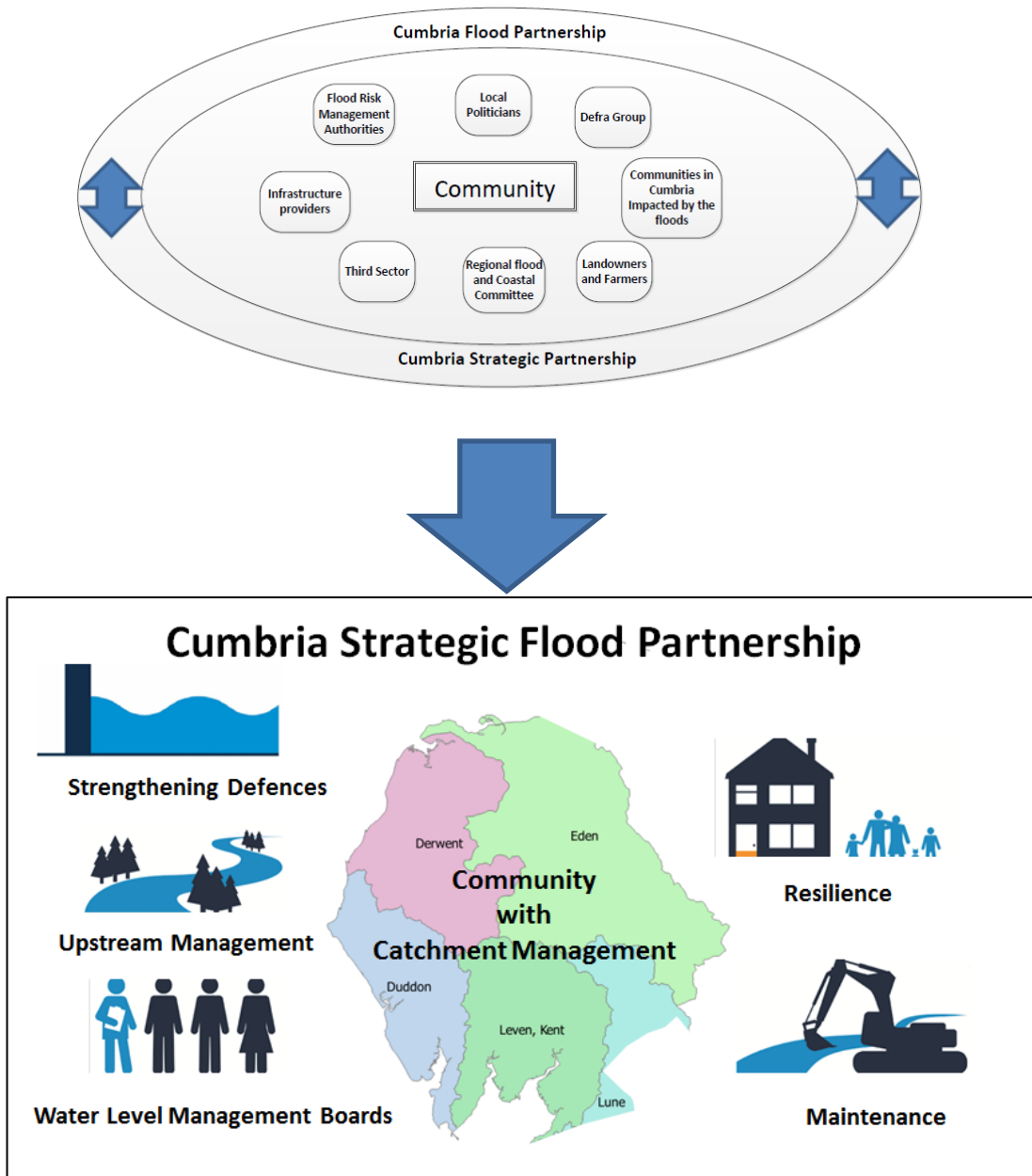
Cumbria Flood Partnership Theme	Action by	Recommended Action	Timescale
	Landowners, Community Groups, Trusts.		
<b>Maintenance</b>	Environment Agency, United Utilities and Cumbria County Council	Carry out inspections and repairs to assets which may have been damaged during the flood event.	Guldrey Terrace area COMPLETED Other locations awaiting update
	Cumbria County Council, South Lakeland District Council and United Utilities	Review the performance of the existing drainage and sewerage systems during the event to better understand where improvements are required.	Guldrey Terrace area COMPLETED Other locations awaiting update
	Cumbria County Council in partnership with the Environment Agency and United Utilities	Conduct a detailed assessment for Sedbergh the Surface Water Management Plan process and identify solutions to mitigate surface water flood risk in high risk areas that will integrate with fluvial flood risk mitigation options as part of a joined up approach	2016-2017

**Table 1 - Recommended actions for consideration**

# Next Steps – Community & Catchment Action Plan

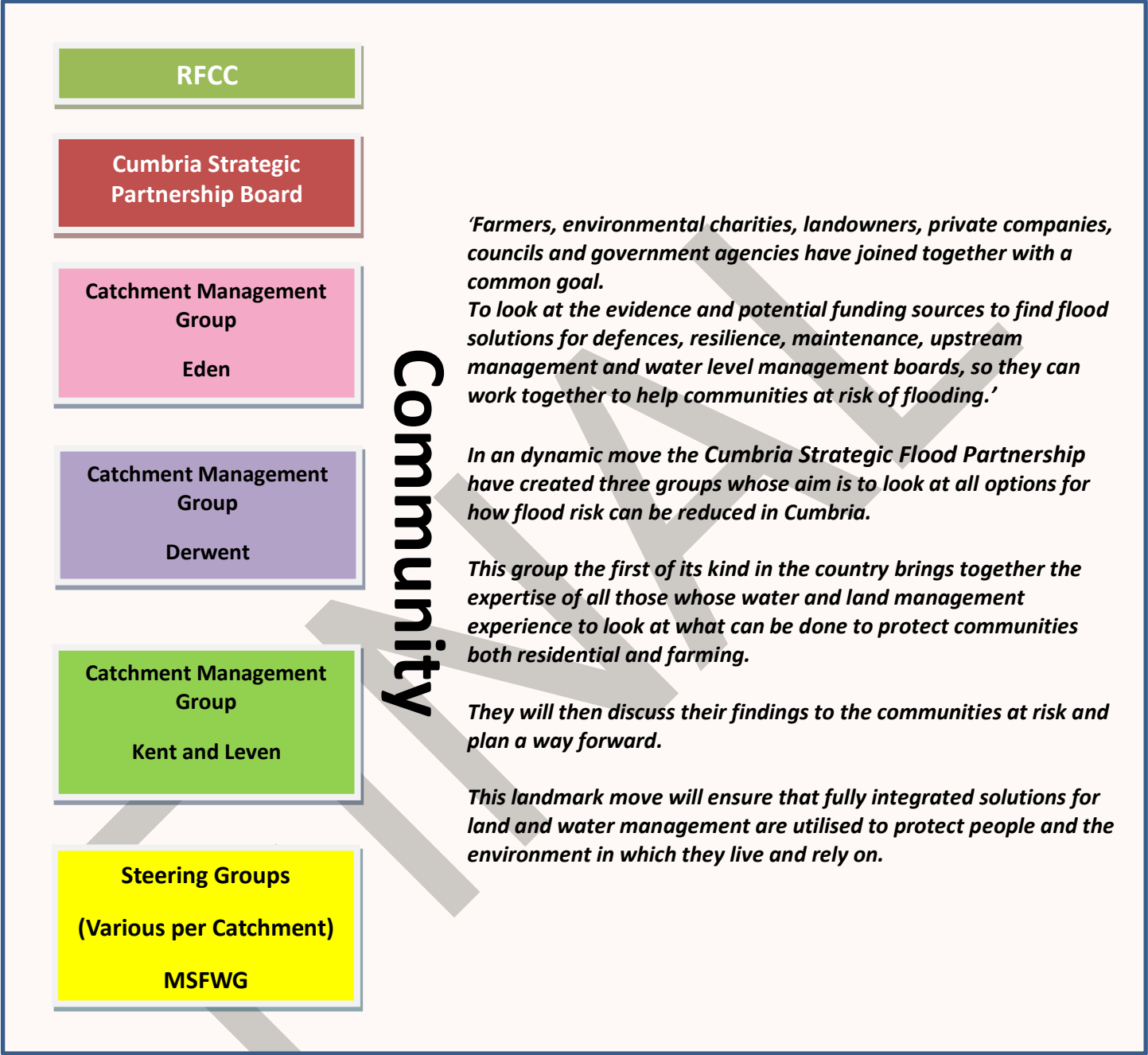
The Cumbria Floods Partnership has brought together a wide range of community representatives and stakeholders from a variety of sectors to plan and take action to reduce flood risk. The Cumbria Floods Partnership, led by the Environment Agency, is producing a 25 year flood action plan for the Cumbrian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





# Cumbria Strategic Flood Partnership



# Appendices

## Appendix 1: Acronyms and Glossary

AEP	Annual Exceedance Probability
CCC	Cumbria County Council
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
FLAG	Flood Action Group
FWD	Floodline Warnings Direct
LLFA	Lead Local Flood Authority (under the Flood and Water Management Act 2010)
MSfWG	Making Space for Water Group
RMA	Risk Management Authority (under the Flood and Water Management Act 2010)
SLDC	South Lakeland District Council
UU	United Utilities

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



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

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

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

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

Flood Source	Environment Agency	Lead Local Flood Authority	District Council	Water Company	Highway Authority
<b>Rivers</b>					
Main river					
Ordinary watercourse					
<b>Surface Runoff</b>					
Surface water					
Surface water on the highway					
<b>Other</b>					
Sewer flooding					
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:** Strategic overview of all sources of flooding and coastal erosion as defined in the Flood and Water Management Act (2010). As part of its role concerning flood investigations, this requires providing evidence and advice to support other RMAs. The Environment Agency also collates and reviews assessments, maps and plans for local flood risk management (normally undertaken by LLFA).

**Lead Local Flood Authorities:** Cumbria County Council is 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 RMAs 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 now responsible for a larger number of sewerage than prior to the regulation. These organisations are classed as RMAs.

**Highway Authorities:** 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 RMAs.

Flood risk in Cumbria is managed through the Making Space for Water (MSfW) process, which involves the co-operation 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 MSfW Groups will meet approximately 4 times per year to co-ordinate operations and work together to mitigate flood risk in the vulnerable areas identified in this report by completing the recommended actions. As LLFA, CCC 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 partner's own capital investment process.

Flood Action Groups are usually formed by local residents who wish to work together to help reduce flood risk in their area. The FAGs are often supported by either CCC or the Environment Agency and provide a useful mechanism for residents to forward information to the MSfW Group.

## 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 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>

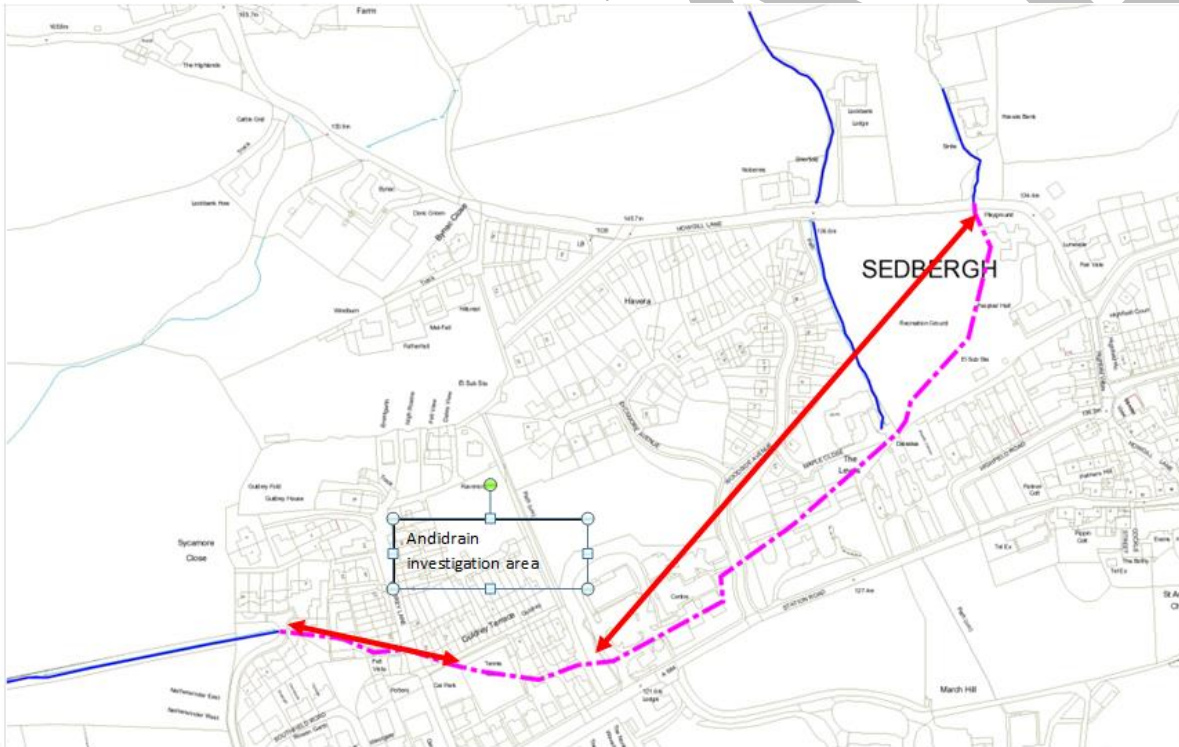
## Appendix 4: Culvert investigation works

Cumbria County Council as Lead Local flood Authority had commissioned Sapphire to undertake a detailed CCTV survey on the section of Culvert between the Spar car park and Guldrey Lane in Sedbergh.

The survey was to follow on from the Andidrain survey which was started on the 21<sup>st</sup> March 2016 however was inconclusive in mapping the section between The Spar and Guldrey Lane as more invasive techniques would be required with landowner permissions needed.

The culverted watercourse which runs across the health centre and Spar is contained within a 900mm diameter concrete ring culvert which discharges into a stone built block culvert in the rear garden of The Nook. The stone box culvert then changes in construction type again back to a concrete 300mm diameter pipe under the road at Guldrey Lane.

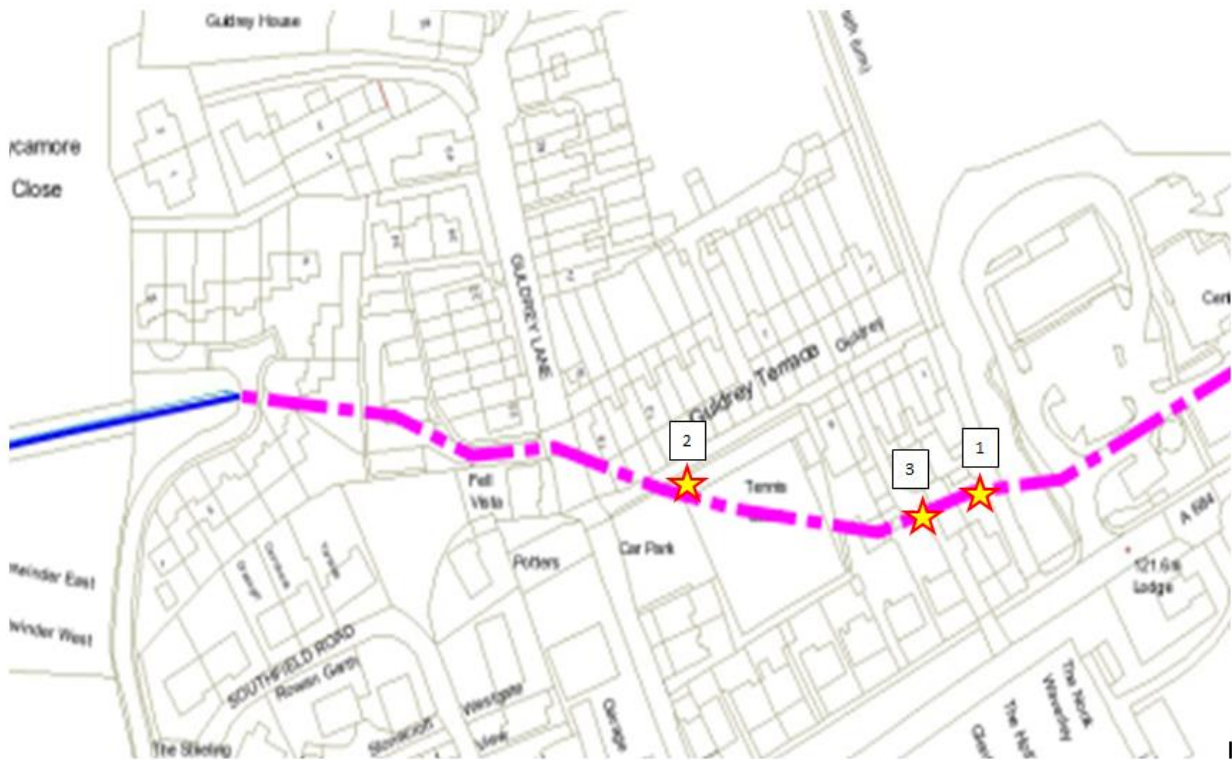
During the original survey undertaken by Andidrain the camera unit was unable to pass through the garden area at the rear of “The Nook” and was also unable to proceed from the downstream access on Guldrey Lane past a mass of roots located in the front gardens of Guldrey Terrace. There were no other obstructions within the culverted watercourse system.



### Location plan 1: Andidrain investigation area March 2016

Once permissions were granted by the riparian landowners Sapphire were then able to start work on the 26<sup>th</sup> September 2016. These works were to further investigate the section of culverted watercourse between the Spar and Guldrey Lane.

The works started with an attempt to clear the debris blocking the culvert in the rear garden of The Nook (Location 1) see location plan 2.



**Location plan 2: Sapphire Access excavation locations**

It was soon evident that although large stones had blocked the culvert and reduced the capacity to as little as 10-15% there was a significant amount of smaller sediment behind this which also reducing the capacity of the stone culvert to between 70% near Guldrey Terrace and 30% at the rear gardens of Waverley and The Nook . Image A below shows the size of stones removed by hand from the access chamber in the rear garden of The Nook.



**Image A: Debris removed from culvert by hand located in the Garden of “The Nook”**

It was then that Sapphire started works to excavate an access onto the stone culvert in the grass verge area between Guldrey Terrace and the Tennis Courts (Location 2), Image B below shows the location of the access excavation.



**Image B: Shows the location of access excavation 2 in the grass verge opposite Guldrey Terrace.**

From this excavation it was evident that the stone built block culvert had more capacity in this location however there was still only 40% of capacity available. The image C below shows the condition of the culvert after jetting and loose sediment had been removed. In the distance a bank of gravel is evident which indicates the amount of material removed from the culvert



**Image C: Condition of the culvert after removal of debris, Note debris bank in the distance.**



The decision was then made to start works to send in the jetting equipment to pull the sediment towards the suction boom on the Vactor unit.

There is always a risk when attempting to jet a stone built culvert that the jetting equipment will cause more damage to the structure and potential lead to the culvert collapsing. In the case of the Sedbergh Culvert we were fortunate that the culvert had a concrete base which prevented the jetting equipment from tunnelling under the side walls of the culvert.

Sapphire continued works to slowly drag out the sediment from the culvert from location 2. On Day 3 it was decided that a second access excavation would be needed in the narrow access track at the rear of the property called Waverley (Location 3). This was needed as access location 1 was too far away and the equipment was unable to drag back the material and a 2<sup>nd</sup> access point would improve the access and allow for more material to be removed.

### **Conclusion:**

There have been two attempts to CCTV survey the culvert on the first attempt the culvert was surveyed from the land above the Phoenix community centre across the football field to the outfall at Guldrey Fold. On the second attempt we only surveyed the section between the Spar and Guldrey Fold, the section from the access point at the rear of the Nook through to the grass verge at the side of the tennis court had a significant build-up of sediment, After the tennis courts this appears to thin out and once the culvert changes construction type to pipe the culvert is completely clear with no sediment deposits.

The sediment build up increased from 30% under the grass verge to 85-90% at the rear of the Nook.

The issue experienced in December 2015 seems to have been caused by sediment build up within the Stone Box Culvert, this could have led to the culvert walls and roof being under a significant hydraulic pressure that the eventually the roof of the culvert was forced off in the rear garden of The Nook. The walls of the culvert in this location also seem to have collapsed and had been washed further into the culvert becoming lodged in which meant even light rainfall events the culvert was unable to take the volume of water. Sapphire has removed in all between 7-8 tonnes of material from the culvert this doesn't include the larger boulders which had to be removed by hand. The 2 images D and E below show what the culvert looked like during the works and how the culvert had been left.



**Image D: Indication of culvert capacity loss during Sapphire works**



**Image E: Indication of the improved capacity following works undertaken by Sapphire**

The culverted system has a number of construction changes from the top of the catchment where the culvert is in old stone box culvert of 450mm, which then discharges into a 450mm pipe in a number of locations where development has altered the design. The culvert then passes through the medical centre and Spar car park in a 900mm concrete rind culvert before reducing back down to a 450mm stone culvert which runs through the Guldrey area before it finally discharges into 450mm concrete pipe which runs from the end of Guldrey Terrace across Guldrey Lane and the new build development and into the open channel in Guldrey Fold.



**Image F: Shows the 450mm pipe through the new build development to Guldrey Fold**



**Image G: Shows the downstream section of the box culvert at the end of Guldrey Terrace before discharge into the 450mm pipe**

F E M N A