

# Stainton



## Flood Investigation Report



Stainton Aqueduct

## Flood Event 5-6<sup>th</sup> 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.

Version	Prepared by	Reviewed by	Date
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# Executive Summary

Stainton experienced flooding on the 5<sup>th</sup> and 6<sup>th</sup> of December 2015 as a result of the effects of Storm Desmond. The 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 Flood Investigation Report has been completed by the Environment Agency as a key Risk Management Authority (RMA) working in partnership with Cumbria County Council as the Lead Local Flood Authority, under the duties as set out in Section 19 of the Flood and Water Management Act 2010.

This report provides details of the flooding that occurred in Stainton on the 5<sup>th</sup> and 6<sup>th</sup> of December 2015, and has used a range of data collected from affected residents, site visits, surveys of the area, and data collected by observers, along with river and rainfall telemetry during the flood event. 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. Further information can be found in Appendix 5.

Approximately 12 properties in Stainton were flooded as a result of high water levels in Stainton Beck. This report indicates the likely causes of flooding and associated flow routes within the village.

Several 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 are detailed in the Recommended Actions section on page 24.

Please note that references to left and right bank in this report are for the observer looking downstream with the flow of the water.

In response to the flooding, a number of meetings with the community have taken place, and these will continue in order to ensure that all those affected have the opportunity to contribute ideas for reducing the flood risk in their area of the village.

Any additional information that can be provided 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, 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 5<sup>th</sup>-6<sup>th</sup> 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 Section 19 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](mailto:LFRM@cumbria.gov.uk).

## Flooding History

The village of Stainton is situated along the banks of Stainton Beck, which drains a rural upland catchment. Prior to the December 2015 flood event, the only record of flooding affecting Stainton is from January 2005, when Stainton Beck flooded a small, localised area around the Ford at Dreamland Farm.

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# Event background

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

## Flooding Incident

Stainton is a small village situated along the banks of Stainton Beck, with an estimated population of 310 people. Stainton is located to the south east of the Lake District National Park in Cumbria, 5.3 miles south of the town of Kendal. At the southern end of the village, Stainton Beck passes under the Lancaster Canal at Stainton Aqueduct. The Lancaster Canal begins at Stainton, with Stainton Beck providing flow to the canal from various abstraction points along the watercourse through the village. Approximately 2.5 miles downstream of Stainton, Stainton Beck joins Peasey Beck to form the River Bela. Figures 1 and 2 show the location of Stainton and the nearby main rivers.

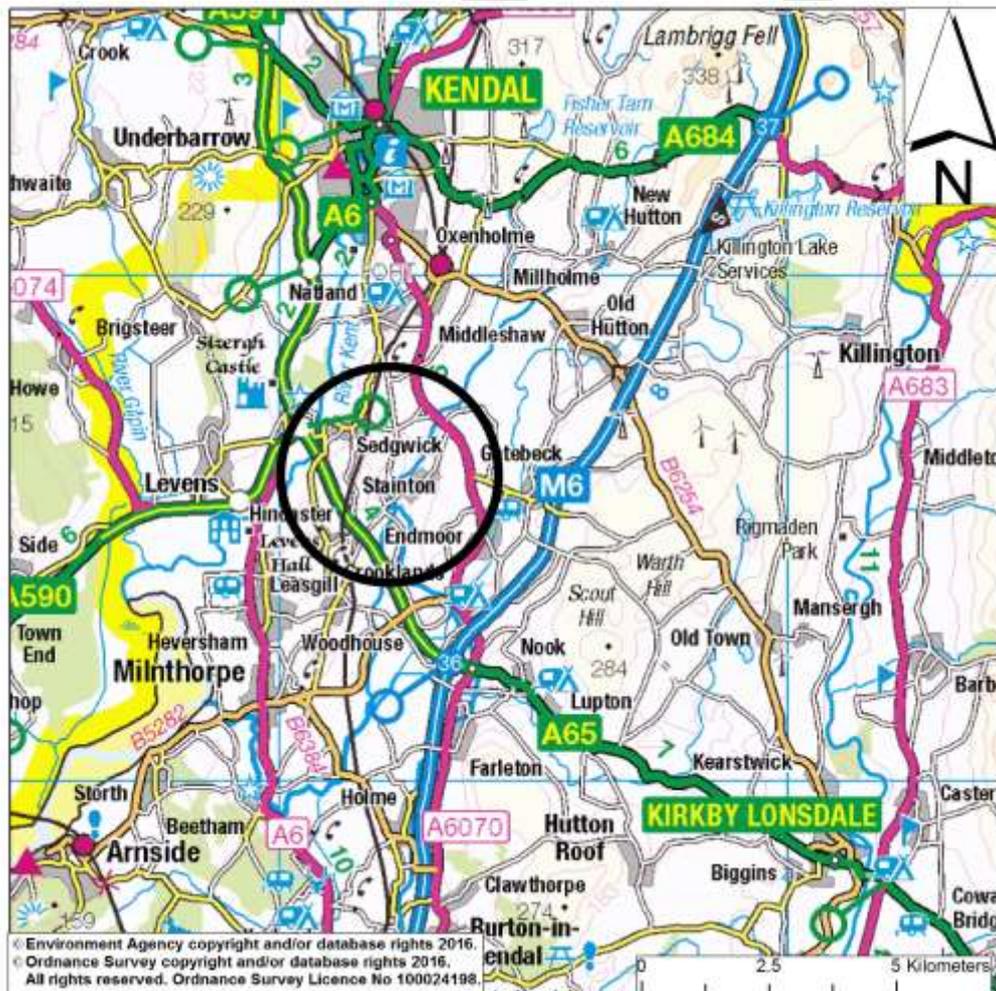


Figure 1 – Location Plan

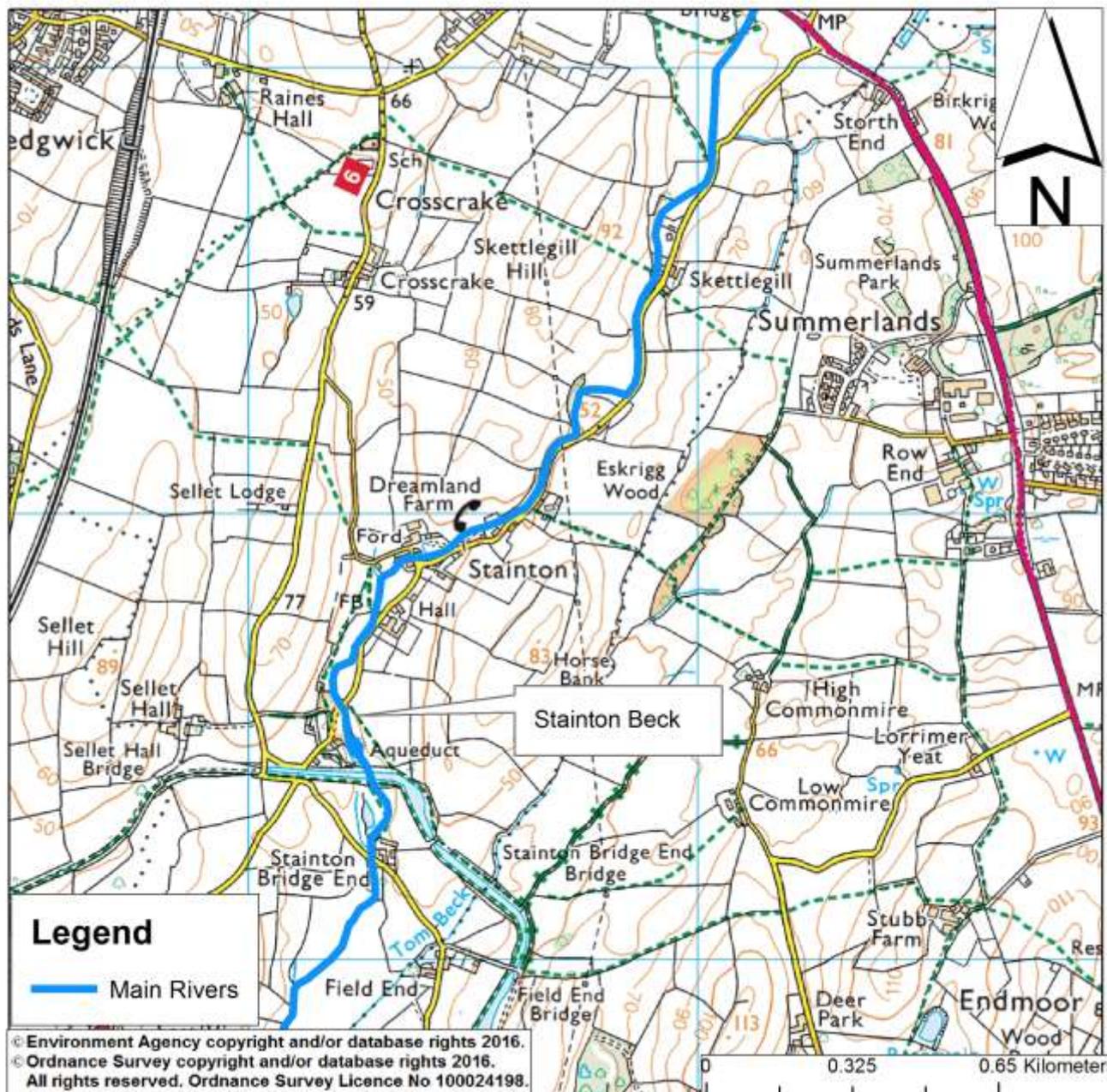


Figure 2 - Main Rivers around Stainton

Due to its position within the floodplain of Stainton Beck, parts of Stainton lie within Flood Zone 3 (1% Annual Exceedance Probability or AEP) and are therefore at risk of fluvial (river) flooding, as illustrated in Figure 3. Parts of the village also lie within Flood Zone 2 (0.1% Annual Exceedance Probability or AEP). The village is also at risk from other sources of flooding, including surface water (see Figure 4).

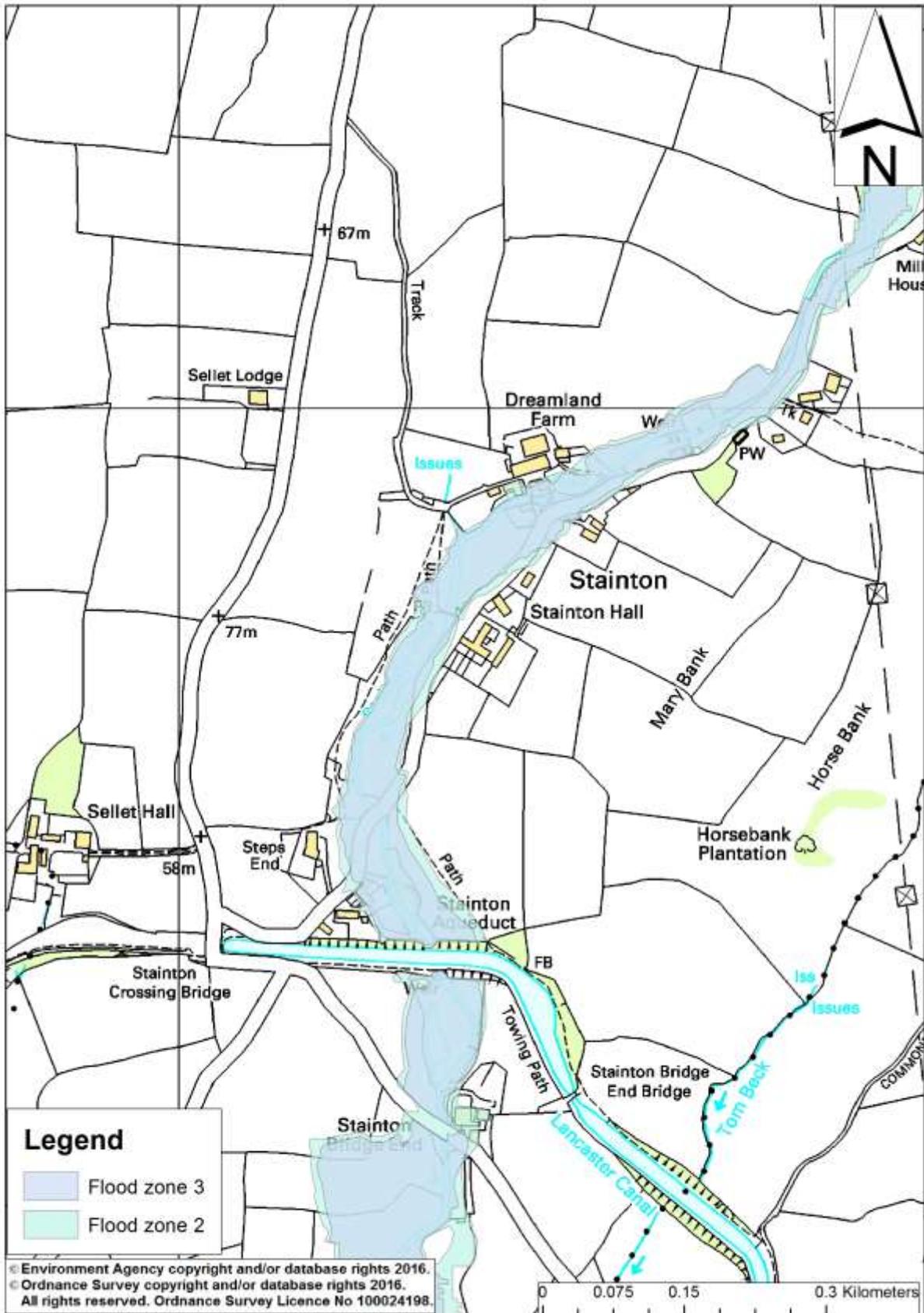
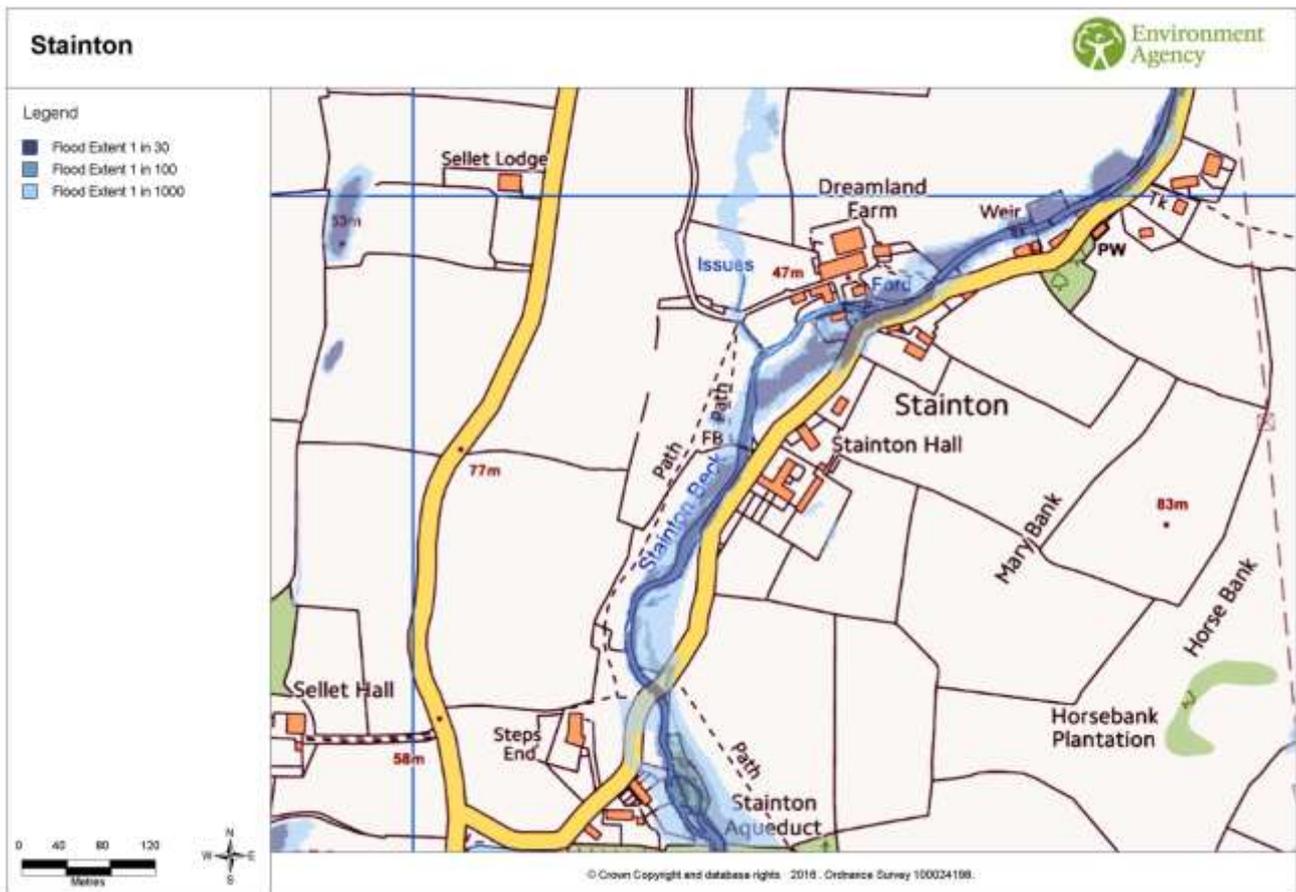


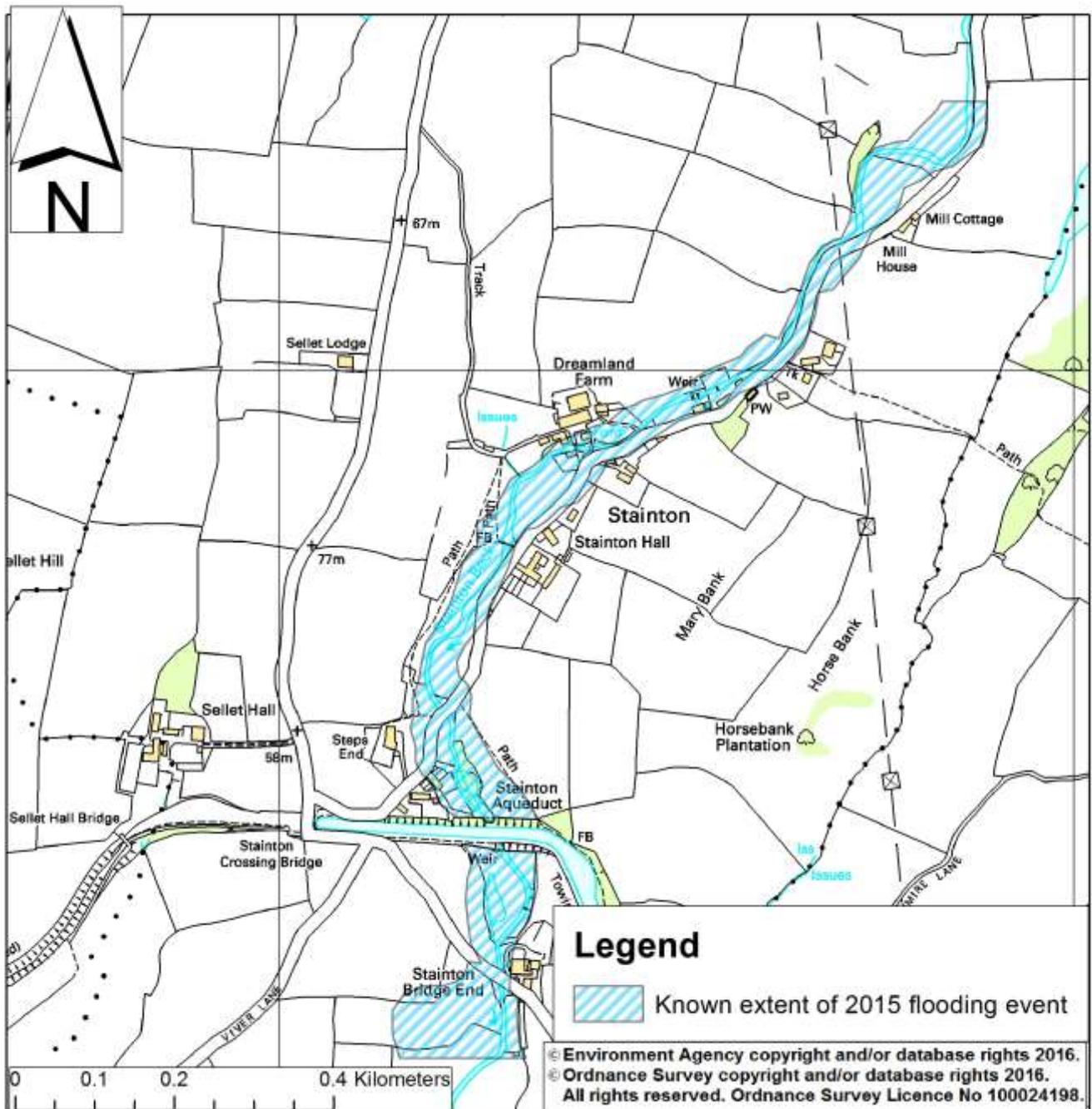
Figure 3 - Indicative risk of flooding to Stainton from rivers (fluvial)



**Figure 4 - Areas in Stainton at risk of surface water flooding**

On the 5<sup>th</sup> and 6<sup>th</sup> December 2015, approximately 12 properties in Stainton were affected by flooding as a result of Storm Desmond, which caused record breaking rainfall over Cumbria and other parts of north-west England. The storm led to widespread river and surface water flooding across Cumbria, with significant flood events occurring on the Eden, Derwent and Kent catchments.

In Stainton, the main source of the flooding was from Stainton Beck as flood water overtopped the banks of the river. This resulted in flooding to properties situated adjacent to Stainton Beck. The area affected by flooding is shown in Figure 5.



**Figure 5 - Extent of Flooding in Stainton on 5-6<sup>th</sup> December 2015\***

\*The flood outline identifies the maximum extent of flooding. Not all properties within the extent may have flooded.

## Existing Flood Defences

There are currently no formal flood defences in Stainton. Along the banks of Stainton Beck there are some areas of raised ground, made from deposits of excavated channel material that have vegetated over time, however these features are not structurally designed to offer a formal standard of flood protection. Other informal flood defences in the village are made up of privately-owned retaining walls and property boundary wall structures adjacent to Stainton Beck. These structures have not been designed as engineered structures to manage flood risk. Figures 6 and 7 show typical examples of informal flood defences along Stainton Beck.



**Figure 6 – Raised ground along the banks of Stainton Beck**



**Figure 7 – Privately-owned boundary wall along Stainton Beck**

# Investigation

This section describes the rainfall and fluvial events that occurred on the local river catchments, the likely causes of flooding and the Environment Agency response in Stainton. It also provides a timeline of the events that occurred over 5<sup>th</sup>-6<sup>th</sup> December 2015.

This investigation was carried out by the Environment Agency using data collected from surveys of the area, and from the communities affected, with help from Cumbria County Council. This report has compiled this data to provide a detailed record of the flooding in Stainton.

## Rainfall and Fluvial 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 4<sup>th</sup> to the 7<sup>th</sup> of December 2015, Storm Desmond resulted in a period of prolonged rainfall across Cumbria, which was particularly intense over 5<sup>th</sup>-6<sup>th</sup> 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 and Workington. The record-breaking total rainfall values are presented in Table 1.

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 1 - UK Rainfall Records**

There are currently no rainfall measurement gauges within the Stainton Beck catchment. As such, it is not possible to quantify the amount of rainfall within the catchment during the December flood event, or to provide any context around the rainfall event within the catchment.

The nearest raingauge to the upper catchments above Stainton is located at Fisher Tarn Reservoir, to the east of Kendal (see Figure 8). Fisher Tarn raingauge recorded record 24 and 48 hour totals during the December 2015 flood event, as detailed in Table 2. Table 2 illustrates that the recorded rainfall far exceeded the previous record rainfall totals from October 2008. 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 local catchments.

Although there is no direct rainfall measurements within the Stainton Beck catchment, from analysing recorded data from neighbouring catchment raingauges, all of which recorded record rainfall totals

during the December flood event, it is highly likely that the rainfall event within the Stainton Beck catchment was very significant.

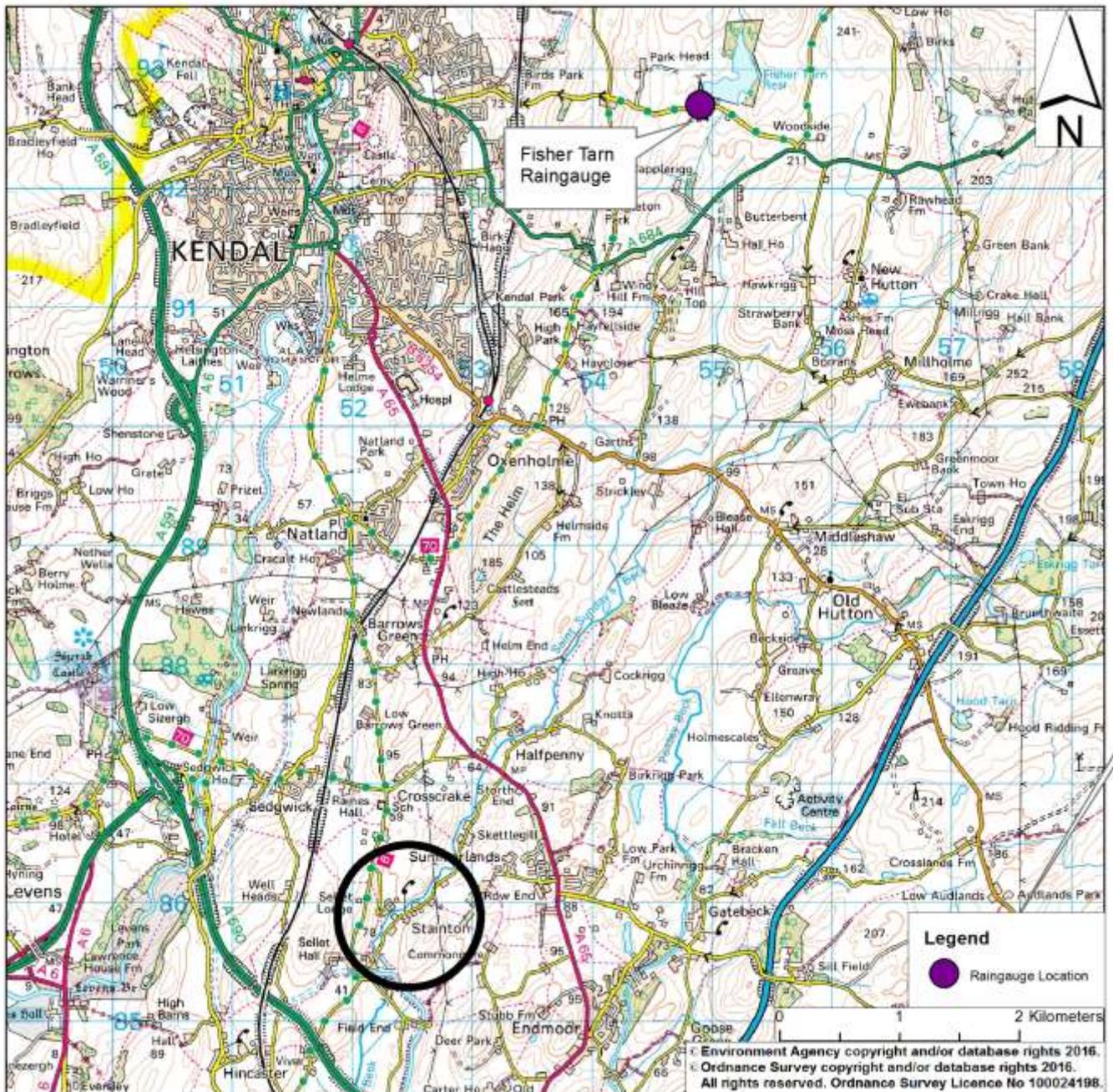


Figure 8 – Location of Fisher Tarn Reservoir Raingauge

Location	Rainfall Period	Storm Desmond		Previous Record	
		Date	Total rainfall (mm)	Date	Total rainfall (mm)
Fisher Tarn	24 hour rainfall	December 2015	114.2	October 2008	70.2
	48 hour rainfall	December 2015	139.6	October 2008	74.0

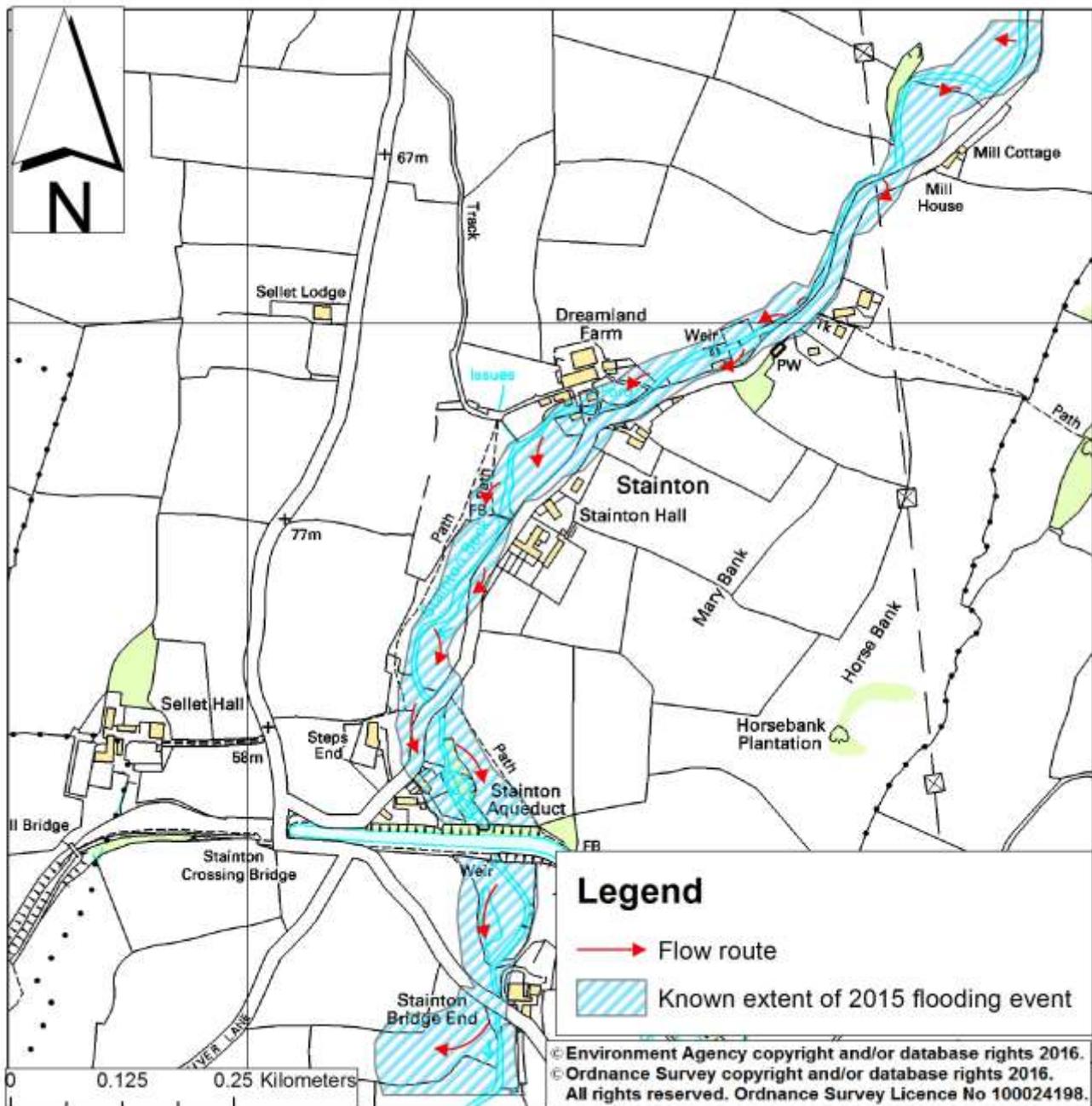
Table 2 - Rainfall data from Fisher Tarn Rain Gauge

There are currently no river flow measurement gauges on Stainton Beck. It is therefore not possible to determine the flow rate of the beck or compare this flood event against a historic gauged record for comparison purposes. However, given that the flood extent from the December 2015 flood event is the largest ever recorded on Stainton Beck, far exceeding the flood extent recorded from the January 2005 flood event, it is highly likely that the December 2015 flood event is the largest experienced in recent times. As with the rainfall data comparison, many neighbouring river catchments recorded record flows during the December 2015 flood event, which would again suggest it is highly likely Stainton Beck will have experienced record flows during the flood event.

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## Sources of Flooding, Flood Flow Routes and Event Timeline

Evidence gathered in the aftermath of the flood event suggests that the main source of flooding in Stainton was Stainton Beck, which exceeded its channel capacity and overtopped informal raised defences along the length of the watercourse through the village. An overview of the principle flood flow routes through Stainton is presented in Figure 9.



**Figure 9 - Map of flood flow routes\***

\*The flood outline identifies the maximum extent of flooding. Not all properties within the extent may have flooded.

There is currently a lack of information and evidence available on the timing and sequence of flooding in Stainton. Further information is hoped to be gathered from the local community during the draft

consultation process to inform our understanding of the flood event and produce a timeline to illustrate the sequence of impacts through the flood event.

## Impacts and Likely Causes of Flooding

A number of properties in Stainton are situated alongside Stainton Beck, many in close proximity to the watercourse. During the flood event on 5<sup>th</sup> December, Stainton Beck exceeded its channel capacity at a number of locations through the village, and also overtopped sections of informal flood defences such as raised boundary walls, resulting in the flooding of 12 properties.

In addition to the flooding of property, there were also localised impacts from deposits of gravel both along the watercourse and on adjacent land. Local infrastructure was also damaged by the flow of water from Stainton Beck, including riverside walls, boundary walls, highway walls, public footpath bridges, a ford and the highway running parallel to Stainton Beck. There was also localised erosion of land along flow routes from Stainton Beck.

Figure 10 shows the locations where gravel was deposited and where damage was caused to highway walls. Figure 11 shows the sections of the highway that have been damaged by the flooding. Figures 12 to 16 show localised impacts of the flooding through the village.



Figure 10 – Location of gravel deposits and damaged highway walls

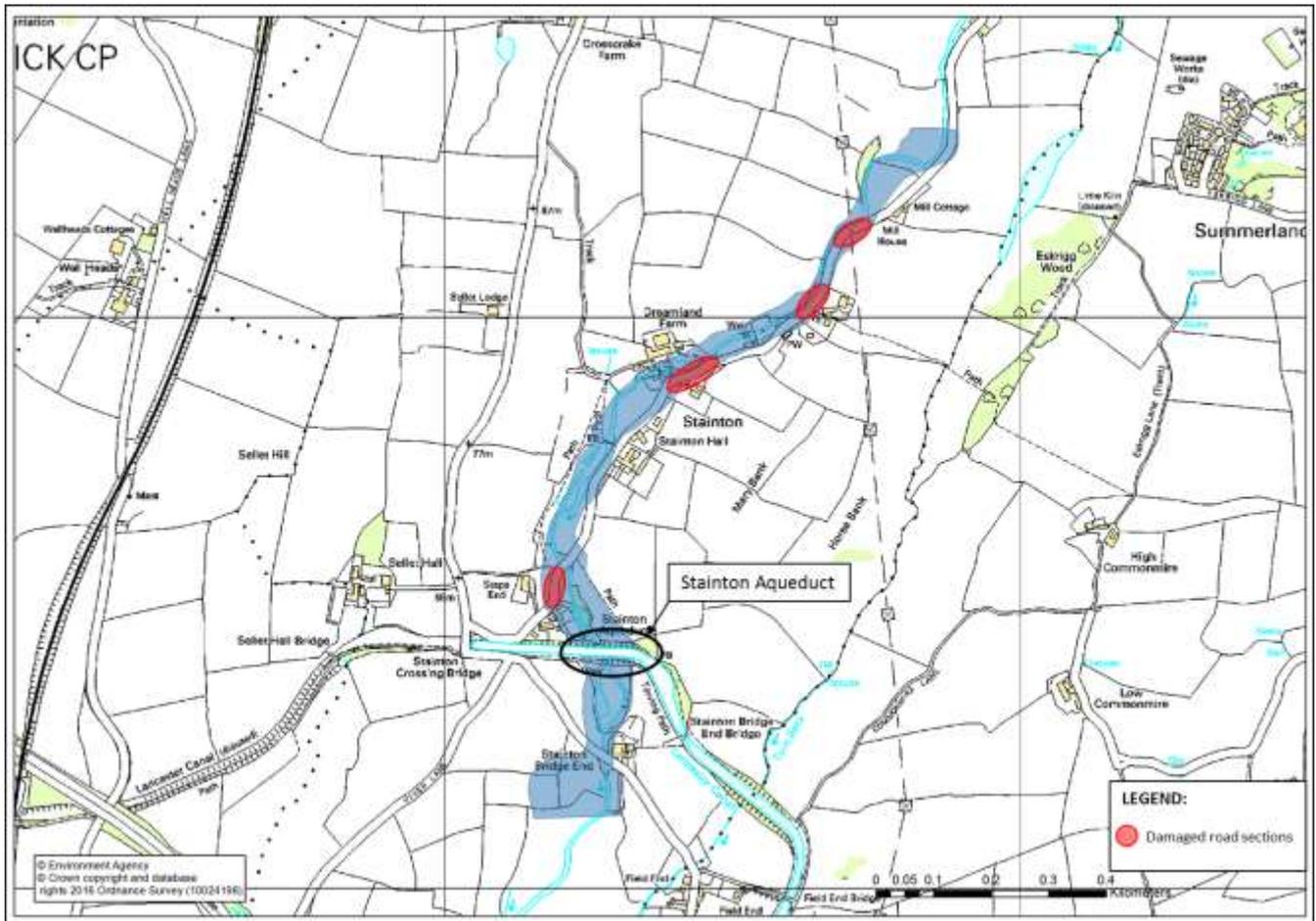


Figure 11 – Locations of Damaged sections of highway



Typical Highway Damage



**Figure 12 – Damaged Ford at Beckside**



**Figure 13 – Wrack mark in the fence on the right bank of Stainton Beck at Beckside**



Figure 14 – Demolished dry stone wall adjacent to Waybend Cottage



**Figure 15 – Erosion and gravel deposition in field downstream of Waybend Cottage**



**Figure 16 – Demolished dry stone wall opposite Stainton Lodge, showing the flow route from the highway to Stainton Beck**

Damage was also caused to Stainton Aqueduct, which carries the Lancaster Canal over Stainton Beck at the downstream extent of the village. Figure 17 shows the location of the Aqueduct, and Figure 18 shows that the Aqueduct has been undermined, causing serious damage to the structure.

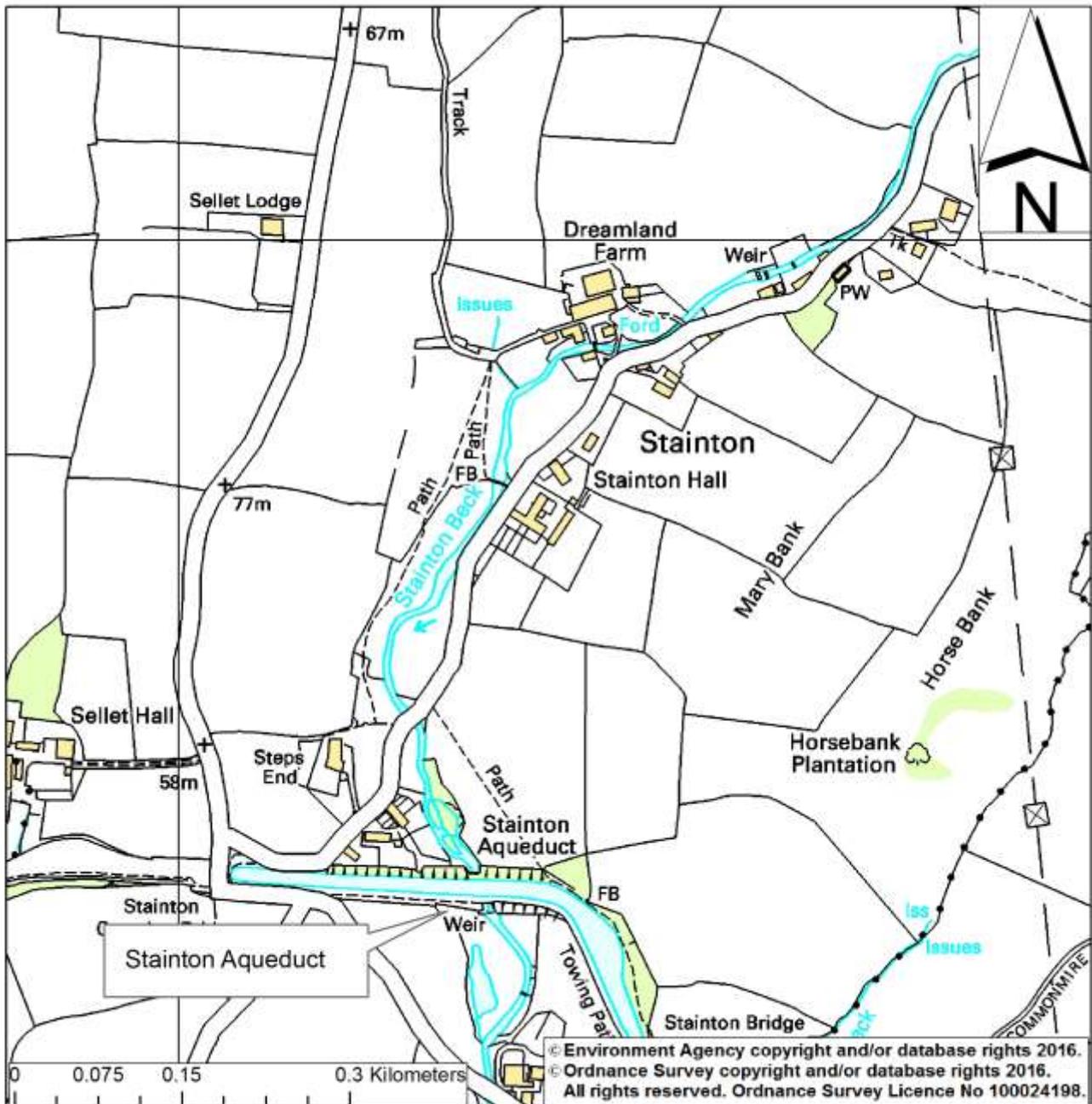


Figure 17 – Location of Stainton Aqueduct



**Figure 18 – Damage to Stainton Aqueduct (courtesy of Geoff Wilson)**

Given that the potential collapse of the Aqueduct poses the risk of additional water flowing into Stainton Beck from the Lancaster Canal, the Aqueduct has been dammed by the Canal & River Trust (CRT), who are responsible for the management of the structure.

## Environment Agency Flood Incident Response

A Flood Alert for the River Kent and Bela catchments was issued on the 4<sup>th</sup> of December at 15:22. A Flood Alert provides advance notice of possible flooding to low lying land and roads, and also acts as an early notification that river levels are expected to rise and that the Environment Agency are monitoring the situation closely. There are currently no Flood Warning Areas for Stainton, so during the December flood incident the Environment Agency updated the Flood Alert daily with relevant information.

During the flood incident the Environment Agency were not able to reach Stainton due to extensive flooding of local highways.

In the aftermath of the flood incident, Environment Agency officers have attended various meetings with Stainton Parish Council and local residents. Environment Agency engineers have undertaken assessments of the various gravel shoals along Stainton Beck, and as a result will be removing accumulated gravel from the Ford area where channel capacity has been reduced towards the historic footbridge. In addition to the gravel removal, the Environment Agency will also be removing any overhanging tree limbs which reduce channel capacity, or have the potential to be undermined and collapse into the Stainton Beck channel, potentially causing a blockage. This work will be undertaken in October 2016.

### Maintenance Activities

The Environment Agency maintains flood risk management structures and sections of river channel where maintenance actively reduces the risk of flooding to people and property. Activities we undertake are summarised below:

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

The Environment Agency undertake annual visual inspections along Stainton Beck to determine whether any of the above maintenance activities are required to manage flood risk in Stainton.

# Recommended Actions

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

Cumbria Flood Partnership Theme	Action by	Recommended Action	Timescale
Resilience	Cumbria Local Resilience Forum*	Review and update plans to enable homes and business to be better prepared for flooding and reduce the impacts of flooding. For example, review of evacuation procedures / emergency response.	2016
	Residents and South Lakeland District Council	Implement flood resilience measures within flooded properties to reduce the impacts of future flooding. South Lakeland District Council is administering the Flood Recovery and Resilience Grants of up to £5000 per property to help people better protect their homes. A further £2000 top up grant can also be applied for from the Cumbria Flood Recovery Fund.	Closing date for grant applications is end of December 2016
	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
	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
	Environment Agency	Work with the local community to develop options to provide advance warning of possible flooding.	2016-2017
Upstream Management	Cumbria Floods Partnership (CFP)	The CFP Action Plan will be published in summer 2016, and will consider natural flood management options to reduce flood risk across the catchment. This may include land use changes and/or flood storage.	CFP Action Plan was published June 2016
	CFP, Farmers, Landowners, Community Groups, Trusts.	Explore opportunities for natural flood management solutions to be used upstream of Stainton in order to 'slow the flow' and manage peak river levels.	Medium term (over next 5 years)

Cumbria Flood Partnership Theme	Action by	Recommended Action	Timescale
Maintenance	United Utilities and Cumbria County Council	Carry out inspections and repairs to assets which may have been damaged during the flood event.	2016
	Environment Agency	Remove accumulated gravel deposited in the Ford area where channel capacity has been reduced towards the historic footbridge. In addition, remove any overhanging tree limbs which reduce channel capacity, or have the potential to be undermined and collapse into the Stainton Beck channel, potentially causing a blockage.	Work to be completed in October 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: <a href="https://www.gov.uk/government/publications/river-andcoastal-maintenance-programme">https://www.gov.uk/government/publications/river-andcoastal-maintenance-programme</a>	2017
Strengthening Defences	Cumbria County Council, South Lakeland District Council and United Utilities	Review the performance of the existing drainage and sewerage systems during the event to better understand where improvements are required.	2016-2017

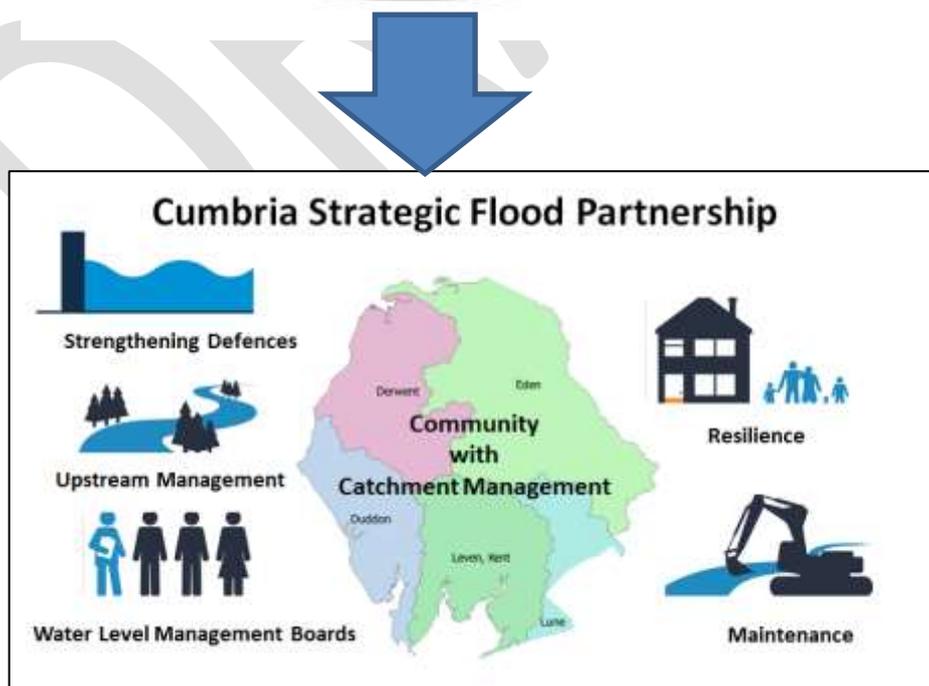
**Table 3 - Recommended actions for consideration**

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

# Next Steps – Community & Catchment Action Plan

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

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





# Cumbria Strategic Flood Partnership



RFCC

Cumbria Strategic  
Partnership Board

Catchment Management  
Group  
Eden

Catchment Management  
Group  
Derwent

Catchment Management  
Group  
Kent and Leven

Steering Groups  
(Various per Catchment)  
MSFWG

## Community

*'Farmers, environmental charities, landowners, private companies, councils and government agencies have joined together with a common goal.*

*To look at the evidence and potential funding sources to find flood solutions for defences, resilience, maintenance, upstream management and water level management boards, so they can work together to help communities at risk of flooding.'*

*In an dynamic move the Cumbria Strategic Flood Partnership have created three groups whose aim is to look at all options for how flood risk can be reduced in Cumbria.*

*This group the first of its kind in the country brings together the expertise of all those whose water and land management experience to look at what can be done to protect communities both residential and farming.*

*They will then discuss their findings to the communities at risk and plan a way forward.*

*This landmark move will ensure that fully integrated solutions for land and water management are utilised to protect people and the environment in which they live and rely on.*

# Appendices

## Appendix 1: Acronyms and Glossary

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

<b>Term</b>	<b>Definition</b>
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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.

<b>Term</b>	<b>Definition</b>
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.
River Catchment	The areas drained by a river.

<b>Term</b>	<b>Definition</b>
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					
The sea					
Groundwater					
Reservoirs					

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

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

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

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

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

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

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

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

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

Flood Action Groups (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 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 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: Flood Alerts

### **011WAFLE: Kent and Bela Catchments**

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

Alert removed on Thursday 10/12/2015 at 16:18

**Customers in Flood Alert area registered on FWD: 227**

**Contacts (landline, mobile, email etc.) in Flood Alert area registered on FWD: 609**

**Successful contacts: 531**

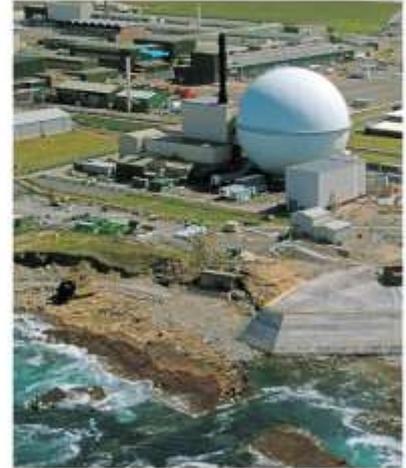
**Unsuccessful contacts: 78**

### **Alert Message:**

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

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

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



#### We partner with your industry

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

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

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

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

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

## Urban Programmes

### Key endorsements:

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

– John Armitt, ODA Chairman

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

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



### London 2012 Olympic and Paralympic Games

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

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



## Water

### Thames Tideway Tunnel and Lee Tunnel

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

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

## Transport

### Crossrail

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

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

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



### High Speed 2 (HS2)



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

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

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

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

### We provide services for your success

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



## Water Resources-Ecosystem Management Services

### Flood Risk Management

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

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

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

#### Sub-technologies

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

##### Flood mapping and appraisal

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

##### Capital works delivery

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

##### O&M and asset management (AM)

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

#### Challenges, Trends, Opportunities

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

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

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

#### Did You Know?

- A review by the Organization for Economic Cooperation and Development on 136 coastal cities found that the estimated damage from sea level rise, storm surge and subsidence for 1 in 100 year flood event in 2070 was estimated at \$35,000 billions.
- In 2070 it is estimated that over 150 million people will live in these 136 coastal cities at risk.
- River flooding is the most common type of flood event.
- Floods are the number one natural disaster in the US, and just a few inches of water from a flood can cause tens of thousands of dollars in damage.
- The flooding in Alberta, Canada in 2013 displaced 100,000 people and is estimated to cost \$6 billion.
- According to the House of Commons library, £2.34 billion has been spent on new flood defenses in England alone since 2011.