NOTE TO FILE

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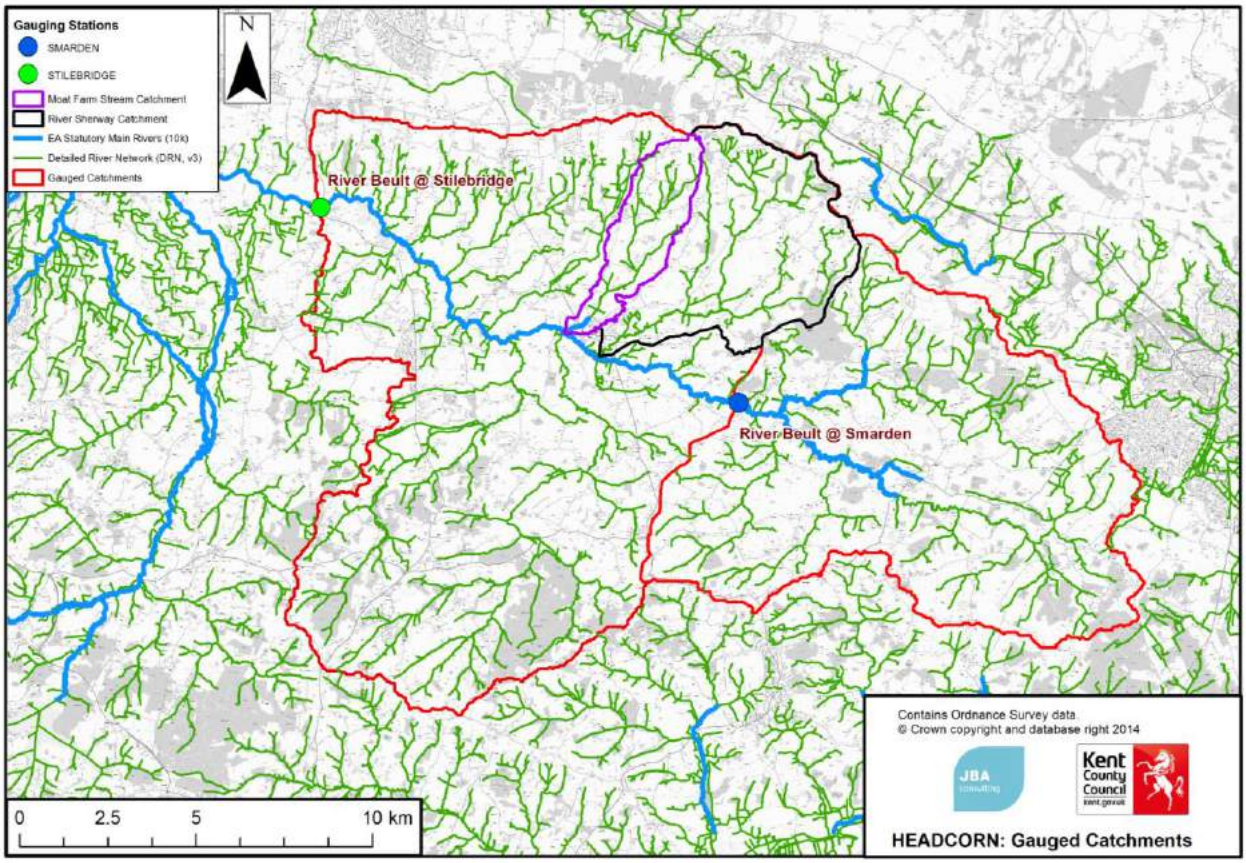
1 Introduction

The purpose of this report is to better understand the rainfall events that lead to flooding within Headcorn in order to determine any potential interactions between adjacent Main River levels (along the River Beult) and the surface water drainage network within Headcorn.

The village of Headcorn is situated between the downstream extent of the River Sherway and Moat Farm Stream and the confluence of these two watercourses with the River Beult.

The Smarden gauging station is located approximately 5km upstream of Headcorn on the River Beult and the Stilebridge gauging station is located nearly 11km downstream of Headcorn on the River Beult. Figure 1-1 below illustrates the Headcorn catchments (River Sherway and Moat Farm Stream) in relation to the gauged catchments at Smarden and Stilebridge.

Figure 1-1: Main River catchments



The majority of the historical flood information available within Marden, Headcorn and Staplehurst is qualitative data i.e. reported flood incidents, highways records, flood hotspots, sources of flooding and occasionally observed flood extents. There are no flow or level gauges within the Headcorn catchments and therefore Tipping Bucket Raingauges (TBRs) will form the basis of the quantitative assessment of event rarity within Headcorn. Headcorn is located within the Beult catchment which is a tributary of the River Medway.

Surface water flooding events usually tend to be as a result of convective summer storms i.e. short intense rainfall events, and therefore 'higher peaked' rainfall profiles would usually be expected if a convective summer event is the main cause of the surface water flooding. These convective summer events also tend to be more critical in urbanised areas.

2 Catchment characteristics

Headcorn is a village located approximately 14km south-east of Maidstone, Kent. The two main watercourses that flow through Headcorn are the Moat Farm Stream (Main River) and the River Sherway (Ordinary Watercourse). These catchments are predominantly covered with Arable (Horticultural) land with a mixture of woodland and grassland. The main built-up area is Headcorn and part of Staplehurst is located in the upper Marden drain catchment.

The catchments within Headcorn are underlain predominantly by mudstone siltstone and sandstone deposits (Weald Clay formation) and therefore the catchments are quite impermeable and consequently a more flashy response is expected. The upper sections of these catchments are characterised by sandstones and mudstones (Lower Greensand Group) and is therefore slightly more permeable but these deposits are of limited extent within these catchments. This is supported by fairly low BFIHOST values in the range of 0.315 to 0.353; the average SPRHOST value is 45%. These geological formations are overlain by superficial deposits of Alluvium and River Terrace deposits which mainly consist of sands, gravel, clays and silts. These superficial deposits are mostly confined alongside river reaches in the lower catchment. There are also some Head superficial deposits in the upper Moat Farm Stream catchment which consist of clays, silts, sands and gravels. It is likely that the areas that are overlain by these superficial deposits are slightly more permeable than the surrounding parts of the catchment.

The soils within the Headcorn catchments predominantly consist of slowly permeable wet clayey soils with impeded drainage. In the lower section of the catchments, the soils are typically more loamy and wet with naturally high groundwater levels. In the upper section of the catchments, the soils are typically more freely draining which is most likely associated with the slightly more permeable Lower Greensand Group geological formation.

There is a reasonable gradient across the catchment with the highest elevation point at approximately 160 mAOD (Green Hill) and the lowest elevation point at approximately 16 mAOD at the downstream model extent.

3 Data availability

There is data available for seven Tipping-Bucket Raingauges (TBRs) in and around Marden, Staplehurst and Headcorn: Staplehurst, Horsmonden STW, Headcorn, Sutton Valence, Charing PS, Bethersden STW and Hollingbourne (Table 3-1 and Figure 3-1). A brief analysis of rainfall data coverage in the catchment was undertaken using Thiessen polygons and the most representative TBRs for the catchment within Headcorn are Headcorn STW TBR and Sutton Valance TBR.

Table 3-1: Tipping-bucket raingauge information

Gauge	Altitude (m)	Aspect
Staplehurst	19.5	NE
Horsmonden STW	34.5	ENE
Headcorn	20.5	SSE
Sutton Valance	34.0	S

Headcorn

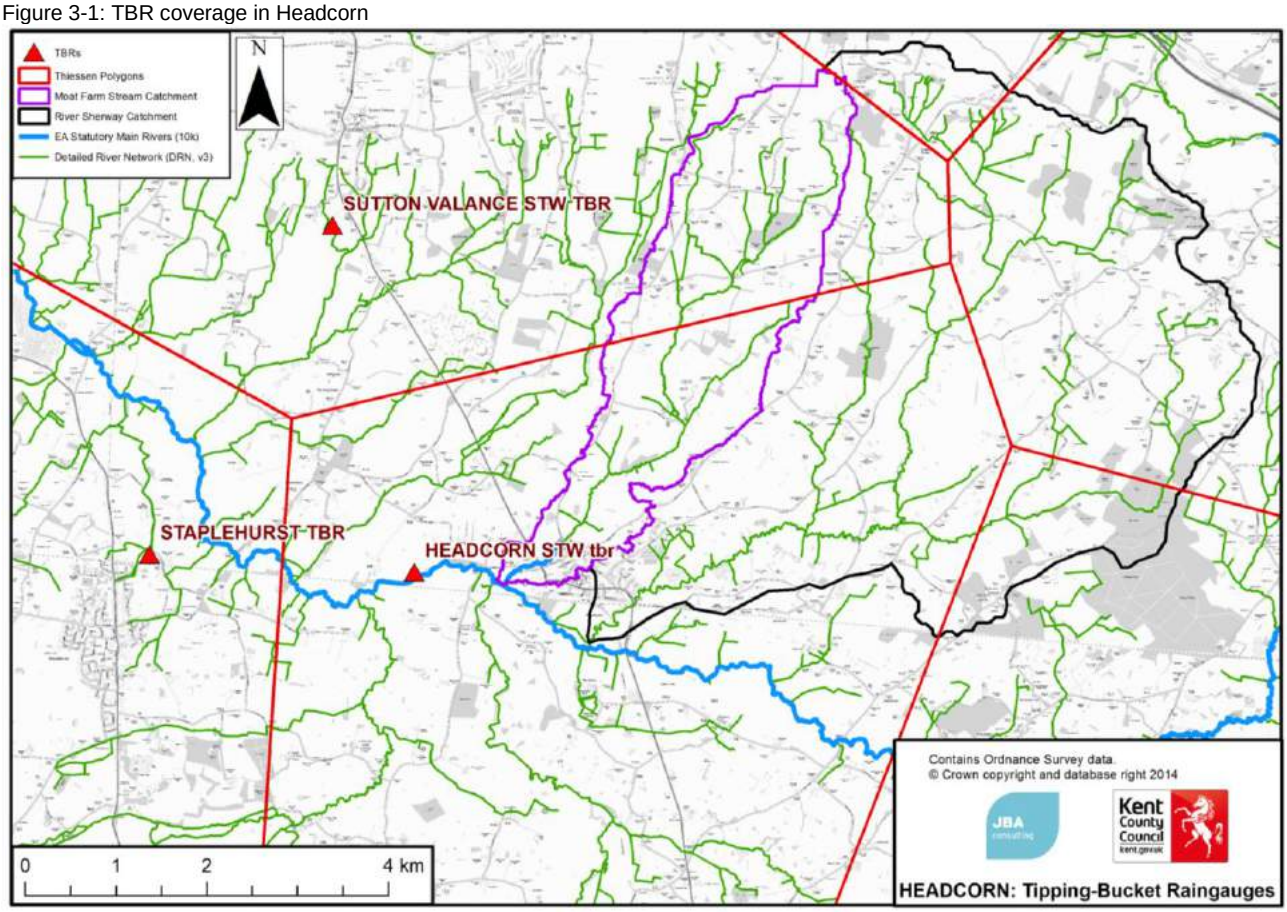
Overall, the Headcorn TBR appears to be good. There are no prolonged periods of missing data. However, the gauge was decommissioned in 2011 and therefore did not record the most recent winter events. As the Headcorn TBR is located immediately downstream of Headcorn, this TBR will be used to determine the rarity of the events pre-2011. For any reported flood events post-2011, either Sutton Valance STW TBR or Staplehurst TBR can be used.

Sutton Valance

Overall, the Sutton Valance TBR appears to be good. There are no prolonged periods of missing data.

For any reported flood events post-2011, the Sutton Valance STW TBR can be used.

Figure 3-1: TBR coverage in Headcorn



4 Historical flood events

This section looks at the flood events in Headcorn as identified during the flood history search.

There are limited reports of flooding within Headcorn to base this assessment on. However, all of the observed flood events are fairly recent and the source of flooding has also been reported (see Table 4-1).

Table 4-1: Reported flood history within Headcorn

Date	Source
2000 (Autumn?)	Fluvial (Moat Farm Stream and Sherway)
January 2009	Surface Water
November 2009	Surface Water and Fluvial (River Sherway)
December 2012 / January 2013	Foul Sewer
December 2013 / January 2014	Foul Water / Surface Water

Based on the reported flood events within Headcorn, it appears as though all of the flood events occur during the winter season (October – January); even the surface water/sewer flood events appear to be during the winter months. Given that the catchments within Headcorn are generally impermeable and slightly urbanised in the lower reaches, it would be expected that Headcorn would be more susceptible to short intense rainfall events which are typically observed during the summer months.

Flood seasonality based on reported flooding suggests that Headcorn may be more susceptible to

flooding due to elevated Main River levels in the River Beult which would prevent excess surface water from being cleared from the surface water drainage network i.e. a rise in the water table and nearby Main River levels during periods of higher than normal rainfall may mean that land drainage networks, such as storm sewers, will be unable to discharge excess surface water properly if the water table is higher than normal.

Therefore flooding within Headcorn may be as a result of the inability to discharge excess surface water during Main River flood events. However, given that there are two significant rivers (River Sherway and Moat Farm Stream) that flow through Headcorn, it is likely that elevated water levels within these ungauged rivers would have a similar effect of limiting the clearance of excess surface water within Headcorn, especially along the Moat Farm Stream which flows directly through Headcorn.

4.1 Rainfall analysis

This section summarises analysis into the return period and duration of rainfall which lead to flooding in Headcorn.

In order to estimate the order of magnitude of the main flood events within Headcorn, the same TBR should be used across all of the reported events to enable consistency between return period estimates. However, as the rainfall data recorded at the Headcorn gauge is only available up until June 2011, the Sutton Valance TBR will be used to assess the event rarity of flood events post-2011 (Table 4-2).

Table 4-2: Rainfall analysis

Date	Rainfall Depth (mm)	Duration (hours)	Rainfall profile	Return Period (years)	Raingauge
12/10/2000	73.2	16.25	Winter	35	Headcorn
23/01/2009	21.8	16.25	Mixed profile	1	Headcorn
30/11/2009	32.8	20.75	Winter	2	Headcorn
December 2012 / January 2013	Multiple events including 19th, 21st - 22nd December 2012, 2nd January and 31st January 2013. All rainfall events individually <1yr RP. Likely to be slightly higher covering the whole winter period.		Multi-peak	<1	Sutton Valance
December 2013 / January 2014	78.8	155.75 (~6.5 days)	Multi-peak	3	Sutton Valance
	Multiple events including 23rd and 27th December 2013, 8th – 9th January 2014. All rainfall events individually <2yr RP.				
Other peak rainfall events (no significant flooding reported within Headcorn) – but raised levels in the River Beult at Smarden and Stilebridge)					
December 2002	47.2	16.50	Winter	6	Sutton Valance
January 2008	32.4	21.75	Winter	2	Headcorn

4.2 Main River analysis

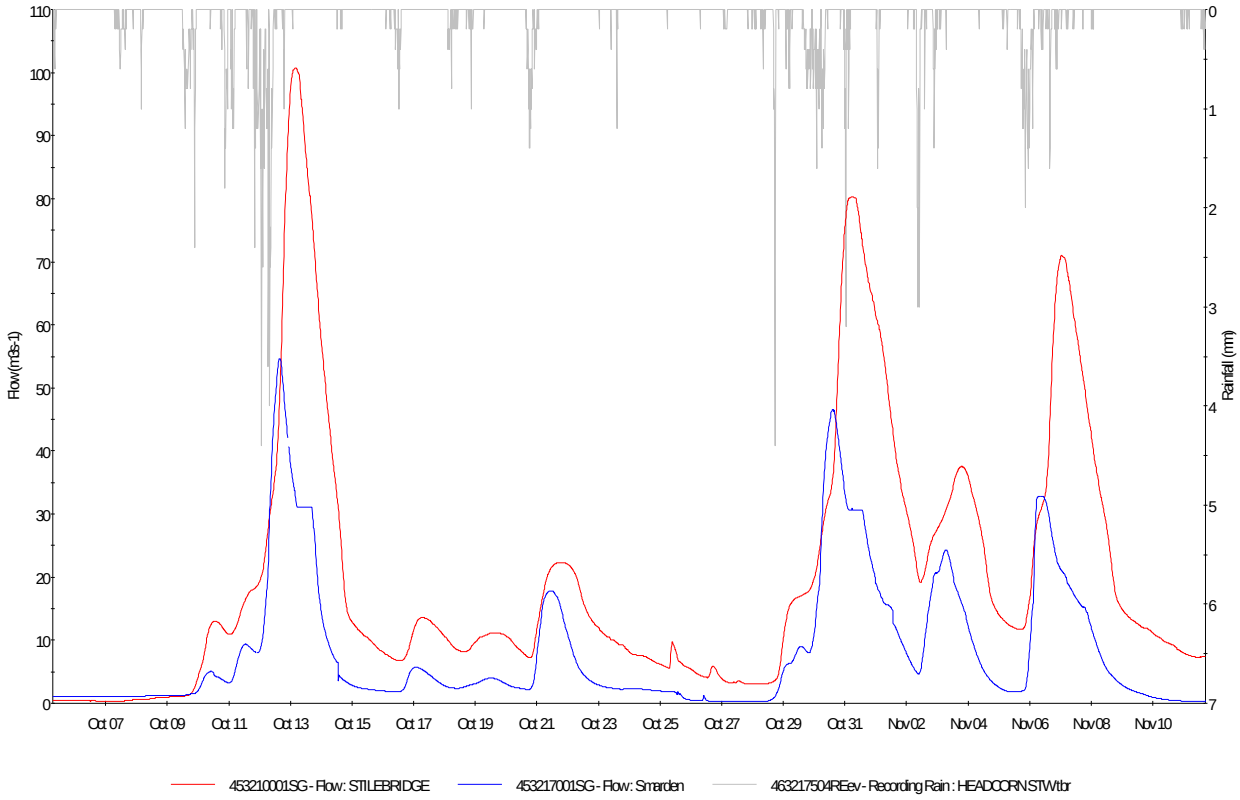
The purpose of this section is to analyse flow patterns on the River Beult (Main River) at the time when flood events have occurred in Headcorn. This analyses will test our hypothesis that local flooding events in Headcorn, coincide with high water levels on the Main Rivers.

Observed hydrographs for the Smarden and Stilebridge gauging stations are shown for each of the reported flood events within Headcorn. Also included on these hydrometric plots is a continuous rainfall record from a nearby representative raingauge (dependent on data availability for each event).

4.2.1 Autumn 2000

In autumn 2000 there was fluvial flooding reported on the River Sherway and Moat Farm Stream in Headcorn. The rainfall recorded at Headcorn STW TBR and the flow recorded on the River Beult at Stilebridge and Smarden are shown in Figure 4-1.

Figure 4-1: Autumn 2000 events



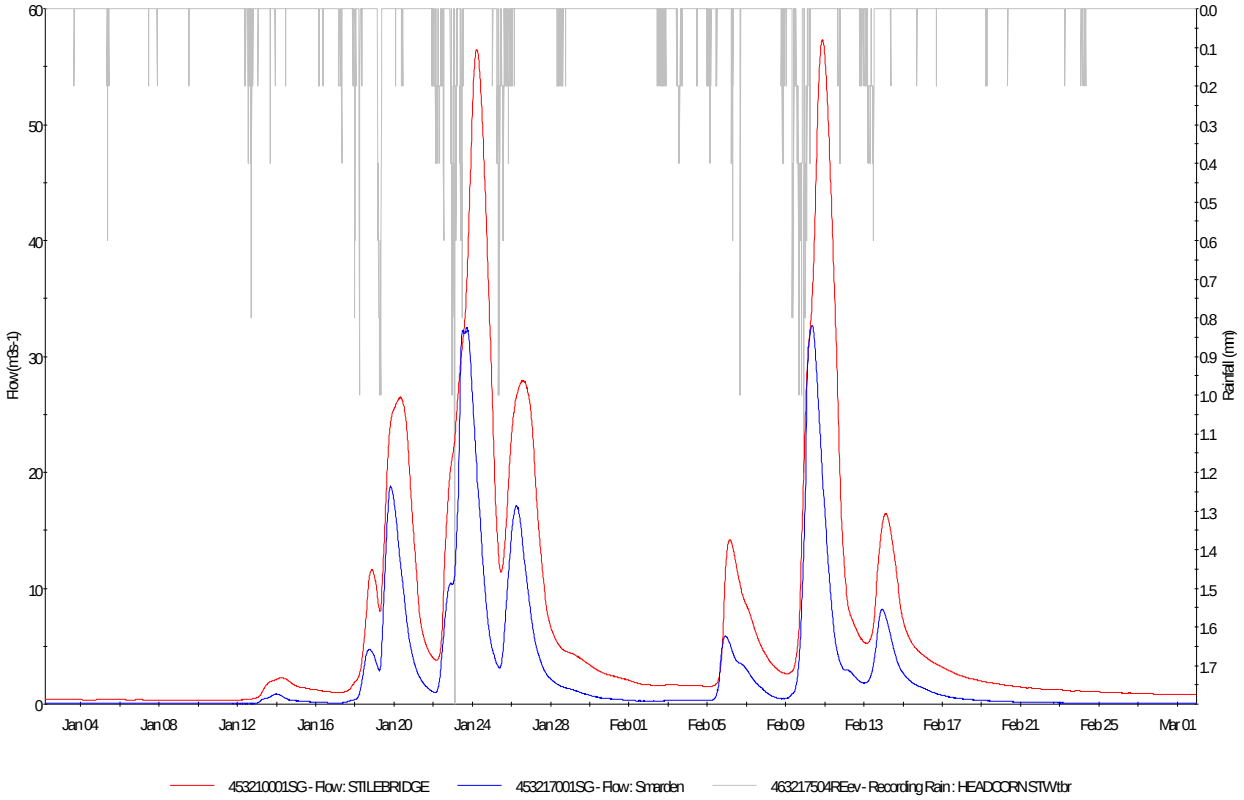
For the autumn 2000 events, the River Beult was characterised by numerous storm events that led to fluvial flooding. The largest peak flows were seen on 12-13 October 2000. Smaller peaks were seen following the storms of 30 October 2000 and 7 November 2000. The autumn 2000 events (particularly the October 13th event) are the highest ranked events at Smarden and Stilebridge.

Therefore it is expected that these events were also significant for the Headcorn catchments. Unfortunately, there is no information on severity or magnitude within the reported flood history in Headcorn. However, the return period for the rainfall that fell on the 12th October is approximately 35 years.

4.2.2 January 2009

In January 2009, surface water flooding was reported in Headcorn. The rainfall recorded at Headcorn STW TBR and the flow recorded on the River Beult at Stilebridge and Smarden are shown in Figure 4-2.

Figure 4-2: January 2009 event



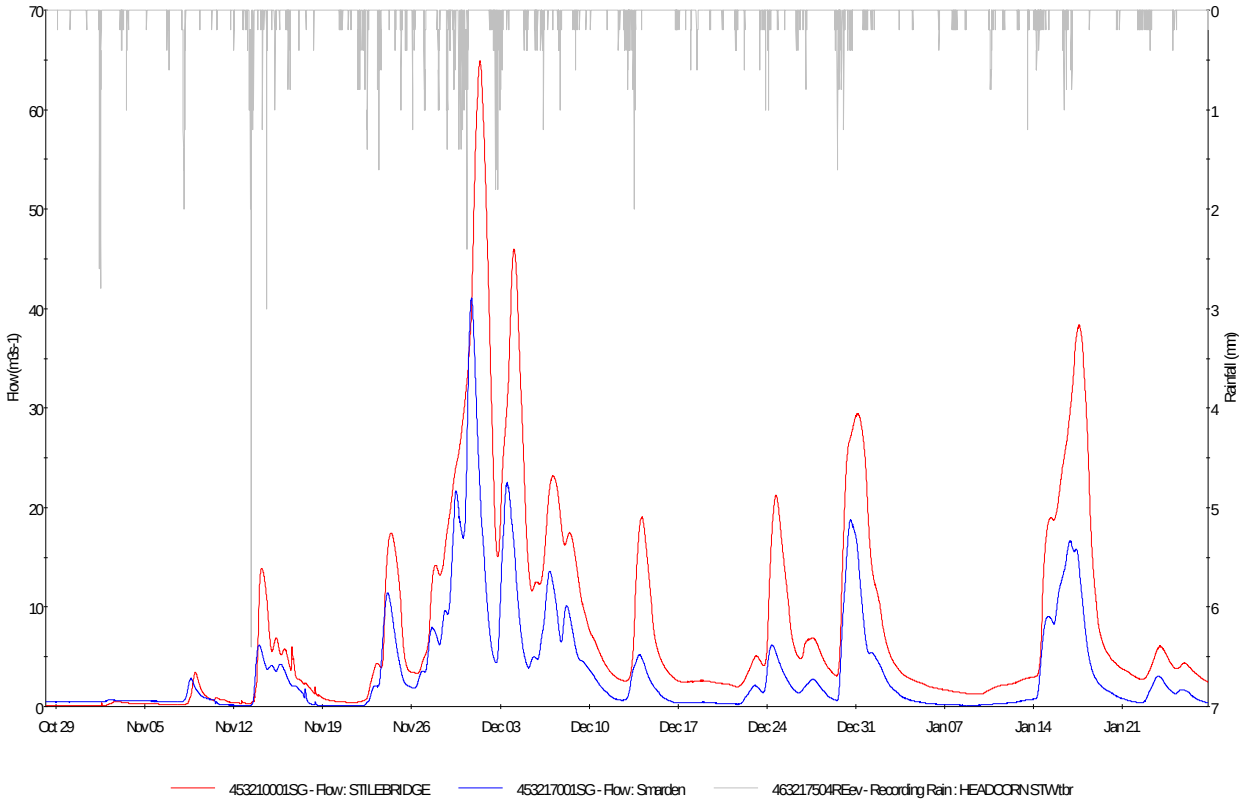
The January 2009 flood event was a result of a period of intense rainfall within the River Beult. The event just 2 weeks later in February 2009 was slightly more severe in terms of peak flow. However, it is likely that flood volumes were higher in the January 2009 event given the volume under the hydrographs at Smarden and Stilebridge.

Given the underlying impermeable geology, soil types and urbanised areas within the Headcorn catchments, it is likely that this intense rainfall event resulted in a combination of fluvial and surface water flooding. This may have also been exacerbated by the elevated Main River levels as the peak flood volumes during the January 2009 event would have prevented excess surface water from being drained into the watercourses.

4.2.3 November 2009

In November 2009, there was surface water flooding reported in Headcorn and fluvial flooding reported on the River Sherway. The rainfall recorded at Headcorn STW TBR and the flow recorded on the River Beult at Stilebridge and Smarden are shown in Figure 4-3.

Figure 4-3: November 2009 event

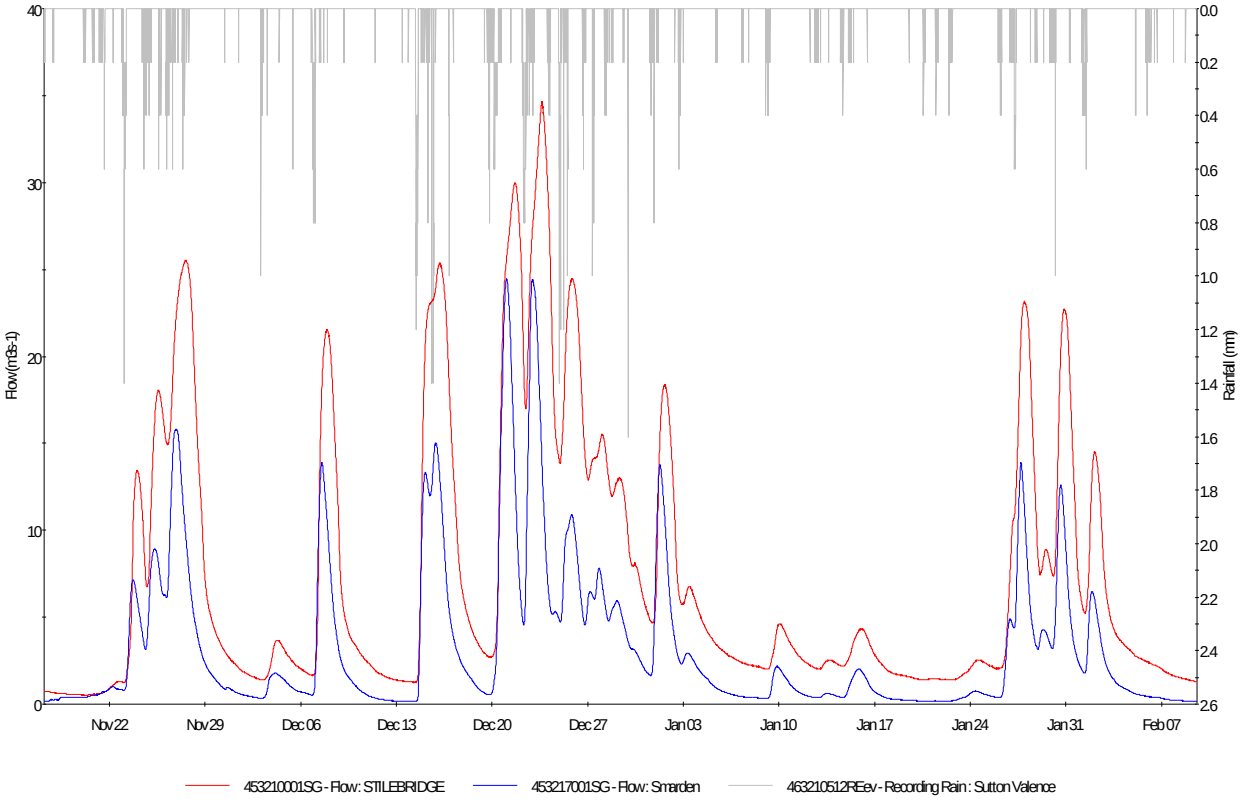


The November 2009 flood event was a result of a sustained period of reasonably intense rainfall (winter profile) within the River Beult . There are also a series of intense rainfall events and corresponding peak flows in the River Beult in December 2009. Given the underlying impermeable geology, soil types and urbanised areas within the Headcorn catchments, it is likely that the sustained period of rainfall resulted in a combination of fluvial and surface water flooding. This may have also been exacerbated by the elevated Main River levels in the Sherway, Moat Farm Stream and Beult as the peak flood volumes during November/December 2009 event would have prevented excess surface water from being drained into the watercourses.

4.2.4 December 2012 – January 2013

In December 2012 and January 2013 foul sewer flooding was reported in Headcorn. The rainfall recorded at Headcorn STW TBR and the flow recorded on the River Beult at Stilebridge and Smarden are shown in Figure 4-4.

Figure 4-4: December 2012 – January 2013 events



There were multiple peaks during these two months. There are also several reported flood events during this winter period. The majority of the reported flood events were due to foul sewer flooding within Headcorn; 19th, 21st - 22nd December 2012, 2nd January and 31st January 2013.

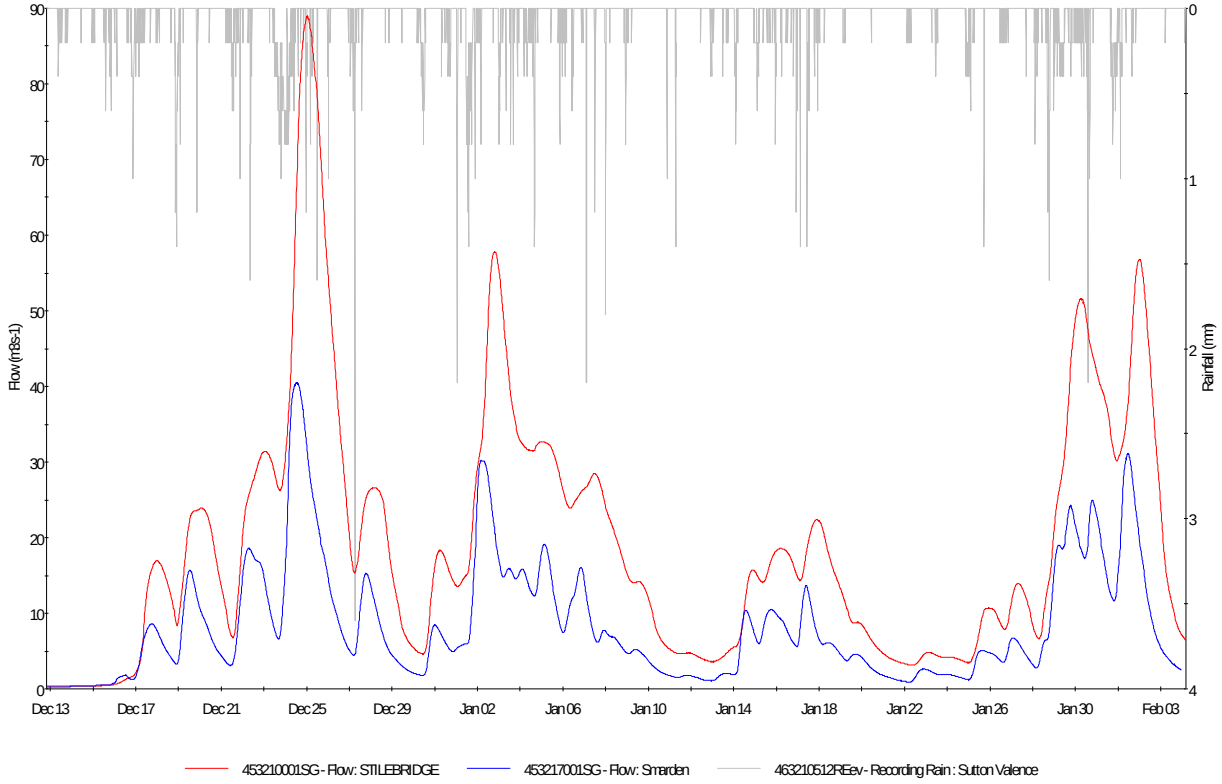
The largest peak flows were seen on 24-25 December 2012. Smaller peaks were seen following the storms of 25 November, 8 December, 16 December and 27 December 2012. Smaller events were also observed on 1 January, 27 January and 1 February 2013.

These events are not highly ranked within the gauged records at Stilebridge (24th out of 47) and Smarden (11th out of 23). Although it is expected that these events could be significant for the Headcorn catchments. Unfortunately, there is no information on severity or magnitude within the reported flood history in Headcorn. The return period for the rainfall that fell on the 24th December is <1 year. However, it is expected that the return period of the sustained rainfall totals across December 2012 – January 2013 could be slightly higher.

4.2.5 Winter 2013-14

In December 2013 and January 2014 fluvial flooding and surface water flooding were reported in Headcorn. The rainfall recorded at Headcorn STW TBR and the flow recorded on the River Beult at Stilebridge and Smarden are shown in Figure 4-5.

Figure 4-5: Winter 2013/14 events



For the winter 2013-14 events, the River Beult was characterised by numerous storm events that led to fluvial and surface water flooding. The majority of the reported flood events were due to foul sewer and surface water flooding within Headcorn; 23rd and 27th December 2013, 8th – 9th January 2014. The largest peak flows were seen on 24-25 December 2013. Smaller events were also observed on 1 January, 27 January and 1 February 2014. The December 2013 event is the second highest ranked event at Stilebridge and the 5th highest ranked event at Smarden. Therefore, it is expected that these events were also significant for the Headcorn catchments. Unfortunately, there is no information on severity or magnitude within the reported flood history in Headcorn. The return period for the rainfall that fell on the 24th December is approximately 3 years. However, it is expected that the return period of the sustained rainfall totals across December 2013 – January 2014 would be significantly higher.

5 Conclusions

All of the reported flood events are in the winter months and this therefore suggests that the Headcorn catchments (River Sherway and Moat Farm Stream) may be more prone to longer duration frontal rainfall events. The Headcorn catchments may be sensitive to short intense rainfall events due to the underlying impermeable geology and the urbanised area in the centre of Headcorn. However, it is clear that the flood events (reported) tend to occur when short intense rainfall events are superimposed on top of elevated Main River levels due to longer duration frontal rainfall events. Therefore the reported flood events within Headcorn are generally associated with elevated Main River levels and high flows in the River Beult and are also likely to be influenced by elevated levels in the Moat Farm Stream.

It is highly likely that the catchments within Headcorn may be more sensitive to short intense rainfall events during periods when there are elevated Main River levels. This would exacerbate the surface water flooding as the excess surface water is unable to be cleared from the surface water drainage network. Therefore flooding within Headcorn may be as a result of the inability to discharge excess surface water during Main River flood events.