

Flood Investigation Report

Flooding affecting the areas of

Borough Green Road and Busty Lane, Ightham

On the 25th June 2016

This document has been prepared by Kent County Council Flood and Water Management Team as the Lead Local Flood Authority under Section 19 of the Flood and Water Management Act 2010, with the assistance of:

- Kent County Council Highways, Transportation and Waste
- Tonbridge and Malling Borough Council
- Ightham Parish Council
- Kent Fire and Rescue Service
- Local Residents and Landowners

The findings in this report are based on the information available to KCC at the time of preparing the report. KCC expressly disclaim responsibility for any error in or omission from this report. KCC does not accept any liability for the use of this report or its contents by any third party.

For further information or to provide comments, please contact us at flood@kent.gov.uk

Document Status:

Issue	Revision	Description	Date
0	0	Draft Report for Internal Comment	31 Jan 2017
0	1	Draft Report for External Comment	9 Mar 2017
0	2	Final Draft for External comment	13 Mar 2017
1	0	ISSUE FOR PARISH / TMBC COMMENT	20 Mar 2017
1	0	PUBLISHED	20 Mar 2018

Contents

1	Introduction	1
1.1	Requirement for Investigation	1
1.2	Trigger for Investigation.....	1
1.3	This Investigation	2
2	Background Information	3
2.1	Site Location and Topography	3
2.2	Flood History.....	3
2.3	Roles and Responsibilities.....	4
2.3.1	Kent County Council.....	4
2.3.2	Tonbridge and Malling Borough Council.....	4
2.3.3	Statutory Undertaker for Public Sewers	4
2.3.4	Riparian Landowners	4
2.3.5	Residents and Property Owners	5
2.4	Existing Drainage Infrastructure	5
2.4.1	Watercourses	5
2.4.2	Public Sewers	7
2.4.3	Highway Drains	7
2.5	Published Flood Risk	7
2.5.1	Fluvial (River) Flood Risk	7
2.5.2	Surface Water Flood Risk.....	8
2.5.3	Other Sources of Flooding	9
3	Overview of the Flood Event and Response	10
3.1	Description of events during the flooding	10
3.2	Emergency Response to the Flooding.....	12
3.2.1	Emergency Services.....	12
3.2.2	Tonbridge and Malling Borough Council.....	12
3.2.3	Kent County Council.....	13
3.3	Follow up Responses to the Flooding to date.....	13
4	Analysis of the Flooding Event	14
4.1	Rainfall Data	14
4.2	General Watercourse Condition	16
4.2.1	Durling's Orchard Culvert Sizing and Condition	16
4.2.2	Orchard House and Mount Farm Entrance Culvert Condition	17
4.3	Flooding Mechanism.....	17
4.4	Conclusions	19
5	Other Reported Instances of Flooding in the Area	20
5.1	Fen Pond Road, Ightham.....	20

5.2	Thong Lane, Borough Green	21
5.3	Mote Road, Ivy Hatch.....	22
6	Future Actions.....	23
6.1	Recommendations	23
6.2	Flood reduction measures	23
6.3	Community Resilience.....	24
	Construction History and Development of the Area	26
	Construction Records.....	26

Appendix A – Extract from ‘Living on the Edge’

Appendix B – Durling’s Orchard Culvert History and Historical Maps

Appendix C – Kent Fire & Rescue Incident Response

Appendix D – Topographical Survey Information

Appendix E - Minutes of Meeting held by Ightham Parish Council on 27th September 2017

Appendix F - CCTV Survey of Durling’s Orchard Culvert

Table of Tables

Table 1	Ezel Villas to The Willows culvert dimensions	16
Table 2	Options for flood risk management	23
Table 3	Site History from Ordnance Survey Mapping and KCC Aerial Photographs	26

Table of Figures

Figure 1	Area of Interest for this investigation	3
Figure 2	Watercourses around Ightham (shown in blue)	5
Figure 3	Risk of Flooding from Rivers or the Sea	8
Figure 4	Risk of Flooding from Surface Water	9
Figure 5	Locations of rain gauges within 10km of Ightham	14
Figure 6	Data from rain gauges within 10km of Ightham	15
Figure 7	Exceedance flow routes for flood water	18
Figure 8	Site Plan for Durling’s Orchard Development with culvert details.	27

Table of Photos

Photo 1	View of the entrance to the culvert during inspection on 28 th October 2016	6
Photo 2	High flow in Busty Stream at the junction of A227 and Busty Lane on 25 th June 2016...	10
Photo 3	Extent of flooding at Busty Lane (published by Sevenoaks Chronicle).	11
Photo 4	Localised damage to driveway at the downstream end of the culvert.....	12
Photo 5	Upstream entrance to culvert (left) and downstream end manhole /road gully.....	20
Photo 6	Out of bank flow adjacent to bridge (left) and view of blocked culvert entrance (right).	21
Photo 7	Reinstated watercourse at the site of the former bridge on 28 th October 2016.....	22

1 Introduction

Significant flooding within the village of Ightham was reported to Kent County Council (KCC) and other authorities on 25th June 2016. This flood caused significant internal flooding to properties in the areas of Busty Lane and Borough Green Road adjacent to the Busty Stream. As a consequence of this, KCC as Lead Local Flood Authority for Kent has undertaken an investigation into the flooding.

1.1 Requirement for Investigation

As the Lead Local Flood Authority (LLFA) for Kent, KCC has a duty to investigate flood incidents as set out in Section 19 of the Flood and Water Management Act 2010 (the Act). Section 19 of the Act says:

(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.

A flood investigation does not necessarily require a thorough investigation of the flood and its mechanisms, only the determination of the risk management authorities who have the relevant functions. However, KCC may choose to undertake a more detailed investigation into a flood incident in order to better deliver the objectives of Kent's Local Flood Risk Management Strategy, for instance to improve the understanding of flood risk in a particular location.

1.2 Trigger for Investigation

As the primary purpose of an investigation is to determine the responsible body or bodies to respond to the flood that occurred, KCC will undertake a flood investigation where no other risk management authority is exercising or is proposing to exercise its functions in respect of the flood and where the flood is significant. A significant flood is defined by Section 5.1 of the Local Flood Risk Management Strategy for Kent 2013, and is one that causes:

- internal flooding to one or more properties;
- external flooding of five or more properties;
- flooding of roads, rail and other transport infrastructure to an extent that they become impassable by vehicles;
- flooding of or near locally important services or infrastructure, for example health centres and electricity substations, to an extent that they cannot function normally.

1.3 This Investigation

The flood event meets the criteria of a significant flood event and therefore requires investigation. An investigation was also deemed necessary due to public interest and to provide information for further studies into flood risk of this area.

2 Background Information

2.1 Site Location and Topography

The area of flooding under consideration within this report is located along the route of the Busty Stream between the junction of Borough Green Road and Busty Lane, and the junction of Borough Green Road and the A25 Ightham Bypass. This is shown in Figure 1.

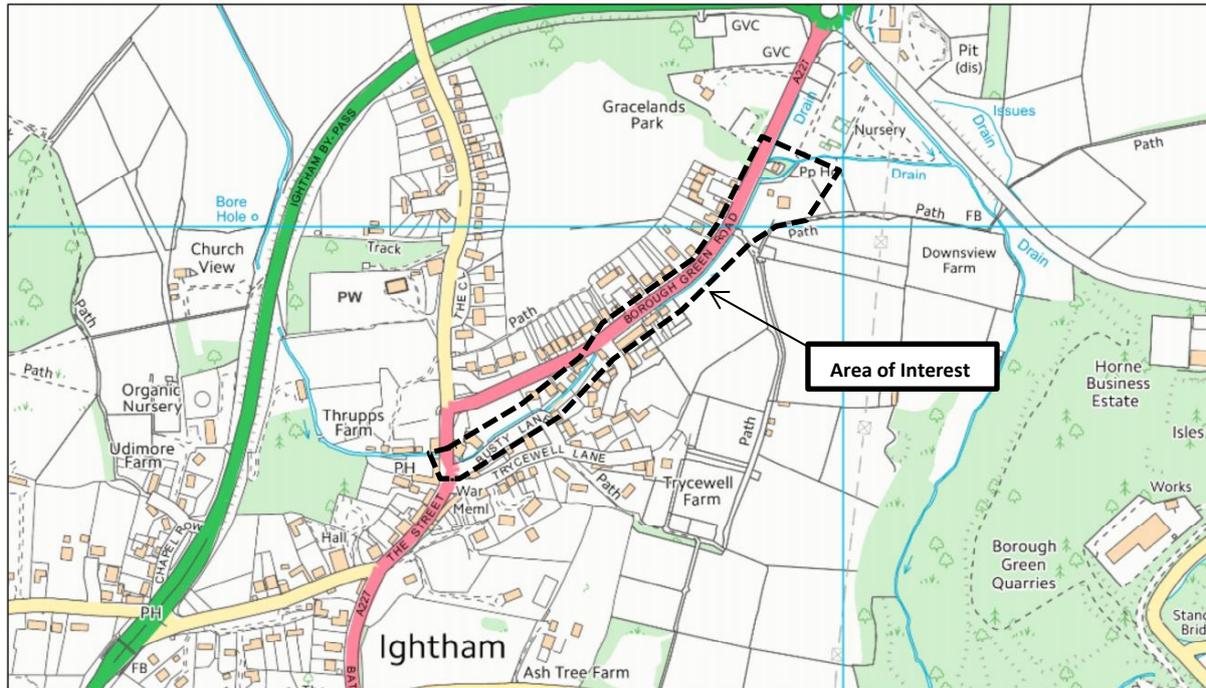


Figure 1 Area of Interest for this investigation

The area of interest is located within a valley feature associated with the Busty Stream with ground levels of around 81mAOD at the junction of Busty Lane and The Street, sloping down to 78.4mAOD at the eastern end of Busty Lane. Beyond Busty Lane, the ground levels alongside the stream are relatively flat with the ground level alongside the Southern Water pumping station at Borough Green Road being 77.5mAOD. The fields south of Borough Green Road and east of the properties are noted to be up to 1m lower than the level of the road at the southern bank of the stream.

2.2 Flood History

Flooding of this area occurred in 1968 causing widespread flooding and damage to property and businesses due to extremely high flows occurring through the watercourse.

There are limited details of flooding occurring since this date although anecdotal evidence suggests high flows are known to occur during wet winter conditions. In particular, the winters of 2000 and 2003 were noted by residents where wet winters had caused high flows in the watercourse and flooding to external areas of properties alongside the watercourse.

KCC records indicate high flows in the watercourse caused flooding at the eastern end of Busty Lane in September 2009, November 2013, and January 2014 although no property flooding was reported in these events.

2.3 Roles and Responsibilities

2.3.1 Kent County Council

KCC is the lead local flood authority for Kent and the highway authority. The Flood and Water Management Act 2010 gives lead local flood authorities powers and duties for the strategic overview of local flooding and for some flood-risk management functions including:

- a duty to investigate flooding
- a duty to maintain a register of significant structures and features
- powers to regulate ordinary watercourses
- A duty as a statutory consultee to review drainage strategies and surface water management provisions associated with applications for major development

As the highways authority KCC are responsible for the maintenance and operation of drainage gullies and the associated connecting pipework for the proper function of highways and safety of highway users.

2.3.2 Tonbridge and Malling Borough Council

Tonbridge and Malling Borough Council (TMBC) is a category one responder under the Civil Contingencies Act 2004, along with KCC and the emergency services during emergency responses such as that required by a flooding event.

2.3.3 Statutory Undertaker for Public Sewers

Southern Water are responsible for the maintenance and operation of the public sewer network and associated assets (such as pumping stations) throughout the area carrying foul water or surface water (where a separate surface water sewer exists).

2.3.4 Riparian Landowners

If you own land adjoining, above or with a watercourse running through it, you have certain rights and responsibilities as a 'riparian owner' of a watercourse. The ownership of watercourses is established in common law:

- If a watercourse runs through your land, it is generally assumed you own the section of watercourse which runs through your land.
- Where a watercourse lies adjacent to your boundary, it is assumed you own up to the centreline of the watercourse (unless the land it is on is owned by someone else).
- Where a watercourse lies between your boundary and a public highway, you will generally be responsible for the full width of the watercourse. Highway authorities are generally only responsible for ditch created by them for the sole purpose of draining the highway.

It should be noted that your property may include a watercourse that runs in a culvert. You have the same responsibilities for the upkeep of the culvert as if it was an open watercourse

Further detailed information about the responsibilities and rights of riparian landowners is contained within the Environment Agency publication '[Living on the Edge](#)'. An extract from this document is included in Appendix A.

2.3.5 Residents and Property Owners

Private landowners are responsible for the maintenance and operation of drainage assets and connecting pipework located on privately owned roads and footways, car parks and other hard standings and for building surface water drainage.

Residents and property owners who know they are at risk of flooding have responsibilities to mitigate the risk of flood damage to their property as far as is reasonably practicable. They should take measures to protect themselves and their property when flooding is imminent. Residents and property owners have the right to defend their property as long as they do not subsequently increase the risk of flooding to other properties.

2.4 Existing Drainage Infrastructure

2.4.1 Watercourses

An ordinary watercourse known as the Busty Stream flows through the village of Ightham and is the main system for surface water drainage of both land and developed areas in this location. An overview of the watercourses in the catchment area of the Busty Stream is shown in Figure 2.

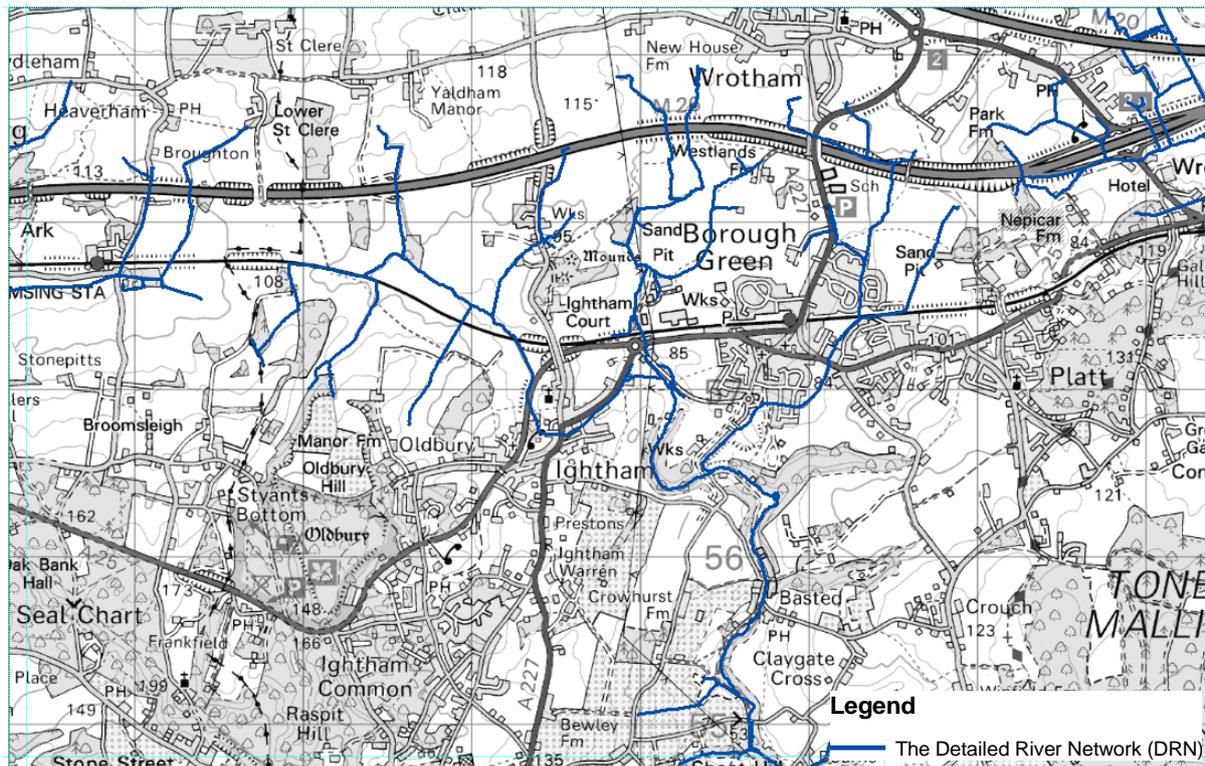


Figure 2 Watercourses around Ightham (shown in blue)

The source of the watercourse is from groundwater springs off Fen Pond Road, Yaldham Farm and Oldbury Hill which combine into a single watercourse just north of the Maidstone Railway Line and the A25 Ightham Bypass. The watercourse flows in a southerly direction under the A25 through a 900 mm culvert and through the wooded area west of the George and Dragon. It then turns to the east and flows past the George and Dragon and under The Street through a bridge. The Busty Stream then flows through a series of bridges and culverts adjacent to The Forge and Ightham Place alongside Busty Lane.

The depth of the channel reduces towards until the end of Busty Lane, where the channel is 0.7m in depth, albeit slightly wider than at the top of the road. Eastwards of Busty Lane, the watercourse remains in an open channel but flattens in gradient. The channel is bordered by property on the southern side and a public footpath on the northern side. From here, the watercourse is again confined by walls of blockwork and ragstone as it flows between properties.

It then flows through a brick arch culvert below Ezel Villas, shown in Photo 1. The culvert turns through 90 degrees to flow due north for a few metres and then 90 degrees again to flow east parallel with Borough Green Road. The culvert has been constructed in a several stages, which now form one continuous structure.



Photo 1 View of the entrance to the culvert during inspection on 28th October 2016

The watercourse emerges by The Willows and flows north easterly. It passes through a small bridge providing access near Orchard House and turns east and flows along the southern boundary of the nursery. At the south eastern corner of the nursey it joins the River Bourne, which is a tributary of the River Medway.

The history of the construction of the culverts from Ezel Villas through to The Willows is described in Appendix B. A topographical survey of the watercourse and a CCTV survey of the culvert from Ezel Villas through Durling's Orchard to The Willows were undertaken as part of this investigation, which can be found in Appendix D.

The Busty Stream is generally dry except during periods of high rainfall and wet winter conditions. The upper reaches of the catchment are situated on impermeable clays and hence there can be rapid response to heavy rainfall when the surface soils are waterlogged. The majority of the

catchment is rural, there are some flows from impermeable areas within the built-up area of Ightham, but these are not a significant portion of the flow.

2.4.2 Public Sewers

Public sewers are often referred to as 'mains drainage' and the area is served by a network of foul water drains designed to carry waste water away from properties to the nearest treatment works.

Newer properties will generally have surface water separated from foul water and discharge it either directly into the ground (via a soakaway), into a watercourse (on or near the property) or into a dedicated surface water sewer.

The only area served by a dedicated public surface water sewer is Durling's Orchard, and this outfalls surface water into the culverted section of the Busty Stream. It is considered likely the majority of drainage of private roofs, hard standings and road is drained via soakaways or privately owned connections into the watercourse.

It should be noted that foul 'mains drainage' is not intended to convey surface water, although misconnections are common on older properties (for example, for roof downpipes or drives). It is important in a flood event that manholes are not opened in an attempt to drain surface water. This could cause flooding elsewhere by inundating the sewer pipework.

2.4.3 Highway Drains

Highway drainage gullies and their associated pipework is owned and maintained by Kent County Council as the highway authority. The highway drainage in this area is generally connected to the watercourse and is intended to clear surface water which falls upon the carriageway for the safety of highway users. These drainage assets are not intended to convey significant flows from areas outside of the highway boundary such as flood flows from rivers.

2.5 Published Flood Risk

Flood risk information can be found on the new Flood Information Service (the service is new, though the data has been available on other websites for a number of years). The new service allows anyone to find out the risk of flooding by simply entering their postcode and confirming their address. The new service can be accessed at <https://flood-warning-information.service.gov.uk> and clicking on 'view your property's long term flood risk'.

2.5.1 Fluvial (River) Flood Risk

The risk of fluvial flooding is defined by mapping produced by the Environment Agency and these generally reflect the extent of a river's floodplain. A floodplain is the area that would naturally be affected by flooding if a river rises above its banks. An extract from this information is shown below.

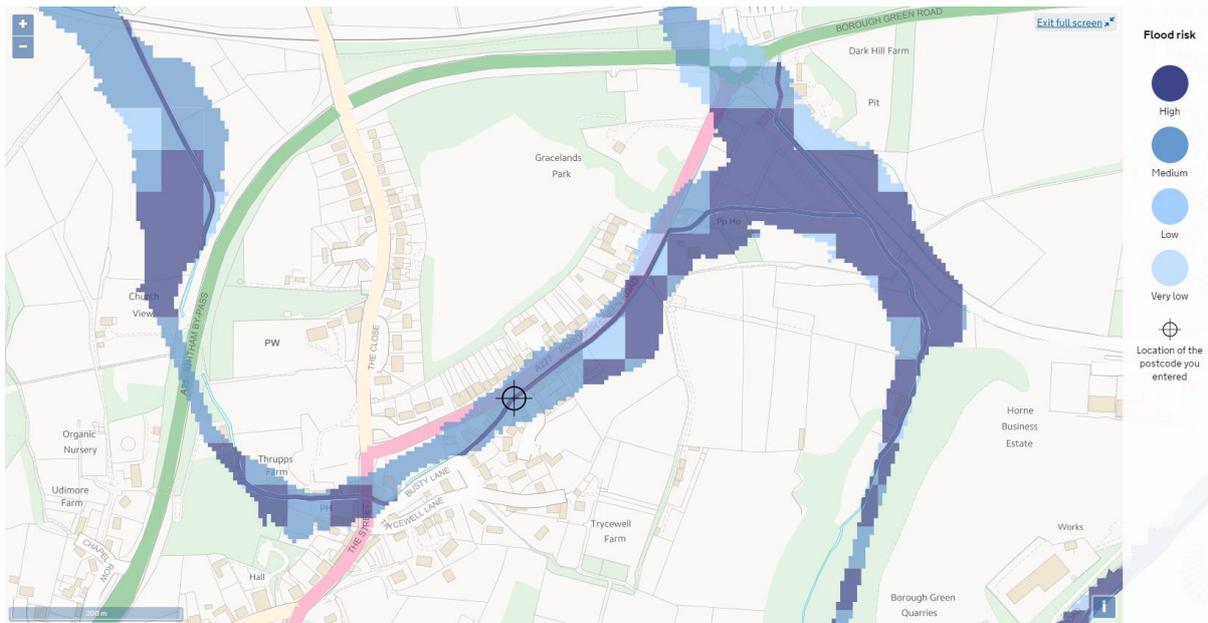


Figure 3 Risk of Flooding from Rivers or the Sea

The area adjacent to the Busty Stream is defined in the mapping as being at a medium to high risk of fluvial flooding, meaning there is between a 1% (1in100) and greater than 3.3% (1in30) risk of flooding occurring in any one year.

It should be noted that this information is suitable for identifying which parts of towns or streets are at risk, or have the most risk. It's also suitable for identifying the approximate extent and depth of flooding. It's likely to be reliable for a local area but not for identifying individual properties at risk.

The site does not benefit from a flood warning service. It is generally impractical to implement a flood warning on a small river catchment such as that of the Busty Stream, as they are difficult to predict and such warning may not allow sufficient time for landowners and residents to prepare for flooding.

2.5.2 Surface Water Flood Risk

The risk of surface water flooding is indicated by the Updated Flood Map for Surface Water and was produced by the Environment Agency and is an updated version of the mapping produced following the recommendations of Sir Michael Pitt's review of the 2007 summer floods.

Surface water flooding occurs when heavy rainfall is unable to drain away through natural or artificial drainage system and hence temporarily ponds or flows overland following the local topography.

The mapping is predominantly based upon topographical information and has some overlaps with the fluvial flooding maps as the local watercourses will provide the pathway for surface water to flow away. An extract from this information is shown below.

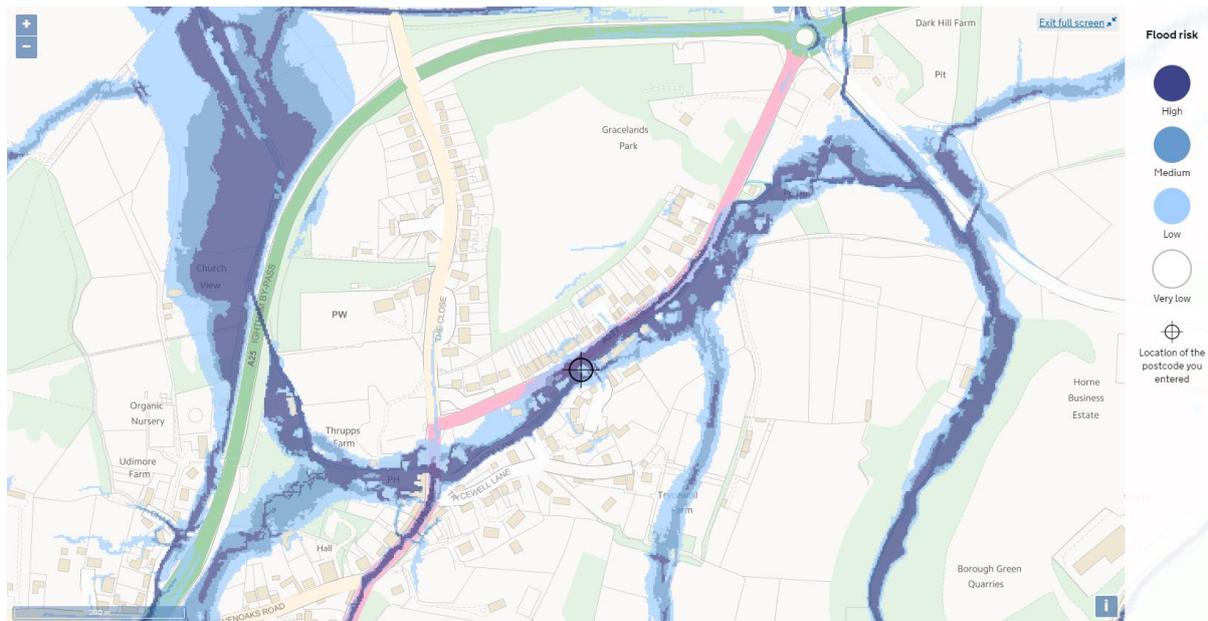


Figure 4 Risk of Flooding from Surface Water

The mapping indicates that many areas local to the Busty Stream are at a high risk of surface water flooding. High risk means that each year this area has a chance of flooding of greater than 3.3% (1in30).

It is noted that the mapping indicates a risk of out of bank flows travelling along Borough Green Road and through the fields to the road due to the topography. Additional sources of overland flow are indicated by this mapping where rainfall could naturally flow over the ground surface should it be unable to soak into the soil. The amount of water following off fields and other areas can substantially increase when the ground has become waterlogged through earlier rainfall or prolonged wet weather.

2.5.3 Other Sources of Flooding

The area is considered to be at a low risk of flooding from other sources such as from groundwater and the sea.

During the investigation reports were received about sewer manholes flooding. However this source of flooding is not considered further within the report as it would not be a significant contributor to the flood event. Any ongoing operational issues with the sewer network must be reported to the sewerage undertaker for the area, in this case this is Southern Water.

3 Overview of the Flood Event and Response

The details of the flooding in the areas affected during the event on 25th June 2016 are set out in more detail in this section of the report to collate details recorded during the flooding event and the subsequent investigations work.

3.1 Description of events during the flooding

The flood even occurred on Saturday 25th June 2016 following heavy rainfall at approximately 17:30 across Kent, in particular in the west and north of the county. This generated rapid run-off into an ordinary watercourse known as the Busty Stream which flows through the village.

High water flows were experienced in the channel of the Busty Stream. These remained within the banks of the watercourse where it crosses the A227 (as shown in photograph 2) with an approximate depth of fast flowing water of 1.2 metres.



Photo 2 High flow in Busty Stream at the junction of A227 and Busty Lane on 25th June 2016.

The flows remained within the watercourse and flowed through the culverts and bridges at the upper end of Busty Lane. As it travelled down Busty Lane the water came out of bank between the stream near the bend in Busty Lane by Elim Cottages and the culvert under Ezel Villas.

During the flood event the high flows of water were unable to drain through the watercourse and culvert downstream of Busty Lane as quickly as the water was flowing in from the higher ground. A significant depth of water backed up between the lower part of Busty Lane and the culvert entrance. It is estimated the maximum depth of flood water was approximately 2 metres as illustrated by the depth of water around a parked van shown in Photograph 3.



Photo 3 Extent of flooding at Busty Lane (published by Sevenoaks Chronicle).

The depth of flooding was such that the water was able to flow out of bank, despite the high bank sides. It flowed through and around properties adjacent to the watercourse, through front and rear gardens and onto Borough Green Road to the north causing the full width of the carriageway to be flooded by flowing water above kerb height, as shown in Photograph 4. The water flowed down the road and entered properties internally via doorways and airbricks.

The flows of water along Borough Green Road continued to flow eastwards where some of the water flow was able to re-enter the watercourse via driveway entrances adjacent No.2 The Willows. It is also at this point where the culverted section of the watercourse re-emerges.

Local residents commented that water was continuing to discharge from the culvert during the event; however the force of water was sufficient to cause a small part of a driveway above the watercourse to collapse as shown in Photograph 5.

Downstream of the culvert, water flows appear to have flowed out of the bank into the adjacent fields upstream of the culvert at Orchard House. Water flows from upstream that flowed along Borough Green Road also appeared to have entered the grounds of Orchard House via the driveway entrance. This caused internal flooding of property here.

Reports of sewer manholes flooding during the event have also been recorded, which is likely to be from inundation of the sewer from flood water entering manholes and through any misconnections with surface water drainage that may be present.

Further flooding was also reported downstream of Ightham and along the River Bourne highlighting the high flows downstream continued to exceed the watercourse's capacity.



Photo 4 Localised damage to driveway at the downstream end of the culvert

3.2 Emergency Response to the Flooding

3.2.1 Emergency Services

The area was initially attended by Kent Fire and Rescue Service (KFRS) from approximately 19:00 on the 25th June 2016. The KFRS are a Category 1 Responder under the Civil Contingencies Act 2004 and have a duty to risk assess, conduct emergency planning, provide the public with advice and share information.

An account from KFRS of their incident response was published on their website and is reproduced in Appendix C.

Following the flooding event some criticism was apparent from residents due to the lack of a police presence. However in this situation the incident response is lead and controlled by KFRS and therefore the attendance of the police is not required.

3.2.2 Tonbridge and Malling Borough Council

Tonbridge and Malling Borough Council (TMBC) are also a Category One Responder under the Civil Contingencies Act 2004; their role in an event like this is to provide respite care and temporary accommodation if homes have to be evacuated. Once TMBC were notified of the event by the KFRS Incident Controller, the senior duty officer was deployed to the George & Dragon and remained on site into the. Once it was established that temporary accommodation was not required in this instance, the director left site and KFRS continued to manage the incident.

TMBC's Head of Technical Services returned to the site the following morning to establish which properties had flooded and to assist with them in contacting their insurance companies. This was assisted by additional representatives from KFRS. A door to door visit of all properties was made and details of the affected properties noted. An officer attended from TMBC to assess the structural integrity of the collapsed driveway to assist the home owner. Arrangements were also discussed in the event that disposal of damaged furnishing would be requested to assist residents.

3.2.3 Kent County Council

KCC is also a category one responder under the Civil Contingencies Act 2004, for highway safety (also for strategic coordination of large events if they are declared to be emergencies by the police, which was not the case in this instance). An out-of-hours Duty Officer from Kent County Council's (KCC's) Highways Department was deployed to site during the flooding to assist other responders with implementing a road closure to allow emergency services to work safely, traffic to be provided with an alternative route due to the flooding and avoid further damage to property from vehicles travelling through flood water.

Follow up visits to the site were made by officers representing KCC as the Lead Local Flood Authority, who's duty is to investigate flooding as detailed at the start of this report. This is described in more detail below.

3.3 Follow up Responses to the Flooding to date

Officers from KCC as the Lead Local Flood Authority were briefed on the flooding event by TMBC's duty officer and Head of Technical Services immediately following the emergency response in order to collate information gathered by those in attendance during the event. Following this, KCC initiated this investigation and began data collection including the collation of rainfall data and information on the culvert in this location.

The community and parish council have been involved in undertaking maintenance of the watercourse to remove excess vegetation from the banks and clear any excess silt from the bed of the watercourse. In particular, the section of watercourse along Busty Lane was cleared.

4 Analysis of the Flooding Event

Following the collation of information and undertaking of site surveys, an analysis was made of the information to determine the causes of the flooding event.

4.1 Rainfall Data

Rainfall around the county is recorded by a series of rain gauges operated by the Environment Agency. Following the event rainfall data was requested by KCC for analysis.

There are no rain gauges within 5km of Ightham, but several are located within 10km of the site. These are at Trosley (5.2km east), Kiln Wood (5.6km south), Sevenoaks (6.5km west) and Hartley (9.7km north). These rain gauges record rainfall depths at 15 minute intervals. The locations of these gauges are shown in Figure 5.

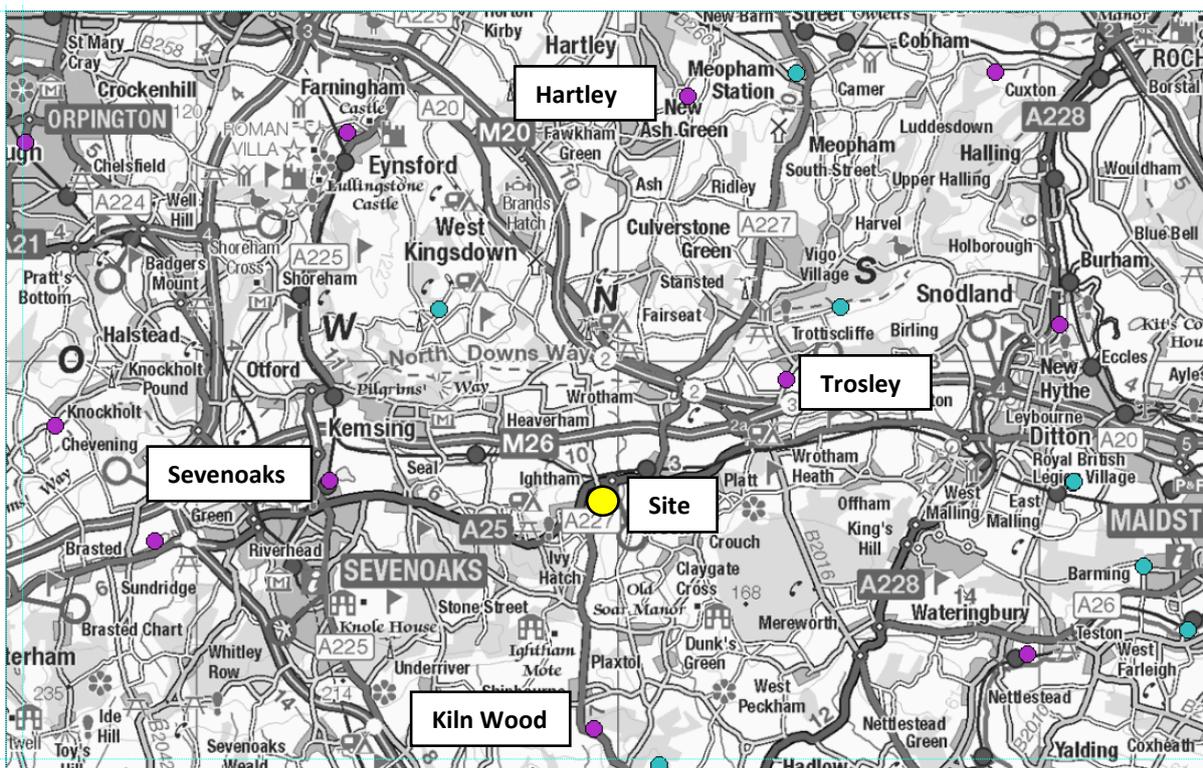


Figure 5 Locations of rain gauges within 10km of Ightham

The data for the 25th June 2016 is shown in Figure 6. The Sevenoaks rain gauge is likely to be the most representative of the Busty Stream catchment; however the data from these rain gauges highlights the highly variable nature of the rainfall during this event.

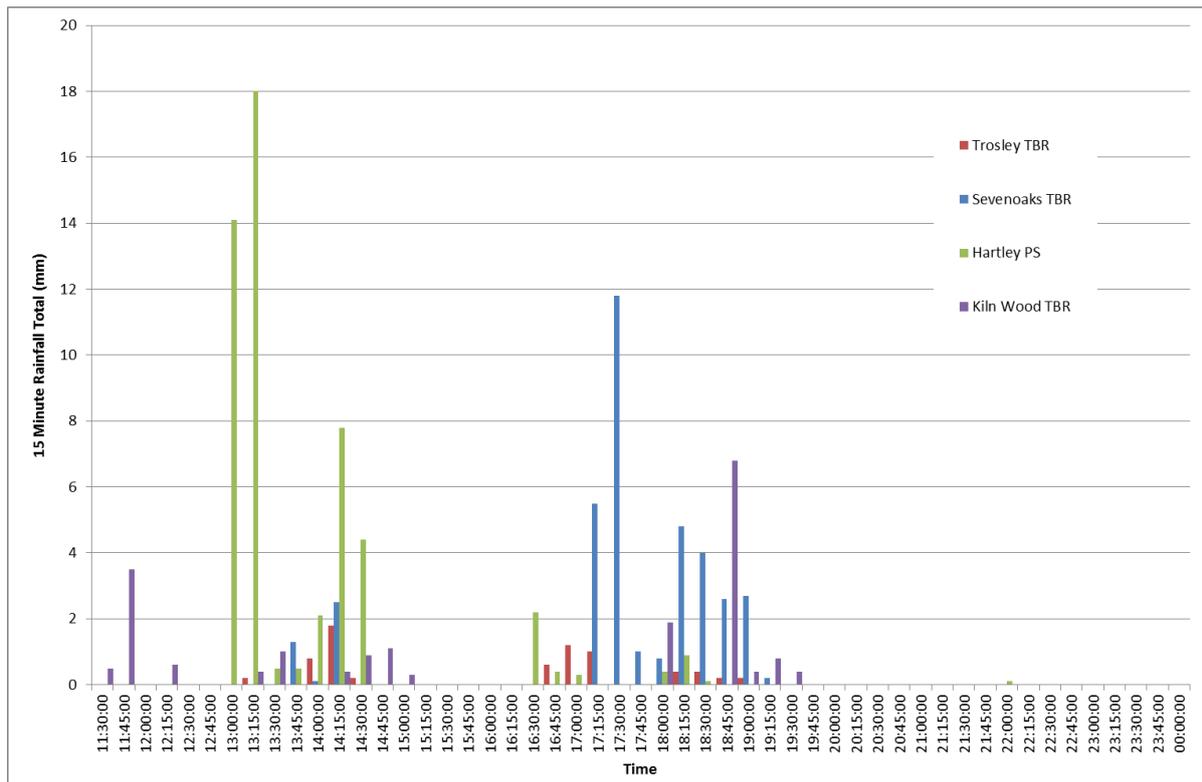


Figure 6 Data from rain gauges within 10km of Ightham

The Sevenoaks rain gauge recorded 33.4mm of rain between 17:15 and 19:15, of which 17.3mm fell in less than half an hour (from 17:15). The exact time of peak flows being experienced within the Busty Stream is unclear; it appears to have occurred between approximately 2 to 3 hours after the initial heavy rainfall was recorded at the Sevenoaks rain gauge. This reflects the time required for the storm to move from the west to Ightham and for the rainfall to runoff the catchment surface and collect in the watercourse at Ightham.

The other rain gauges near Ightham recorded only 4 to 10mm of rainfall between 17:15 and 19:15, which indicates the localised area these storms were affecting. Applying the Sevenoaks rainfall to the Busty Stream catchment using the Flood Estimation Handbook Event Rarity Calculator gives an estimated 5.34% Annual Exceedance Probability (AEP) for this rainfall event (or a 1 in 18.7 year return period). This means that there is a 5.34% change of this rainfall intensity or greater occurring in any one year, or that over a period of 100 years approximately 5 events of this size or greater would be expected to occur.

Between 11:30 and 15:00 on the 25th June 2016, 47.4mm of rain fell at Hartley, 9.7 km to the north (however, only 3.9mm of rain was recorded at the Sevenoaks rain gauge, 3mm at Trosley and 8.7mm at Kiln Wood during this time). This rainfall is known to have caused localised surface water flooding in the areas around Hartley. It is likely that there was rainfall earlier in the day in the Busty Stream catchment, which would have had the effect of pre-wetting the ground, causing a greater volume of run-off to enter the stream during the rainfall later in the day than otherwise would have done.

The variation of rainfall depths at the rain gauges throughout the day highlights the localised nature of these storms. It is common with small, intense summer storms that the rain gauge network does not fully record the intensity of the event as it occurs away from a rain gauge. As a consequence, it is

possible that rainfall within Busty Stream catchment prior to and during the flooding event was greater than that recorded by the Sevenoaks rain gauge

4.2 General Watercourse Condition

A walkover survey was undertaken on the 1st July 2016 by officers from KCC's Flood and Water Management Team and the Highways Drainage Team along accessible parts of the watercourse. No blockages were found, however some debris was noted in places that is likely to have been deposited during the flooding event (e.g. pieces of wood and rubbish). A small build-up of silt was noted within the watercourse at the end of Busty Lane, however this is not considered to have been significant due to the limited depth (less than 150mm).

It was noted that some sections of the watercourse was overgrown and lined within small trees and shrubs. Whilst it is unlikely these would impact the flow of water and exacerbate flooding, some management of vegetation in the future will maximise the conveyance of high flows and ease inspection of the watercourse in the future.

4.2.1 Durling's Orchard Culvert Sizing and Condition

During the course of this investigation, significant concerns have been raised by local homeowners and members of the public about the capacity and condition of the culverts located at Durling's Orchard and beneath the entrance to Orchard House and Mount Farm.

Due these concerns, KCC arranged for a CCTV survey to be undertaken to confirm this details. This information was combined with the topographical survey in Appendix A to provide an accurate record of the condition, size and levels of both the culvert and the surrounding sections of open watercourse. A copy of the results of the culvert survey is included in Appendix D.

The survey results show that the culvert is in a sound structural condition throughout. Two areas are noted to have timber roofs; this is likely to be the formwork used to construct cast insitu concrete slabs above. The small area that collapsed at the downstream end of the culvert has been repaired; it is not clear from the CCTV survey why there was a localised failure at this point during the event.

No blockages were noted in the culvert during the survey, although it is noted that two areas of the culvert have minor amounts of debris (e.g. sticks and small branches) or silt deposits. Some of this material is likely to have been deposited during the flooding event. It is unlikely that this would be a significant contributor to the extent of flooding.

The capacity of the culverts is found to be smallest at the entrance to the culvert at Ezel Villas, which is a brick arch culvert 1.8 m wide 1.2 m high. The dimensions of the culvert are shown in Table 1.

Table 1 Ezel Villas to The Willows culvert dimensions

Location	Dimensions (W x H), m	Length, m	Shape
Ezel Villas	1.8 x 1.2	15.81	Arch, with two 90 degree bends
Durling's Orchard (road)	1.35 x 1.0	8.40	Rectangular
Durling's Orchard properties	1.35 x 1.0	26.35	Rectangular
Durling's Orchard properties	1.8 x 1.0	9.80	Rectangular

Old School Cottages	1.8 x 1.8	1.93	Square
Old School Cottages	1.8 x 1.2	19.51	Arch
The Willows	1.8 x 1.8	9.56	Square (with clear span structure above)
The Willows	1.8 x 1.2	1.00	Arch (footbridge)

4.2.2 Orchard House and Mount Farm Entrance Culvert Condition

The topographical survey in Appendix A also includes the culvert under the access road near Orchard House. This culvert was not surveyed by CCTV due to its short length and it is possible to undertake a visual inspection.

Information from the topographical survey notes this culvert is a 1.5 wide by 0.9m high brick arch, with a short extension constructed from a 0.9m diameter concrete ring. Inspection shows the culvert is in a sound structural condition; however the culvert extension detail presents a risk of blockage due to the change in shape from that of the arched upstream section of culvert.

At the time of the inspection, debris was trapped in this section which may restrict flow during high flow conditions. It is expected that this would cause water to flow around the culvert, into the adjacent fields and access road, contributing to flooding downstream of this location.

4.3 Flooding Mechanism

Anecdotal evidence suggests high flow conditions are not uncommon along the Busty Stream; however the flooding of property appears to be rare.

Residents have commented that some flooding at the end of Busty Lane and of external areas of property has occurring in previous wet winter conditions; however it is understood the flows have not internally flooded properties since the 1968 flood event. During the June 2016 event, it is clear that there was a significant depth of flood water upstream of the entrance to the culvert, in places reaching as much as 2 metres deep, which led to internal flooding.

The route of flood water exceedance flow around Busty Lane and Borough Green Road was close to that predicted by the updated Flood Map for Surface Water, shown in Figure 8. Though the flooding upstream of Busty Lane shown on this map was not experienced (this is likely to be due to the composite way in which these maps are compiled, which uses different types of events to portray the worst case for a given likelihood of flooding).

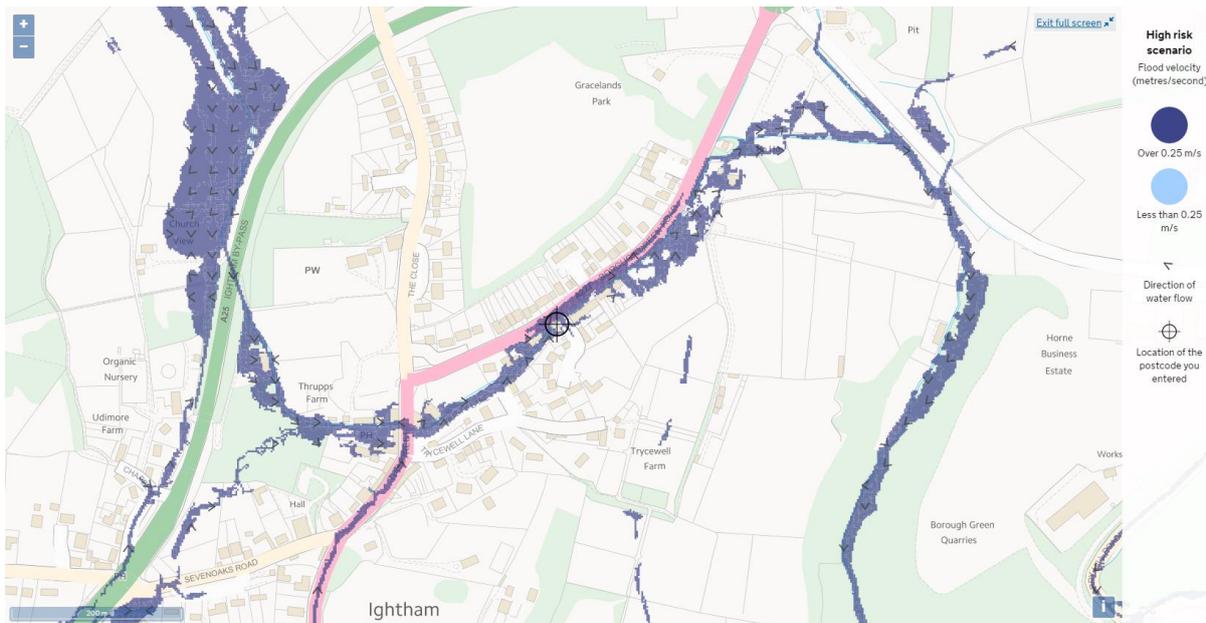


Figure 7 Exceedance flow routes for flood water

Whilst we cannot rule out that a blockage of the watercourse or culvert occurred during the event, there is no conclusive evidence that this occurred and was sufficient to cause the flooding. No blockage has been found on subsequent inspections at Durling's Orchard Culvert although some debris was obstructing the culvert at Orchard House.

As noted previously, the topography along the line of the culvert at Durling's Orchard (and for some distance downstream) is relatively flat and therefore the capacity of the watercourse to convey high flows is reduced compared to the steeper parts of the watercourse along and upstream of Busty Lane. This is illustrated within the long section in Appendix D (not available for the draft report). There was no flooding experienced at the bridges at the top of Busty Lane, some of which are similar dimensions to the culvert, this is likely to be due to the greater gradient at that location compared to the culvert.

At Orchard House the culvert capacity is smaller than the Durling's Orchard culvert and this was found to be blocked after the flood. At this location the watercourse came out of bank again and flowed downstream over land, flooding Orchard House.

Residents have voiced concerns that more recent alterations to the Durling's Orchard culvert have increased flood risk; however the inspections and records show that the new sections of concrete box culvert have a significantly larger cross-sectional area (minimum 1.35m²) than the older brick arch sections of culvert (approximately 0.85m²).

It is not clear whether there has been any significant loss of storage for flood water that could have collected within the former Durling's Yard. Had the watercourse remained an open channel, a small amount of extra storage would be available, however it must be noted this is downstream of the culvert entrance and is unlikely to have been sufficient to have prevented property flooding in this instance.

Additional concerns were raised that a blockage occurring at the culvert at Orchard House may also contribute to flooding further upstream. Any blockage at this culvert would lead water preferentially

flowing into the field to the south, which is approximately 0.6 m lower than the top of the culvert outlet at The Willows. This field would have to flood substantially before water would back up sufficiently to cause the outlet of the culvert at The Willows to be full.

Flooding at the Orchard House culvert places downstream land and property at risk of flooding if a blockage occurs during high flows.

4.4 Conclusions

Heavy localised rainfall occurred on the 25th June 2016 generated flash flooding in the Busty Stream. 33.4mm of rain was recorded between 17:15 and 19:15 at the Sevenoaks rain gauge, of which 17.3mm fell in less than half an hour (from 17:15). This followed heavy rain earlier in the day that would have wetted the catchment.

Rainfall at Ightham and on the Busty Stream catchment may have been higher than that recorded at Sevenoaks, due to the localised nature of the rain storms that day.

The flattening of the topography local to and along the line of the culverts in this area will affect the capacity for conveyance of higher flows from the steeper sections of the watercourse upstream. This could also lead to the pooling of flood water upstream of the culvert at the end of Busty Lane.

Subsequent surveys indicate that there is no evidence of any blockages of the watercourse or the culvert at Durling's Orchard, though a temporary blockage that was washed away cannot be ruled out. Debris was found to be trapped in the culvert at Orchard House, however this would have a greater impact at and downstream of this culvert.

The watercourse was not found to be in an unmaintained state and hence a lack of maintenance is unlikely to be a significant contributory factor to the flooding. Regular clearance of vegetation, silt and debris along the line of the watercourse will help to maximise the watercourse's capacity to convey high flows in future and to prevent blockages occurring. The geometry of the watercourse and culvert (that is, regular changes of shape and direction in a confined space) could make it susceptible to blockages if the watercourse is not maintained.

5 Other Reported Instances of Flooding in the Area

The Sevenoaks and Gravesend areas in particular received high numbers of reports of highway flooding on the 25th June 2016 which were attended by KCC Highways duty officers.

These instances of flooding have not warranted detailed investigations under Section 19 of the Flood and Water Management Act due to Risk Management Authorities already exercising their relevant powers. Three particular locations have been noted; however this is not exhaustive of what may have occurred during the event as there may be other instances of localised flooding that have not formally been reported to the Lead Local Flood Authority.

5.1 Fen Pond Road, Ightham

It has been report to KCC by Ightham Parish Council that flooding occurred at Fen Pond Road, which itself is located upstream of Ightham and within the catchment of the Busty Stream. The flooding was reported to have occurred adjacent to Fen Pond where the watercourse flows through the pond and crosses the road in a culvert. There are unconfirmed reports that adjacent properties were flooded due to high flows in the watercourse flooding the road.

The site was inspected on 28th October by officers from the KCC Flood and Water Management Team. All inlets and outlets to the culvert under the road appeared to be clear at the time of the visit as shown in the photographs below, although this was some time since the flood event. It is assumed high flows exceeded the watercourse culvert capacity causing water to flow overland.



Photo 5 Upstream entrance to culvert (left) and downstream end manhole /road gully

5.2 Thong Lane, Borough Green

Flooding of the highway occurred due to exceedance of adjacent watercourse which is part of the River Bourne. Flows out of the bank ran out onto the road adjacent to an old bridge which formally joined the quarries in the area. The road was flooded to a depth sufficient that it was impassable except for high vehicles and 4x4s. The culvert under the bridge abutment was noted to be blocked with mud and silt. This flooding was reported to KCC Highways by several parties. Photographs of the water exceedance flow during the event and a view of the blocked culvert from subsequent inspection are shown below.



Photo 6 Out of bank flow adjacent to bridge (left) and view of blocked culvert entrance (right)

Issues with the watercourse have been discussed with the Environment Agency (as the watercourse is designated 'main river'). The site is part of a future housing development currently seeking planning permission. The developer of the adjacent housing site has demolished the bridge since the flooding occurred and reinstated the watercourse channel as part of their works as shown in photograph 8. Further improvements to the watercourse have been proposed within the current planning permission which will further reduce the likelihood of a recurrence of this flooding. The developer has undertaken discussion with the Environment Agency regarding these proposals and with KCC as the Lead Local Flood Authority regarding the disposal of surface water generated on the site.



Photo 7 Reinstated watercourse at the site of the former bridge on 28th October 2016

5.3 Mote Road, Ivy Hatch

Flooding was reported to affect Mote Road and the surrounding areas adjacent cottages and internal flooding of Ightham Mote due to run-off from adjacent fields exceeding capacity of highway drains and watercourses. A significant amount of mud, gravel and debris was deposited over the road, filling drainage gullies and pipework. This reported to KCC Highways and Flood and Water Management Teams.

KCC Highways arranged clearance of debris undertaken following flooding. Maintenance and repair work on highway drainage system undertaken under a road closure. All drainage works have been completed as of November 2016.

National Trust staff has also undertaken some discussion regarding flooding and watercourse issues with KCC Flood and Water Management Team.

6 Future Actions

6.1 Recommendations

Following this investigation we would recommend the regular maintenance of the Busty Stream watercourse to remove silt and debris, routine inspection of the culverts, at least through manholes for standing water, would also be recommended.

Further works may be able to reduce the risks further; these are identified in Section 6.2. However there do not appear to be any obvious feasible options to significantly reduce the risk of flooding.

6.2 Flood reduction measures

There are a number of options that have the potential to reduce the risk of flooding in Ightham. These options are detailed in Table 2, together with some advantages and disadvantages of each option.

Table 2 Options for flood risk management

Option	Advantages	Disadvantages
A) Do minimum and enhance maintenance of existing watercourse and culverts as part of a community group, including areas downstream of the culverts	Low cost preventative maintenance approach. Can be implemented immediately. Would formalise existing riparian responsibilities.	Landowners need to be willing for works to be undertaken. May offer a low reduction in flood risk. May not benefit all properties in the flooded area.
B) Install trash screen at Busty Lane to minimise risk of culvert blockages	Relative low cost to implement. Reduces risk of large objects and debris flowing into parts of the watercourse which are inaccessible during high flows.	Limited suitable locations to implement. Would require a community group to undertake maintenance. Minimal reduction in flood risk compared to existing situation unless a blockage occurred.
C) Fit properties with Property Level Resilience Features such as flood doors, self-closing airbricks, flood walls or barriers.	Can be funded using FDGiA grants of approx. £5000 per property. Potentially prevents internal flooding occurring when well maintained.	Some properties not suitable. Funding cannot be obtained for other measures in future. Does not prevent flooding, but does minimise damages.
D) Construct flood storage area upstream of the village	Potential to offer the biggest reduction in flood risk compared to other options. Offers protection to a wider area and a possible benefit to off-site areas downstream.	Unlikely to be feasible either technically or financially.
E) Natural flood risk	Relatively cost effective to	Limited opportunities to install

management measures in catchment	install. Relatively low maintenance.	and probably only limited reduction in flooding. Would require willing land owners to participate and maintain features.
----------------------------------	---	--

Flood defence works may be eligible for grants from Flood Defence Grant in Aid, a government fund for flood defence investment. This fund provides grants allocated largely depending on the number of residential properties those benefits (i.e. if more properties benefit more grant can be obtained). Typically, the grants are for between approximately £5.5k and £8k per property depending on the standard of protection offered and the lifetime of the project. As a consequence, the level of funding available for Ightham is quite limited.

Grants for property level resilience also come from Flood Defence Grant in Aid. These grants are fixed at £5,500 per property, £500 of which is for the survey to determine the measures required £5,000 for the purchase and installation of the chosen products. If more is needed the homeowner would need to subsidise it.

Further assessment of the options above will need to be made prior to applying for funding in order to determine if it is feasible and eligible for funding. Depending on the options that are preferred detailed analysis may be required to determine the economic benefits.

6.3 Community Resilience

Kent County Council has asked the National Flood Forum to work in some areas of Kent that have suffered flooding to support communities by facilitating partnership engagement and networking. Ightham is one of the communities they are working in as it is identified an area that would benefit from this work.

The National Flood Forum is an independent charity that supports and represents flood risk communities. To find out more about the National Flood Forum visit www.nationalfloodforum.org.uk.

The main point of contact for this work will be Sanjay Johal Sanjay.johal@floodforum.org.uk who has begun working in the community and making contact with residents who experienced flooding.

KCC and the NFF will be working together with the residents and Parish Council to manage flood risk in Ightham.

Appendix A – Extract from ‘Living on the Edge’

Appendix B – Durling’s Orchard Culvert History and Historical Maps

Construction History and Development of the Area

The culverting of the Busty Stream has been undertaken over a long period of time. Table 2 provides an overview of the major changes in the culverting taken from historical Ordnance Survey mapping and aerial photographs held by KCC. An extract from this information is presented in Appendix C.

Table 3 Site History from Ordnance Survey Mapping and KCC Aerial Photographs

Date of Mapping	Site Details
1871 to 1890	The buildings at Old School Cottages appear on this edition of the mapping and this time and the watercourse is covered or culverted outside the present nos. 3 & 4. An access track culvert is present at the present day access to Orchard House.
1897 to 1900	Ezel Villas have now been constructed and the watercourse culverted around the properties.
1907 to 1923	The culvert outside Old School Cottages has been extended and now extends across the frontage of all four properties.
1946 Aerial Photo	By this date, 1 and 2 The Willows have been constructed and the watercourse appears to remain as largely as open channel. It is expected the footbridge accesses to the properties were constructed at the same time as the properties.
1929 to 1952	The area north and east of Busty Lane is not covered by the mapping of this date.
1990 Aerial Photo	By this date, Durling’s Builder’s yard is present and shows the watercourse is culverted for approximately half the width of the site adjoining Ezel Villas. It is understood that development of the site into garages and the builders yard commenced in the early 1960’s. A driveway over the watercourse appears to have been added to 2 The Willows. A large building is present at the site of Orchard House understood to have been constructed during the 1980s. This utilises the same access point as the culvert present in the earlier mapping and aerial photographs.
2008 Aerial Photo	By this date the builder’s yard has been re-developed into housing and the watercourse is now culverted across the full length of the site between Ezel Villas and Old School Cottages. The bridge over the watercourse for the driveway of 1 The Willows has been constructed. Orchard House has been constructed and utilises the same access as previous developments on the site. The Southern Water pumping station has been constructed by this date.
Present Day Maps	There appears to be no significant changes to the watercourse since the 2008 Aerial Photograph.

Construction Records

Limited details are available for the construction of the culverts at the site due to the age of the structures. Some details are available for the ‘Durling’s Orchard’ culvert from KCC’s structures records.

The records indicate that there were at least two sections of culvert associated with the former garage and Durling's builder's yard. One section of brick construction, 2.25m in width and 0.825 m in height was located beneath the main site entrance. Although not noted on the drawing, it is likely this was constructed as a brick arch to match that of the upstream culvert.

There is also a structure of steel, brick and concrete culvert noted adjoining the culvert carrying the main site entrance over the stream. It is not clear whether this clear span structure or constructed akin to an 'Armco' culvert.

It appears it was originally planned for there to be a short section of open ditch remaining; however the final design extends the culvert to meet with the existing at old School Cottages. It is considered that the reason for this was due to the limited benefit of a short section of open ditch remaining. The layout of this culvert is shown in Figure 7.

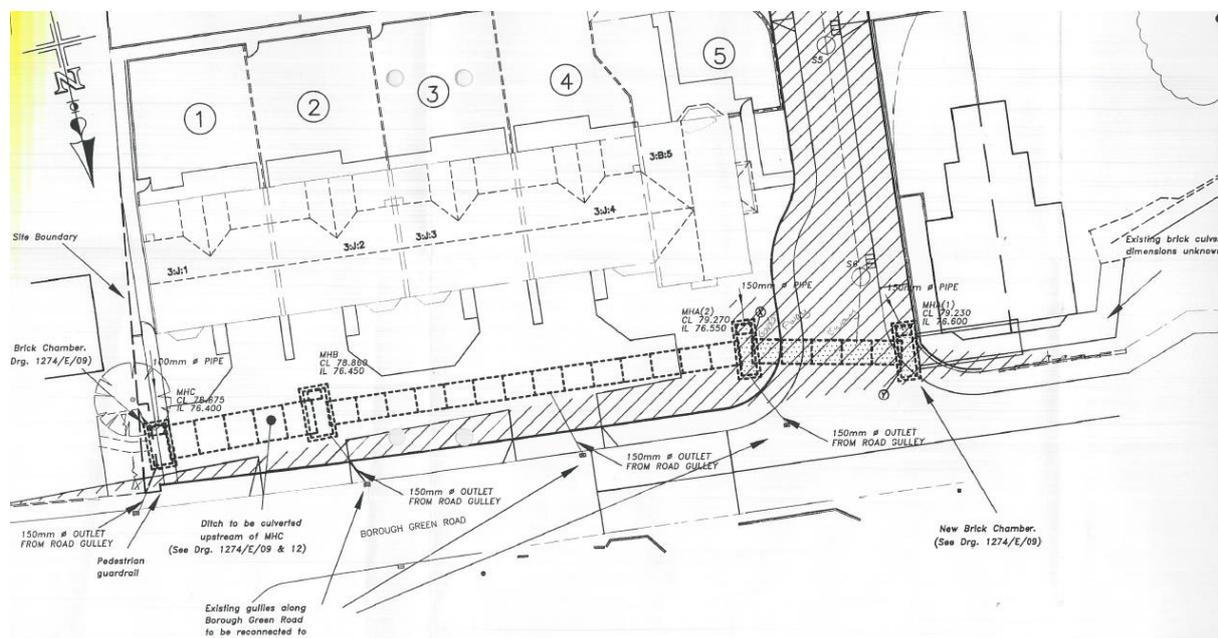


Figure 8 Site Plan for Durling's Orchard Development with culvert details.

The culvert was proposed for adoption by KCC Structures Management; however this process was never formally completed by the developer. The structure therefore remains under the riparian responsibility of each landowner for the sections of culvert within their land.

KCC does not hold any records of the construction of the culvert at the entrance to Orchard House and Mount Farm as this is in private ownership.

Appendix C – Kent Fire & Rescue Incident Response

Appendix D – Topographical Survey Information

Appendix E - Minutes of Meeting held by Ightham Parish Council on 27th September 2017

Appendix F - CCTV Survey of Durling's Orchard Culvert