

# Flood Investigation Report

Location of Investigation: Swanley

Date of incident: 20 July 2021 and 20 - 21 October 2021

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 (KCC)
- Environment Agency
- Kent Fire and Rescue Service (KFRS)
- Swanley Town Council

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.

It should be noted that although this Section 19 flood investigation covers both of the 20<sup>th</sup> July 2021 and 20<sup>th</sup> - 21<sup>st</sup> October 2021 flood events, this report focuses predominately on the 20<sup>th</sup> July flood event based upon the available information and consultation undertaken.

This report can be found [here](#) where more information can be found about the requirements and trigger for a Section 19 investigation and the roles and responsibilities of Risk Management Authorities.

For further information or to provide comments, please contact us at [flood@kent.gov.uk](mailto:flood@kent.gov.uk)

## Summary of Flood Events

### 20th July 2021

On the 20<sup>th</sup> July 2021, a period of thunderstorms and intense rainfall fell leading to flooding in Swanley and the surrounding areas. The Met Office initially issued a yellow weather warning for the south-east of England, including Kent, on the 20<sup>th</sup> July 2021 between 13:00 - 23:59. The warning was then upgraded to an amber weather warning which was issued for select areas of Kent, including Swanley, for thunderstorms for the 20<sup>th</sup> July 2021 between 15:45 - 19:00, anticipating that the amount of rainfall could reach up to 40 - 60 mm over 1 to 2 hours<sup>1</sup>.

The closest rain gauge at Eynsford approximately 3 km to the south-east, recorded a total of 33.69 mm between 13:30 and 17:45, the rain gauge at Orpington approximately 5.3 km to the south-west recorded a total of 16 mm of rainfall on the 20<sup>th</sup> July from 16:30 – 17:30. Rainfall radar data purchased from the Met Office, recorded an average of 94.70 mm from 13:00 – 17:00 across the Swanley and Hextable catchment. The average monthly rainfall for July in Kent is approximately 50.4 mm<sup>2</sup>.

<sup>1</sup> Source: [digital nmla metoffice SOht](#)

<sup>2</sup> Source: [southern water regional rainfall](#)

Approximately 53 properties including two schools were affected by flooding on the 20<sup>th</sup> July 2021, of these it is known that 30 flooded internally. This was as a result of the intense rainfall causing large volumes of surface water runoff predominantly from the urban network leading to surcharging of gullies and there were also reports of overland flows from the surrounding agricultural land to the east of Swanley and the south-east of Hextable. The approximate locations of the reported flood incidents are shown in Annex 1 for the 20<sup>th</sup> July (please note: only the roads where the properties are located have been mapped, and not the individual properties).

## **20th - 21st October 2021**

On the 20<sup>th</sup> October 2021 a period of thunderstorms and intense rainfall fell leading to flooding in Swanley and the surrounding areas as similar to the earlier July flood event. The Met Office initially issued an amber weather warning for the south of England, including Swanley, between 21:00 on the 20<sup>th</sup> October and 02:00 on the 21<sup>st</sup> October 2021. It was anticipated that the amount of rainfall could reach up to 20 - 30 mm of rain in an hour and up to 60 mm in 2 - 3 hours<sup>3</sup>.

As previously described the closest rain gauge at Eynsford recorded 29.53 mm between 19:45 on the 20<sup>th</sup> October – 01:30 on the 21<sup>st</sup> October. The rain gauge at Orpington recorded a total of 47.60 mm between 19:15 on the 20<sup>th</sup> October to 01:30 on the 21<sup>st</sup> October. Rainfall radar data purchased from the Met Office recorded an average of 38.16 mm between 19:00 on the 20<sup>th</sup> October – 01:00 on the 21<sup>st</sup> October.

Approximately 17 properties were affected by flooding, with 11 properties flooding internally, as a result of surface water runoff predominantly from the urban network, leading to surcharging of gullies. The approximate locations of the reported flood incidents are shown in Annex 2 (please note: only the roads where the properties are located have been mapped, and not the individual properties).

## **Flood Surveys**

KCC undertook a survey of affected residents in April 2022 collating information about the flood events on the 20<sup>th</sup> July and 20<sup>th</sup> - 21<sup>st</sup> October to inform this Section 19 investigation. Table 1 and Table 2 provide a summary of the investigated flooding issues and known flood extents across the two flood events. 309 surveys were sent out to residents based on local reports of the locations of flooded road and properties. Additional properties were also surveyed based on the Surface Water Flood Risk map. In total there were 30 responses received by KCC, nine of the responses received reported flooding during both flood events.

In addition, 39 flood surveys were collated by the County Councillor for Swanley from two public meetings held with Swanley residents in September 2021. As a result, the information detailed in Table 1 (20<sup>th</sup> July flood event) and Table 2 (20<sup>th</sup> - 21<sup>st</sup> October flood event) below may not include a complete summary of the properties affected or the impacts of the flooding. Appendix A provides a breakdown of the number of flood surveys that were sent to each road within Swanley.

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<sup>3</sup> Source: [digital.nmmla.metoffice.io](https://digital.nmmla.metoffice.io)

Table 1 - Summary of the investigated flooding issues on 20th July 2021

Location		
Almond Drive	1 property reported external flooding.	KCC / Local Councillor / Flood Survey
Apple Orchard	Multiple properties possibly affected; exact details unknown.	KCC / KFRS
Beech Avenue	1 property reported external flooding. 1 property reported internal flooding.	KCC / KCC Highways / Local Councillor / KFRS
Court Crescent	1 property reported flooding.	Local Councillor
Edgar Close	Multiple properties possibly affected; exact details unknown.	KCC / Local Councillor
Glendale	3 properties reported external flooding.	KCC / Local Councillor / KFRS
Goldsel Road	Vehicle rescued from flood water by the KFRS.	KFRS
Heather End	1 property reported external flooding.	KCC / Local Councillor
Hibbs Close	10 properties reported internal flooding. Depth was estimated from 5 cm to 50 cm.	KCC / Local Councillor / KFRS / Flood Survey
Ladds Way	1 property reported internal flooding. Depth was estimated to be 40 cm.	KCC / Local Councillor / Flood Survey
Laura Drive	1 property reported internal flooding and 4 properties reported external flooding.	KCC / Local Councillor / Flood Survey
Leechcroft Avenue	3 properties affected by flooding the details are unknown.	KCC / Local Councillor / KFRS / Flood Survey
Lower Road	1 property reported internal flooding and 2 properties reported external flooding.	KCC / Local Councillor
London Road	1 property reported internal flooding.	KCC Highways
Lullingstone Avenue	2 properties reported external flooding.	KCC / Local Councillor

Location	Details of Reported Flooding	Source of Report
Oliver Road	3 properties reported internal flooding and 1 property reported internal flooding. Depths were estimated at knee to waist height externally.	KCC / Local Councillor / KFRS / Flood Survey
Overmead	2 properties reported internal flooding.	KCC / Local Councillor / KFRS / Flood Survey
Pinks Hill	17 properties reported flooding: 10 internal, 4 external and 3 unknown. Flooding depths were reported up to range from 90 cm to externally and up to 15 cm internally.	KCC / KCC Highways / Local Councillor / KFRS / Flood Survey
Sermon Drive	1 property reported external flooding.	KCC / Local Councillor
Sheridan Close	4 properties reported flooding, of these 2 flooded internally and 2 are unknown.	KCC / Local Councillor / Flood Survey
St Georges Road	3 properties reported to have been affected. It is unknown if they flooded internally.	KFRS
St Mary's Road	2 properties reported internal flooding.	KCC / Local Councillor
Stuart Close	1 property reported internal flooding.	Local Councillor
Strawberry Fields	1 property reported internal flooding, 1 property reported external flooding. Flooding depths were reported to be between 25 cm to 60 cm externally.	KCC / Flood Survey
Swanley Village Road	1 property reported external flooding.	Local Councillor
The Spinney	2 properties reported to have been affected. It is unknown if they flooded internally.	KFRS
Waylands	1 property reported to have been affected. It is unknown if they flooded internally.	Local Councillor / KFRS

Location	Details of Reported Flooding	Source of Report
West Harold	1 property reported internal flooding. Flooding depths were reported by to reach 60 cm externally.	KCC / Local Councillor / KFRS

*Table 2 - Summary of the investigated flooding issues on 20th - 21st October 2021*

Location	Details of Reported Flooding	Source of Report
Hibbs Close	1 property reported internal flooding. Flooding depth was estimated at 7 cm.	Flood Survey
Laura Drive	3 properties reported external flooding. Depths on the road were reported to reach up to 70 cm.	Flood Survey
Leechcroft Avenue	2 properties reported internal flooding and 1 property reported external flooding. Flood depths reported to be up to 60 cm internally.	Flood Survey
Oliver Road	1 property reported external flooding.	Flood Survey
Pinks Hill	6 properties reported internal flooding. Flooding depths estimated at 10 cm.	Flood Survey
Strawberry Fields	1 property reported internal flooding.	Flood Survey
West Harold	1 property reported internal flooding.	Flood Survey

## Site Location, Topography and Flood Risk

The town of Swanley is located approximately 5 km to the south of Dartford, on the edge of KCC's administrative boundary. There are no main rivers or ordinary watercourses located within Swanley, with the closest main river, the River Darent, located approximately 3 km to the east of Swanley. A review of the Cranfield University Soilscape database indicates that the underlying soils in Swanley are freely draining slightly acid loamy soils.

A review of the Environment Agency's Flood Map for Planning (Rivers and Sea) indicates that all of Swanley is located within the low-risk Flood Zone 1<sup>4</sup>. The nearest Flood Zones are located approximately 2.5 km to the east of Swanley, with the flood risk associated with the River Darent.

<sup>4</sup> Flood Zone 1 is defined as having a less than 1 in 1000 year (0.1%) chance of flooding from fluvial sources. Flood Zone 2 is defined as having between 1 in 100 year (1%) and 1 in 1000 year (0.1%) chance of flooding from fluvial sources. Flood Zone 3 is defined as having a greater than 1 in 100 year (1%) chance of flooding from fluvial sources.

Annex 3 shows an extract from the Environment Agency's Flood Risk from Surface Water Map. Flooding from surface water is typically associated with natural overland flow paths and local depressions in topography where surface water runoff can accumulate during or following heavy rainfall events. The Environment Agency's map indicates that there are two main surface water flow routes through Swanley at a high risk of surface water flooding<sup>5</sup>. One route flows from the western area of Swanley in a northern direction towards Hextable and the other route flows from the south of the A20 across the western areas of Swanley in a north direction to join with the other flow path in Hextable. The areas indicated to be at a high risk of flooding from surface water sources are relatively consistent with the locations of reported properties affected by the flood event.

## Flood History

There have been approximately 133 reported flood incidents to KCC across Swanley and Hextable between 2008 – 2021, prior to the July 2021 flood event. These have been collated and are shown in Appendix B at the end of the report.

In summary, the most frequently affected roads are Pinks Hill, Waylands, The Spinney, Farm Avenue, Button Street and Goldsel Road. The majority of these roads were also affected during both flood events in 2021.

## Rainfall Data Analysis - 20<sup>th</sup> July 2021

This section assesses the annual exceedance probability (AEP) of the flood event on 20<sup>th</sup> July 2021 using observed rainfall from the Eynsford and Orpington rain gauges, which lie 3 km and 5.3 km respectively from Swanley. Radar data across the approximate catchment draining towards Swanley and Hextable was also purchased from the Met Office. Land to the east of the M25 has been excluded from the catchment as it is likely this forms a barrier to surface water runoff from the east reaching the study area. No other rain gauges were considered to be appropriate to use within the assessment of the flood event due to the significant distances from Swanley.

It is important to note that this rainfall analysis and the AEP estimates are approximates based off observed rainfall data which comes with a degree of uncertainty. Other factors such as catchment characteristics and antecedent rainfall conditions have not been considered for this analysis. Assessment of AEP based solely on rainfall data can only ever provide an approximation of the resultant flood event. Other local factors, such as asset condition and blockage, may also have had an effect on the flooding seen, rather than simply the magnitude of the event.

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<sup>5</sup> High risk of flooding from surface water is defined as having a greater than 1 in 30 (3.3%) chance of flooding. Medium risk of flooding from surface water is defined as having between 1 in 100 (1%) and 1 in 30 (3.3%) chance of flooding. Low risk of flooding from surface water is defined as having between 1 in 1000 (0.1%) and 1 in 100 (1%) chance of flooding.

## Methodology

The Flood Estimation Handbook<sup>6</sup> (FEH) web service Event Rarity Calculator assesses the AEP of the recorded rainfall. This is the likelihood of rainfall of this depth being exceeded in a typical year in that location when compared with the FEH13 rainfall probability model. For instance, a rainfall event with an AEP of 1% means that rainfall of this depth or greater would have a 1% chance of occurring in any one year in that location. This is also known as a '1 in 100 year' return period event. The assessment has assumed that the rainfall recorded at each of the rain gauges is the same as the rainfall experienced at Swanley.

The assessment has been undertaken using the FEH13 rainfall model. [Figure 1](#) shows a comparison of the measured rainfall at the two rain gauges (Eynsford and Orpington) and the rainfall radar between 12:00 and 20:00 on the 20<sup>th</sup> July. Two distinct intense periods of rainfall are shown, between around 13:00 and 14:30 and 16:30 and 17:30. The first period of intense rainfall was not recorded at the Orpington gauge; assuming the gauge was operating correctly it suggests this first storm was more localised, affecting the eastern area only. The second intense period of rainfall is shown in all three datasets, indicating it was more widespread, albeit with significant differences in rainfall depth. The second intense period of rainfall recorded between 16:30 – 17:30 is consistent with the flooding reported by the majority of the resident surveys between 17:00 – 18:00. The radar measurements are consistently higher, suggesting the storm was focussed closer to Swanley. Considering the timing of the flood reports it seems likely both periods of rainfall contributed to the flooding and the AEP of the storm has been analysed for the whole event.

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<sup>6</sup> FEH is the standard tool in the UK to estimate flood frequency. It is used by the Environment Agency and professional hydrologists.

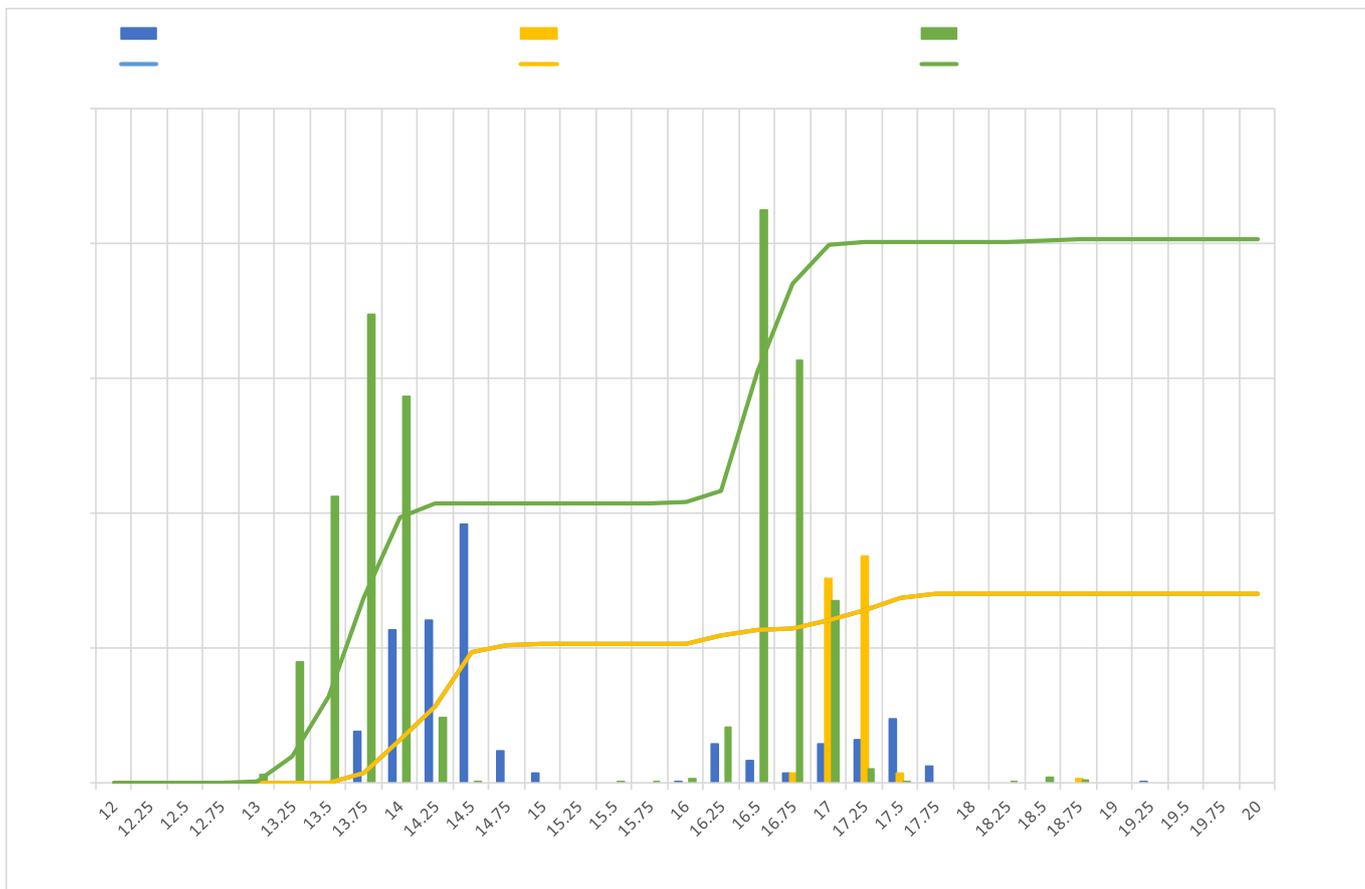


Figure 1 - Comparison of measured rainfall between the Eynsford (blue) and Orpington (yellow) rain gauges data and the radar data (green)

## Rain Gauge Analysis

Rainfall data from Eynsford (Station Number: 290580. Grid Reference: TQ535654) on 20<sup>th</sup> July 2021:

Rainfall: 33.69mm (4 hours 15 minutes, 13:30 – 17:45)

Estimated Annual Exceedance Probability (13:30 – 17:45): 1 in 5-year return period, 20% occurrence in any given year.

Rainfall data from Orpington (Station Number: 291241TP. Grid Reference: T459652) on 20<sup>th</sup> July 2021:

Rainfall: 16.00mm (16:30 – 17:30)

Estimated Annual Exceedance Probability (16:30 – 17:30): 1 in 4-year return period, 25% occurrence in any given year.

The closest Environment Agency rain gauge to Swanley is located in Eynsford, approximately 3 km to the south-east of Swanley. Annex 4 at the end of the report shows the location of the Eynsford rain gauge. The rain gauge recorded a total of 33.69 mm for the whole rainfall event between 13:30 and 17:45. During this event there were two intense periods of rainfall recorded; between 13:30 – 15:00, which recorded 24.88 mm and 15:45 – 17:45 which recorded 8.81 mm of rainfall.

Also, within reasonably close proximity to Swanley is the rain gauge located in Orpington, approximately 5.3 km to the south-west of the estimated Swanley catchment. Annex 4 at the end of the report shows the location of the Orpington rain gauge and the estimated Swanley catchment. This rain gauge recorded intense rainfall on the 20<sup>th</sup> July from 16:30 – 17:30, where a total of 16 mm was recorded. Assuming the same depth of rainfall fell on the Swanley catchment in this time period gives an estimated 25% AEP. However, it should be noted that there is no guarantee that this is recording the same rainfall event. It should be noted this analysis is for a different time period. The equivalent AEP would be higher if the analysis was completed for the same time period as Eynsford.

## Rainfall Radar Analysis

**Rainfall: 94.70mm (13:00 – 17:00)**

**Estimated Annual Exceedance Probability (13:00 – 17:00): 1 in 444-year return period, 0.2% occurrence in any given year.**

Due to the significant distance between the rain gauges and the affected flooded properties and the localised nature of the intense rainfall events, it is possible that the rain gauges assessed for the flood event do not accurately represent the rainfall experienced across the Swanley catchment. As a result, rainfall radar data was purchased from the Met Office to support the rainfall analysis. Assessing the radar data also provides an indication of the spatial distribution of the rainfall across the area.

The radar data was purchased for twelve 1x1 km grid squares across Swanley, this covered all of the recorded flooded properties from the flood event and the majority of the main catchment draining towards Swanley and Hextable. The rainfall distribution of the twelve 1x1 km grid squares were extrapolated to encompass the estimated Swanley catchment area and then averaged, producing hourly rainfall values for the catchment.

The highest hourly rainfall was recorded between 13:00 – 14:00, with average rainfall across the catchment at 45.02 mm. There was also another significant intense period of rainfall between 17:00 – 18:00, with average hourly rainfall across the catchment at 44.98 mm. The whole rainfall event between 13:00 – 17:00, an average of 94.70 mm was recorded. The two significant periods of rainfall are a similar trend to what is recorded by the Eynsford rain gauge, albeit with the radar data recording much more significant rainfall depths and at slightly different timings.

Figure 2 below shows the recorded distribution across the main Swanley catchment based on the radar data between 13:00 – 17:00. The radar data suggests the rainfall was more intense across the south of the catchment. The figure shows the two intense rainfall periods, between 13:00 – 14:00 and 16:00 – 17:00.

The catchment rainfall derived from the radar data has an estimated AEP of 0.2% for the rainfall falling between 13:00 – 17:00.

Whilst it is likely that this was a severe event given the results of this assessment and the impacts across Swanley on this day, it may not be as extreme as indicated by the radar data. There is a great deal of variability in the recorded rainfall depths, supported by the discrepancy in values between the radar data and the rain gauge data, and the accuracy of the radar data is not

confirmed. Other factors such as catchment conditions and the pattern of the rainfall through the storm can all influence the severity of the flood event.



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Figure 2 - Hourly rainfall radar data from the Met Office from 13:00 - 17:00 across the approximate Swanley catchment

## Rainfall Data Analysis - 20<sup>th</sup> - 21<sup>st</sup> October 2021

This section assesses the return period of the flood event from the 20<sup>th</sup> - 21<sup>st</sup> October 2021 using the same rain gauges and radar data as for the event which affected Swanley on 20<sup>th</sup> July 2021. The same limitations and uncertainties apply.

According to the resident surveys, the flood event occurred between 22:00 – 23:00 and lasted for a couple of hours. Figure 3 shows the comparison of recorded rainfall data from 18:00 on the 20<sup>th</sup> October. All three datasets show a similar pattern, with a fairly continuous storm lasting for around 6 hours from approximately 19:15 on the 20<sup>th</sup> October to 01:30 on the 21<sup>st</sup> October. The main difference is the high rainfall shown at the Orpington gauge for one 15-minute interval. It is possible this could be a data quality issue. The AEP of the whole storm has been assessed as it seems likely it is this relatively long storm that led to flooding. The differences in estimated AEPs reflect the varying rainfall depths recorded in each dataset.

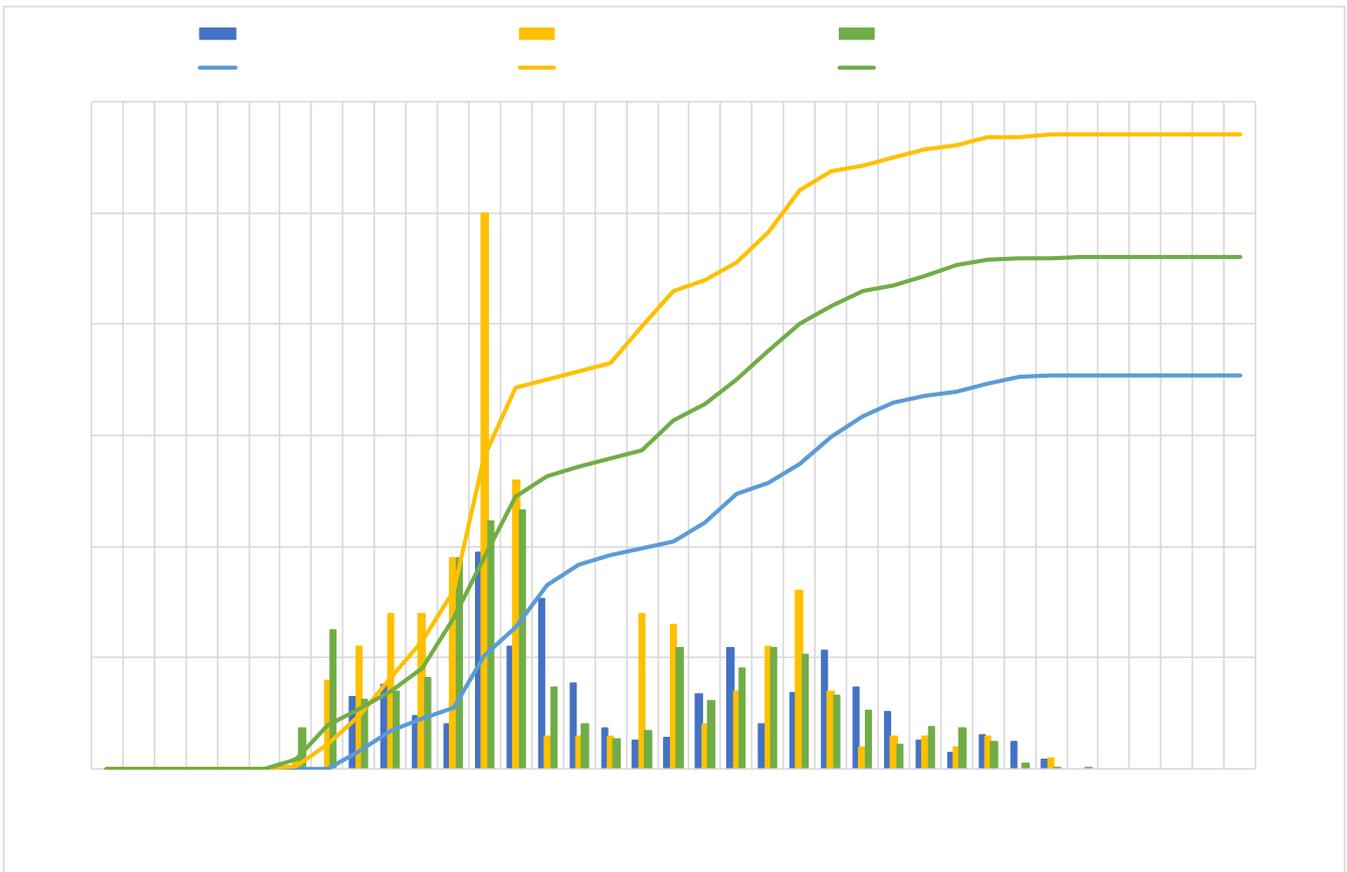


Figure 3 - Comparison of measured rainfall between Eynsford rain gauge (blue), Orpington rain gauge (yellow) and the radar data (green)

## Rain Gauge Analysis

Rainfall data from Eynsford (Station Number: 290580. Grid Reference: TQ535654) on 20<sup>th</sup> – 21<sup>st</sup> October 2021:

Rainfall: 29.53mm (19:45 – 01:30)

Estimated Annual Exceedance Probability (19:45 – 01:30): 1 in 3-year return period, 33% occurrence in any given year.

Rainfall data from Orpington (Station Number: 291241TP. Grid Reference: T459652) on 20<sup>th</sup> – 21<sup>st</sup> October 2021:

Rainfall: 47.60mm (6 hours 15 minutes: 19:15 – 01:30)

Estimated Annual Exceedance Probability (19:45 – 01:30): 1 in 14-year return period, 7% occurrence in any given year.

The Eynsford rain gauge, recorded a total of 29.53 mm for the whole rainfall event between 19:45 on the 20<sup>th</sup> October - 01:30 on the 21<sup>st</sup> October. Assuming the same depth of rainfall fell on the Swanley catchment in this time period gives an estimated 33% AEP.

The next nearest rain gauge to Swanley, Orpington, recorded 28.40 mm of rainfall between 19:30 and 21:15, and a total of 47.60 mm between 19:15 on the 20<sup>th</sup> October - 01:30 on the 21<sup>st</sup>

October. Assuming the same depth of rainfall fell on the Swanley catchment in this time periods gives an estimated 7% AEP for the 6 hours and 15 minute duration event.

## Rainfall Radar Analysis

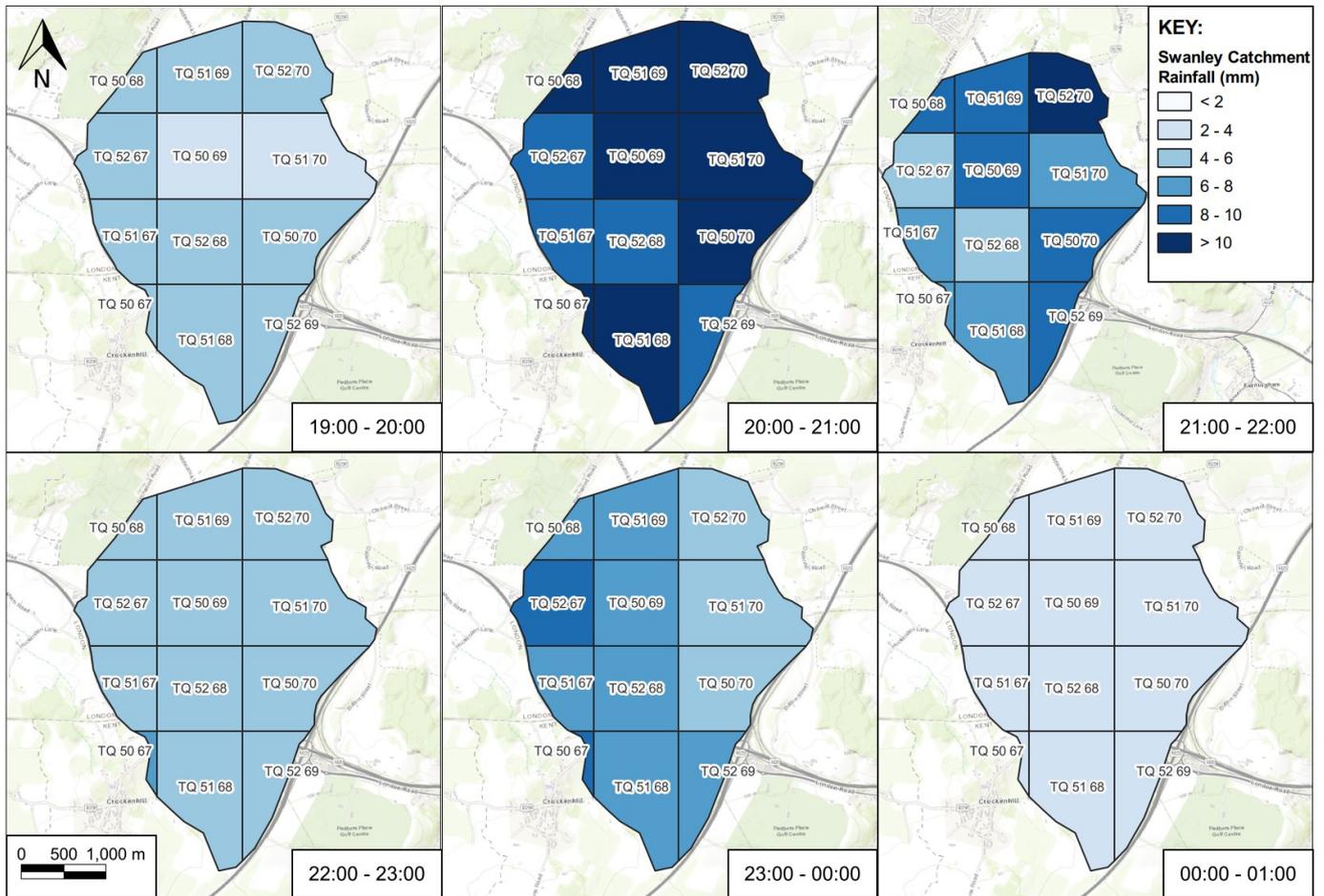
**Rainfall: 38.16mm (6 hours: 19:00 – 01:00)**

**Estimated Annual Exceedance Probability (20<sup>th</sup> October 19:00 – 21<sup>st</sup> October 01:00): 1 in 6-year return period, 17% occurrence in any given year.**

Radar data was also assessed as described previously for the 20<sup>th</sup> July flood event. The highest hourly rainfall was recorded between 20:00 – 21:00, with an average rainfall across the catchment at 11.03 mm. Further rainfall was recorded between 19:00 on the 20<sup>th</sup> October – 01:00 on the 21<sup>st</sup> October, at an average of 38.16 mm over the 6 hours. Rainfall depths recorded by radar data may be less accurate than those recorded at rain gauges, however as there is no overlapping data available to verify the recorded depths they have been taken as accurate. The rainfall depths are similar to those recorded at the two rain gauges, suggesting this storm was reasonably consistent over the wider area.

Figure 4 shows the recorded rainfall distribution across the main Swanley catchment based on the radar data between 19:00 20<sup>th</sup> October – 01:00 21<sup>st</sup> October. The radar data suggests that there was no significant spatial pattern over the duration of the rainfall event with little indication of where the storm tracked. The peak intense hour between 20:00 – 21:00 shows the intensity to be generally uniform and the following hour (21:00 – 22:00) showing no significant intensity directional trend.

The catchment rainfall derived from the radar data has an estimated AEP of 17% for the rainfall falling between 19:00 – 01:00.



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Figure 4 - Hourly rainfall radar from the Met Office from 20th October 2021 19:00 - 21st October 2021 01:00 across the Swanley catchment

## Flooding Description and Mechanism

Annex 1 and Annex 2 at the end of the report shows the areas of Swanley that were affected during both the 20<sup>th</sup> July and 20<sup>th</sup> - 21<sup>st</sup> October flood events respectively. The sections below detail the flood mechanisms for the main affected areas. The flooding mechanisms for both flood events are similar and have subsequently been discussed together.

### St. Mary's Estate

#### **Apple Orchard**

Surface water runoff as a result of the intense rainfall led to water flowing from St Mary's Road from the east towards Apple Orchard. KCC Highway gulley cleansing records indicate that the gullies located along Apple Orchard were cleaned in July 2019 prior to the flood event. The intense rainfall as detailed in the section above meant that the surface water drainage infrastructure surcharged as it is not designed to accommodate intense rainfall as experienced on the 20<sup>th</sup> July 2021. The combination that Apple Orchard is an area of low topography, and the gullies surcharging meant that there was significant ponding across the street causing flooding to properties.

## St. Mary's

Surface water runoff flowed in a north-east to south-west direction along St Mary's Road and was funnelled through the alleyway located between St Mary's Road and Hewitt Place. Surface water runoff continued along Hart Dyke Road in a north-westerly direction, causing the surface water drains to become overwhelmed and surcharge. The flood water flowed towards areas with lower topography at Almond Drive and Hibbs Close where significant flooding was reported.

Surface water flows along Hart Dyke Road and Hibbs Close were exacerbated by runoff from areas of higher topography, including from Oliver Road and West Harold Drive to the east, and Sermon Drive and Lavender Hill from the west. Flood depths of approximately 75 cm were estimated along the alleyway located between Oliver Road and Almond Drive.

Prior to the flood event on the 20<sup>th</sup> July 2021, the gullies along Almond Drive were cleansed in September 2013 and along Hibbs Close in June 2019. The surface water drainage infrastructure is not designed to accommodate the volume of rainfall that is detailed in the section above and as a result surcharged. There are also soakaways within the local area, the condition of the soakaways prior to the flood event is not known but the soakaways would not have been able to sufficiently deal with the volume of rainfall experienced.

Figure 5 below shows the surface water flow paths described which affected the area of St. Marys and the reported flood incidents (please note: only the roads where the properties are located have been mapped, and not the individual properties).

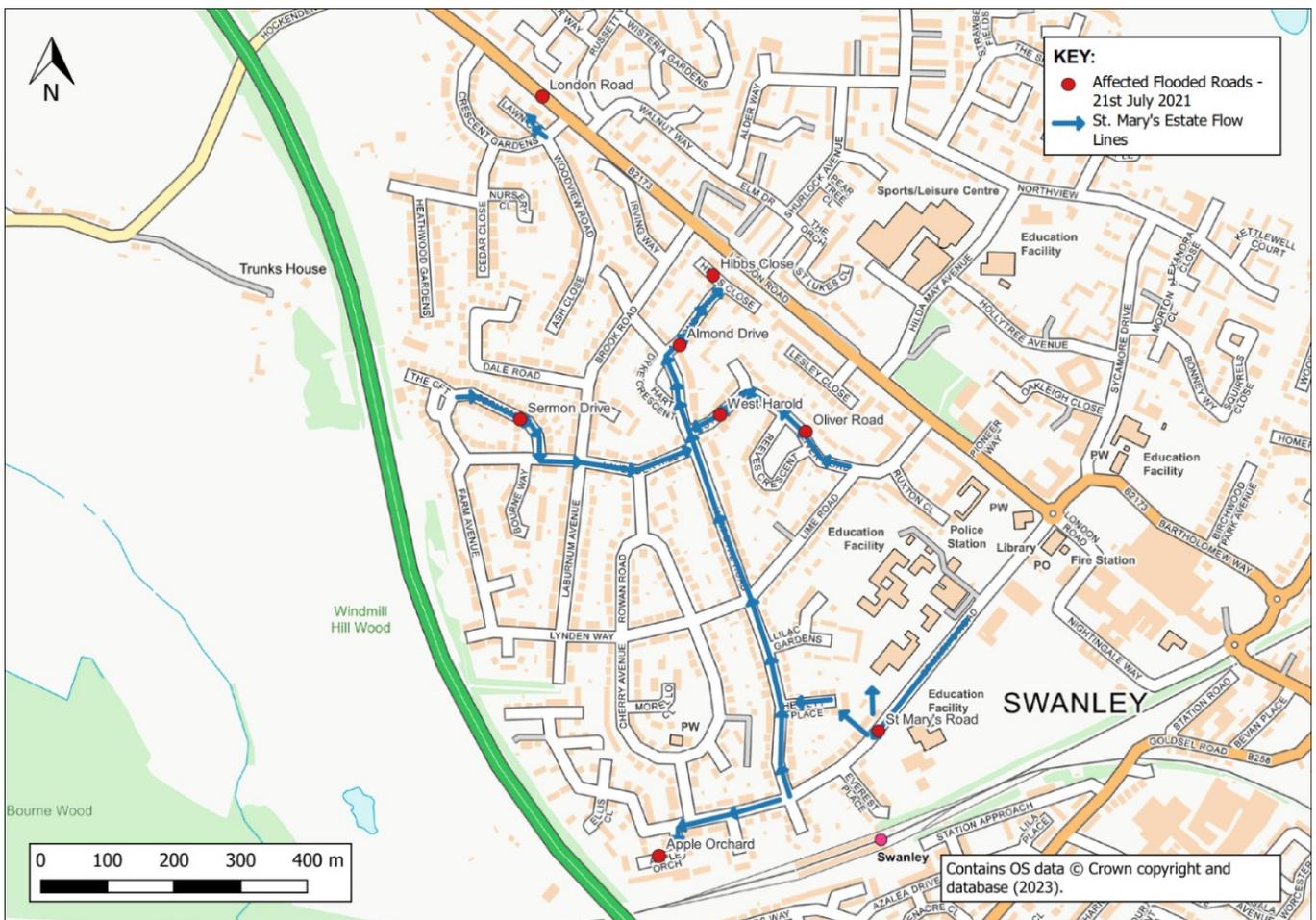


Figure 5 - St. Mary's Estate Flood Mechanisms

## **High Firs Estate**

Overland flows from the south of the A20 and from the A20 itself flowed towards Pinks Hill and Overmead and across the southern areas of High Firs estate, contributing to the heavy flooding experienced in the area. It is likely that the overtopping of the balancing pond located between the A20 and Pinks Hill also affected properties in close proximity. The balancing pond was reported by Swanley Town Council to overflow during periods of intense rainfall, including during the July flood event. National Highways are responsible for the maintenance of the balancing pond, correspondence with National Highways indicates that the pond was previously cleaned in April 2021 to remove any build-up of material that may restrict the flow of water prior to the flood events.

Surface water runoff from Pinks Hill flowed in a south-westerly to north-easterly direction to Waylands, as it is an area of lower topography in comparison to the surrounding areas. The highway gullies located along Pinks Hill and Waylands were cleaned by KCC Highways in January and March 2021. The intense rainfall as detailed in the section above meant that the surface water drainage infrastructure surcharged as it is not designed to accommodate intense rainfall as experienced on the 20<sup>th</sup> July 2021. The combination that Pinks Hills and Waylands are an area of lower topography, and the gullies surcharging meant that there was significant flooding causing flooding to properties.

## **Heather End / Ladds Way**

Surface water runoff flowed along Philip Avenue and Cyclamen Road in a north-westerly direction until it ponded causing flooding along Ladds Way, an area of lower topography. Swanley Town Council reported that soakaways frequently flood in this area as the outfall may discharge onto the adjacent Network Rail land located just to the north. An installation of fence work in the area has caused damaged to the drainage pipes, which exacerbated flooding in the area experienced.

## **Goldsel Road**

It was reported to Swanley Town Council that the S-bend section of Goldsel Road was affected by surface water flooding as it is an area of lower topography. Figure 6 **Error! Reference source not found.** below shows the different surface water flow paths described above within the High Firs area and the reported flood incidents (please note: only the roads where the properties are located have been mapped, and not the individual properties).

Goldsel Road is a principal transport route into Swanley from the surrounding areas and subsequently caused major traffic disruption for Swanley. KCC Highways records indicate that the gullies located along Goldsel Road were cleaned in February 2021 and the soakaways were cleaned in June 2020, prior to the flood events.

The intense rainfall as detailed in the section above meant that the surface water drainage infrastructure surcharged as it is not designed to accommodate intense rainfall as experienced on the 20<sup>th</sup> July 2021. The combination that Goldsel Road is an area of lower topography, and the gullies surcharging meant that there was flooding to properties.

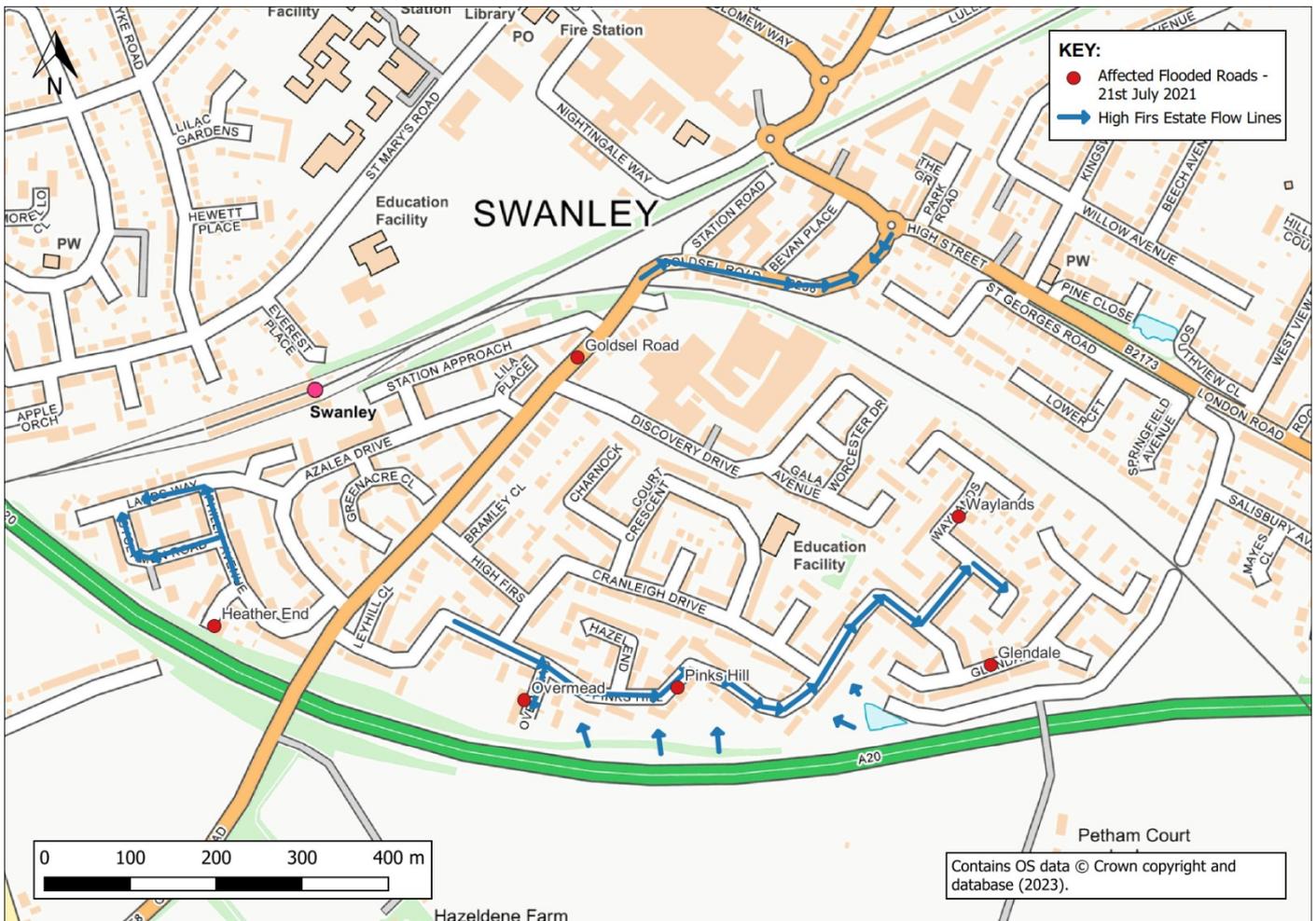


Figure 6 - High Firs Estate Flood Mechanisms

## **North-Eastern Swanley**

### **Lullingstone Avenue**

Surface water runoff flowed from the Network Rail embankment, located to the south-east of Lullingstone Avenue, and flowed to areas of lower topography, towards Lullingstone Avenue. It was reported by Swanley Town Council that the land had been coppiced prior to the flood event; this may have contributed to the surface water runoff flooding experienced during the flood event.

KCC Highways cleaned the gullies along Lullingstone Avenue in July 2019 prior to the flood events. There is also a record indicating that a collapsed chamber was rebuilt during July 2020. The intense rainfall as detailed in the section above meant that the surface water drainage infrastructure surcharged as it is not designed to accommodate intense rainfall as experienced on the 20<sup>th</sup> July 2021. The combination that Lullingstone Avenue is an area of lower topography, and the gullies surcharging meant that there was flooding to properties.

### **Leechcroft Avenue**

During the flood event surface water runoff flowed from multiple directions towards Leechcroft Avenue. Surface water runoff flowed from the west to the east along Leechcroft Avenue and Kingswood Avenue. Additionally, surface water runoff flowed from the embankments to the north, flowing along the service road, located just to the south of the Network Rail embankment. KCC Highways cleaned the gullies along Leechcroft Avenue in March 2021 and the soakaways in

October 2019 prior to the flood events. The intense rainfall as detailed in the section above meant that the surface water drainage infrastructure surcharged as it is not designed to accommodate intense rainfall as experienced on the 20<sup>th</sup> July 2021.

### Sheridan Close

Sheridan Close is an area of lower topography, so during heavy rainfall surface water runoff ponds along the road. Swanley Town Council reported that surface water flowed from Park Road which runs parallel to Sheridan Close from the west during the July 2021 flood event. The intense rainfall as detailed in the section above meant that the surface water drainage infrastructure surcharged as it is not designed to accommodate intense rainfall as experienced on the 20<sup>th</sup> July 2021.

### Beech Avenue

Overland flows from the agricultural fields to the north-east and surface water runoff along the road surfaces flowed from Hillside Court and Mountain Hill towards Beech Avenue as it is an area of lower topography. The intense rainfall as detailed in the section above meant that the surface water drainage infrastructure surcharged as it is not designed to accommodate intense rainfall as experienced on the 20<sup>th</sup> July 2021.

Figure 7 below shows the different flows routes and reported flood incidents within the north-east areas of Swanley (please note: only the roads where the properties are located have been mapped, and not the individual properties).

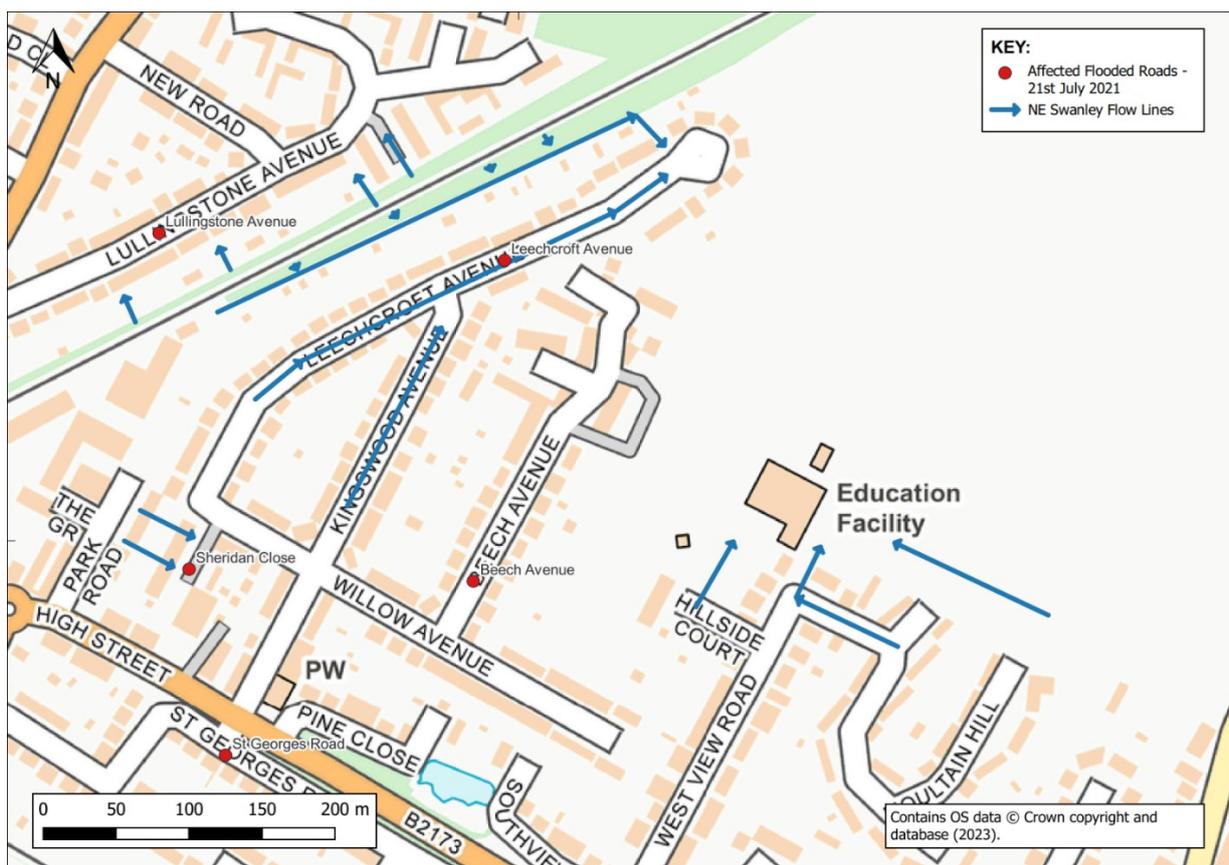


Figure 7 - North-East Swanley flood mechanisms

### Strawberry Fields / The Spinney

[www.kent.gov.uk](http://www.kent.gov.uk)

Surface water runoff flowed from The Spinney in a northern direction towards Strawberry Fields, an area of lower topography, leading to significant ponding along the road. It was also reported from Swanley Town Council that surface water flows were funnelled through the alleyway located between Strawberry Fields and The Spinney. The threshold of the properties located along Strawberry Fields and The Spinney are lower than the adjacent road which contributed to the internal flooding of properties. It was also reported that drains in the area surcharged and could not cope the high surface water on the roads.

KCC Highways records indicate that the road gullies along Strawberry Fields were cleaned in September 2021 after the flood event and a CCTV survey was undertaken in November 2021 which identified a number of defects in the system including: fractures in the drainage pipes, roots within the pipes and a number of sections that had previously been repaired poorly. This is likely to have contributed to the flooding as the drainage infrastructure would not have been able to cope with the intense nature of the rainfall experienced during the flood events.

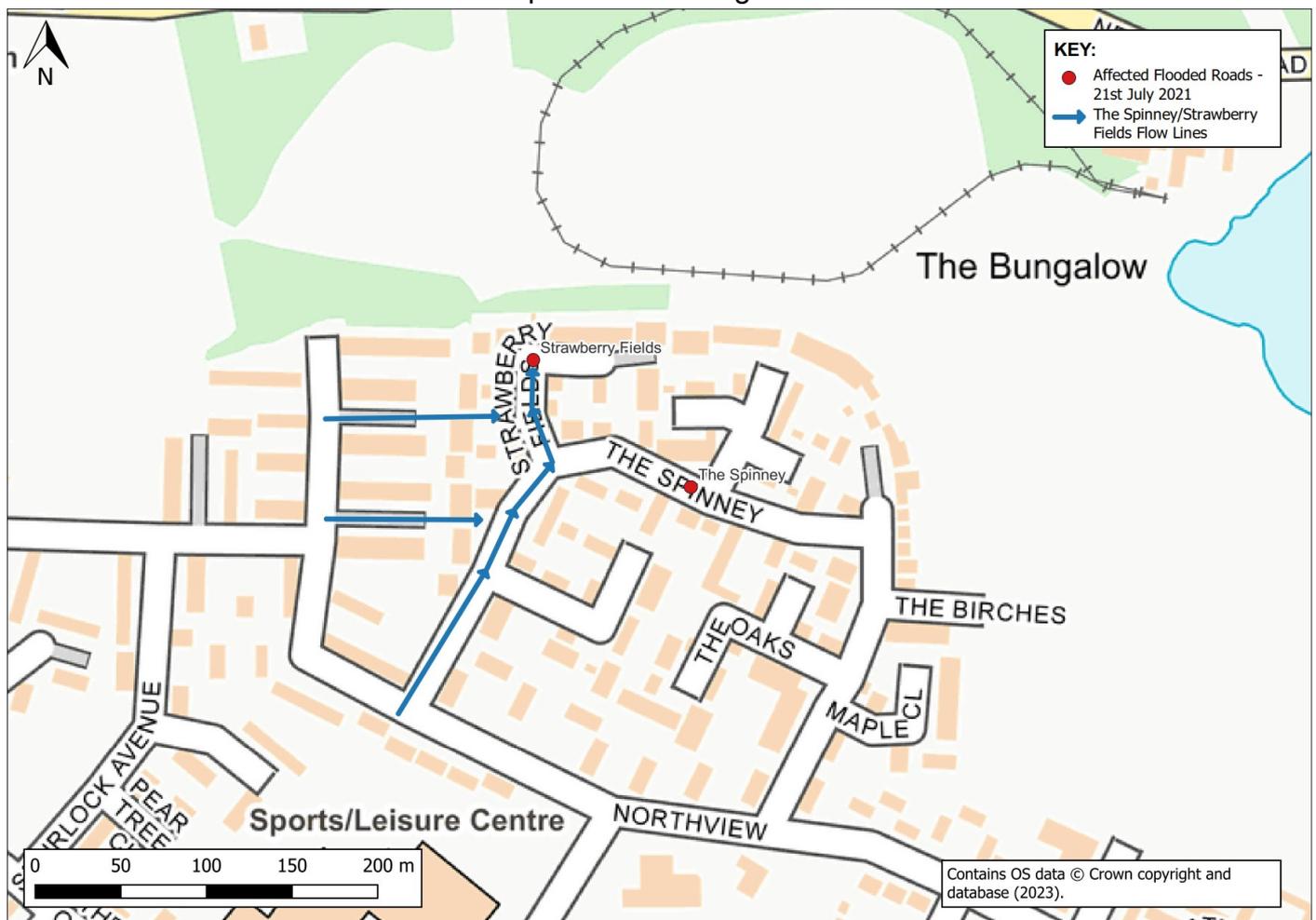


Figure 8 below shows the different flows routes and reported flood incidents within the Strawberry Fields and The Spinney area of Swanley (please note: only the roads where the properties are located have been mapped, and not the individual properties).



Figure 8 - The Spinney / Strawberry Fields flood mechanisms

## **Hextable**

It was reported that the section of College Road located between Egerton Avenue and the Post Office were impassable to local traffic due to carriageway flooding, but no properties are reported to have been impacted.

## **Stuart Close**

Surface water flowed towards Stuart Close as it is within an area of lower topography in comparison to the surrounding areas, leading to significant flooding along the road and to properties. KCC Highways records indicate that the gullies were last cleaned in September 2016 prior to the flood event in July 2021. KCC Highways cleaned the gullies along Stuart Close in September 2021 and also undertook a CCTV survey of the drainage system in October 2021 which identified roots within the system which were removed. This would have contributed to the flooding during the flood event as the gullies could not cope with the volume of surface water runoff experienced during the event.

## **Lower Road / Laura Drive**

During the flood event surface water runoff flowed from west to east along Lower Road until it reached Laura Drive, located parallel to Lower Road. Laura Drive is an area of lower topography, leading to flooding along the road. There was also surface water runoff from the upland agricultural areas to the south of Lower Road, flowing in a northerly direction to Laura Drive. KCC Highways records indicate that gullies, soakaways and chambers were cleaned in June 2021 along Lower Road and in September 2014 along Laura Drive prior to the flood events. The intense rainfall as detailed in the section above meant that the surface water drainage infrastructure surcharged as it is not designed to accommodate intense rainfall as experienced on the 20<sup>th</sup> July 2021.

Figure 9 below shows the different flows routes and reported flood incidents within the Hextable area of Swanley (please note: only the roads where the properties are located have been mapped, and not the individual properties).

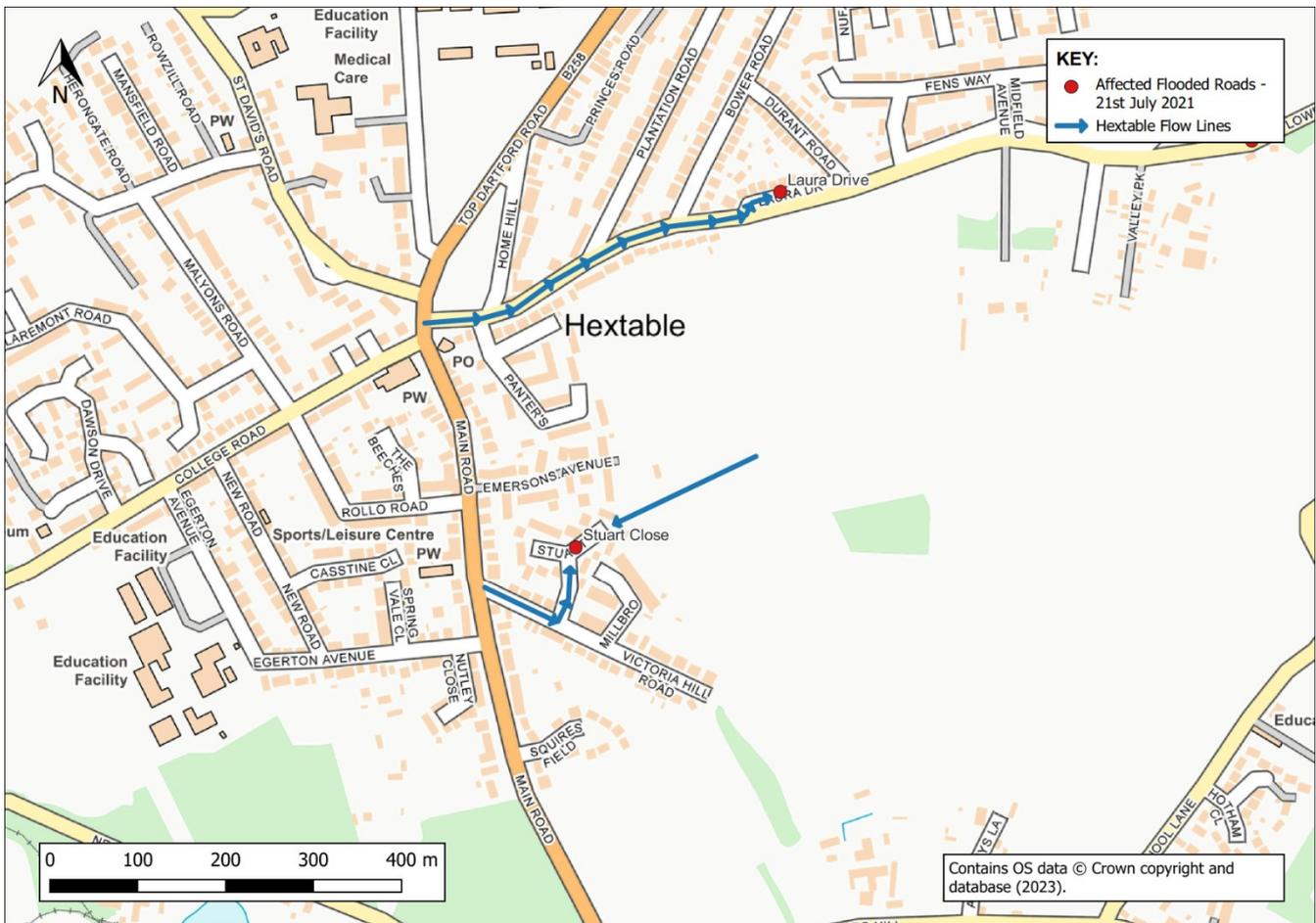


Figure 9 - Hextable flood mechanisms

## Flood Response

KFRS received 19 calls on the 20<sup>th</sup> July and 20 calls on the 20 - 21<sup>st</sup> October. For the 20<sup>th</sup> July 2021 KFRS attended 9 out of the 19 incidents which involved rescuing vehicles from floodwater, unblocking storm drains and pumping floodwater. For the 20<sup>th</sup> – 21<sup>st</sup> October flood event KFRS received 20 reports of flooding, although did not attend any of the reported incidents. KCC also provided flood saxs to properties across Swanley and Hextable who requested them.

Since the two flood incidents on the 20<sup>th</sup> July 2021 and 20<sup>th</sup> - 21<sup>st</sup> October 2021, KCC Highways have attended to clear any gullies that were reported to be blocked. CCTV surveys were carried out on the drainage systems where required and the relevant repairs were undertaken.

The capacity of the balancing pond located between the A20 and the south of Swanley has continued to be maintained in order to cope with surface water runoff from the A20 and consequently affects properties within High Firs. In June and July 2022, silt and sedimentation were removed from the pond and vegetation cleared to expand the overall size of the pond to enable it to have greater capacity for water. In 2023 Highways England have undertaken further work to enlarge the pond to almost double its capacity.

West Kent Housing Association have commissioned consultants to investigate and provide a remediation strategy for flooding at Hibbs Close. KCC Flood and Water Management Team are also investigating opportunities for improving flood resilience in the affected areas.

## Conclusions and Recommendations

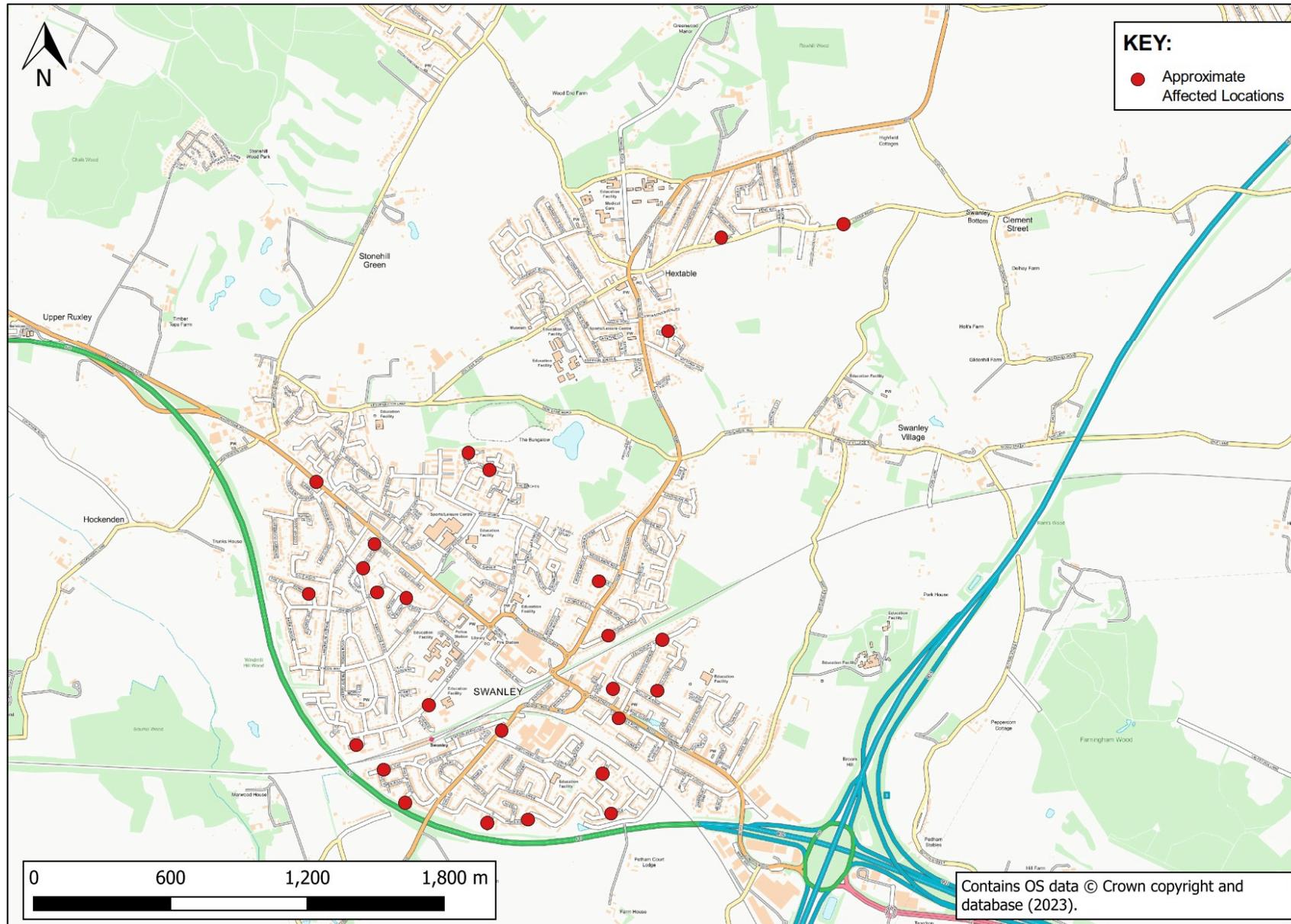
On the 20<sup>th</sup> July 2021 and 20<sup>th</sup> - 21<sup>st</sup> October 2021 flood events, short and very intense periods of rainfall overwhelmed the local surface water drainage infrastructure causing flooding to 68 properties across the two flood events and causing disruption to local roads.

The rainfall analysis undertaken for the two flood events included an assessment of the Eynsford and Orpington rain gauges. For the 20<sup>th</sup> July event, the Eynsford rain gauge recorded an estimated 20% AEP between 13:30 – 17:45 and the Orpington rain gauge recorded an estimated 25% AEP between 16:30 – 17:30. For the 20<sup>th</sup> -21<sup>st</sup> October event, the Eynsford rain gauge recorded an estimated 33% AEP event between 19:45 – 01:30 and the Orpington rain gauge recorded an estimated 7% AEP event between 19:15 – 01:30. However, due to the localised nature of intense rain events, it is possible that the rain gauges assessed for the Swanley flood events do not accurately represent the rainfall experienced across the Swanley catchment. As a result, rainfall radar data was also assessed across the catchment. For the 20<sup>th</sup> July event the radar data recorded an estimated 0.2% AEP event and for the 20<sup>th</sup>- 21<sup>st</sup> October event recorded an estimated 17% AEP. However, it should be noted that radar data may be less accurate than those recorded at rain gauges.

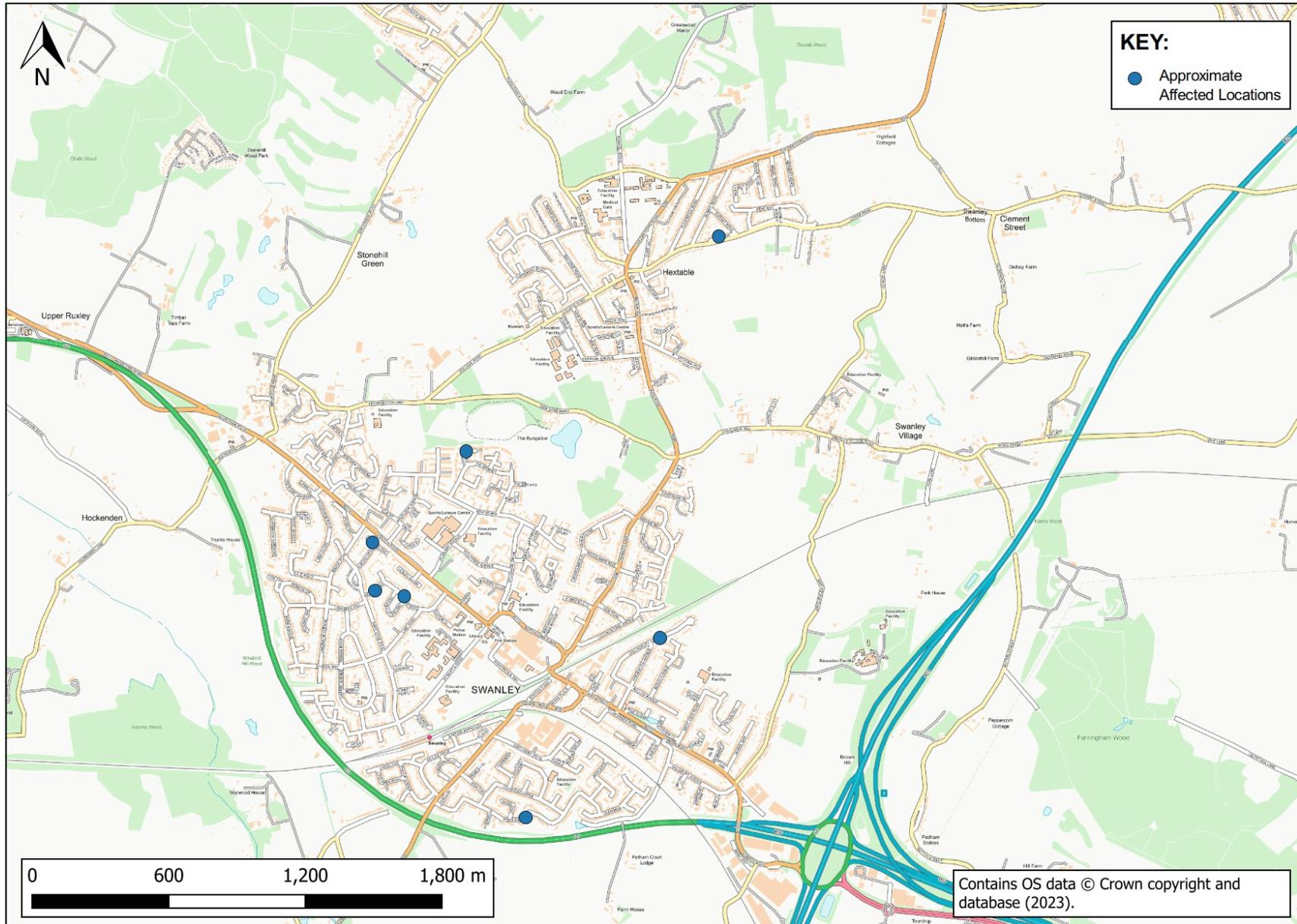
It is likely that the flood events were a result of the intense rainfall overwhelming the surface water drainage infrastructure, as it is not designed to accommodate such large volumes of surface water. CCTV surveys since the flood events identified a number of defects within the systems which would have also contributed to the local flooding issues experienced.

A number of options to be considered as a result of the flood event are detailed below:

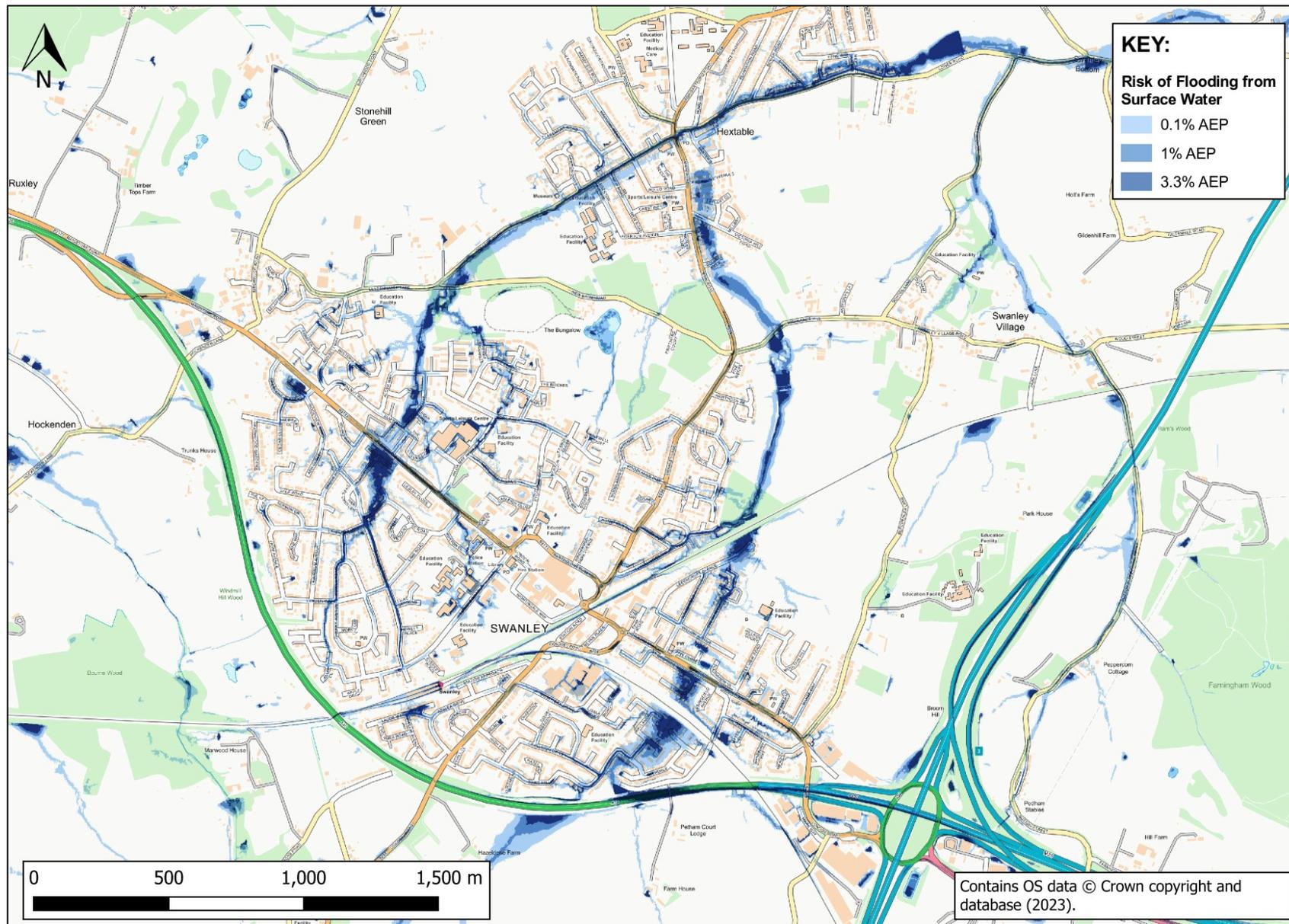
- Further training of flood wardens to cover the whole of Swanley through the Kent Resilience Forum. Currently flood wardens are already available across the southern areas of Swanley.
- Review of the local gully maintenance regimes to ensure that they are being appropriately maintained and managed.
- Creation and implementation of a Local Flood Plan for the local community. KCC will be working with the local community to explore potential opportunities and support available from the Environment Agency.
- Swanley Town Council have provided funding to provide a greater number of electric pumps for Pinks Hill and High Firs Estate, to assist properties pump out flood water during a flood event.
- KCC Highways to contact Network Rail regarding the damage to drainage infrastructure located around Ladds Way.
- The KCC Flood Water Management Team are investigating the potential for SuDS in the Swanley and Hextable area to improve flood resilience in the most affected areas.



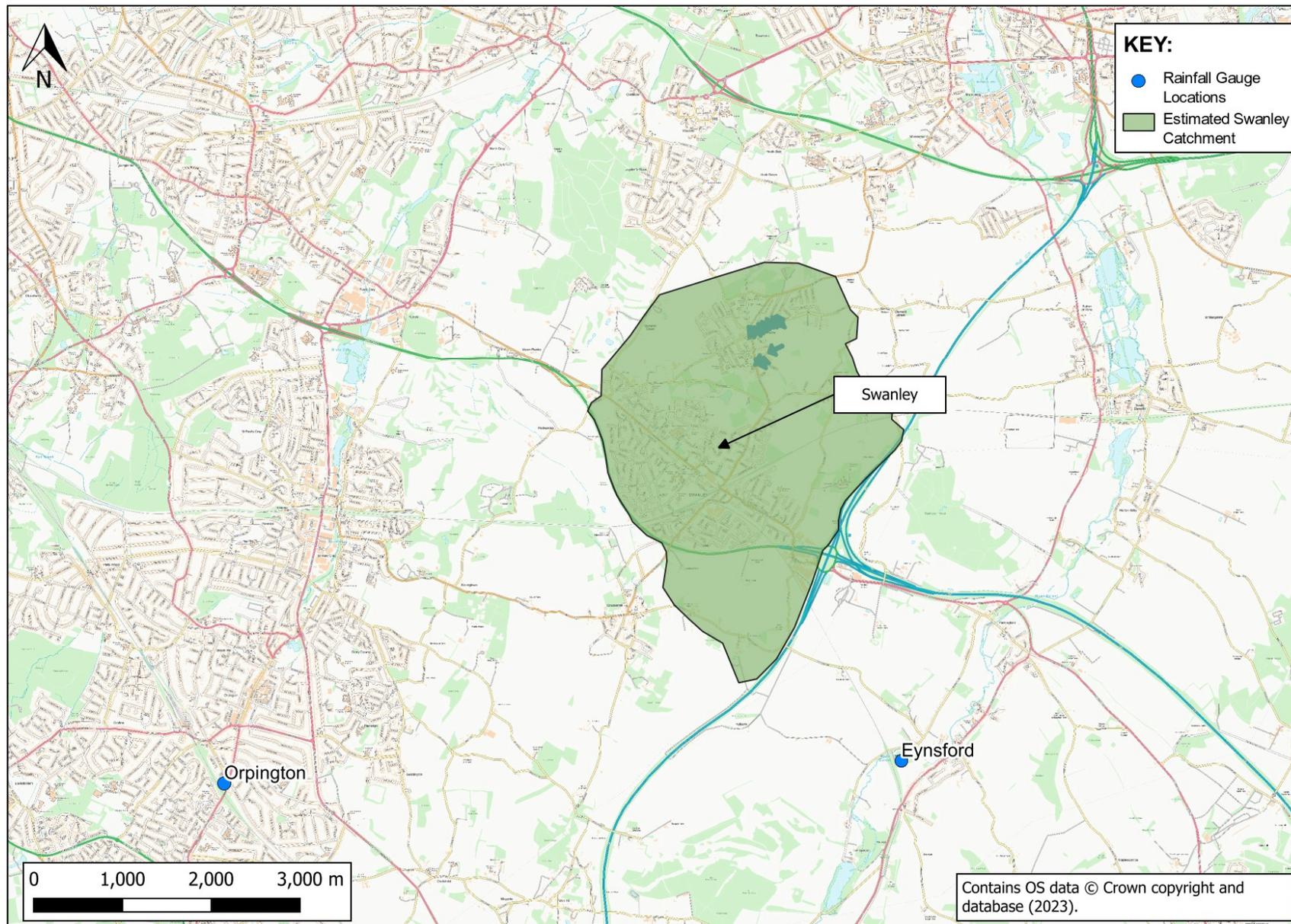
*Annex 1 – Location of reported flood incidents in Swanley – 20th July 2021*



*Annex 2 – Location of reported flood incidents in Swanley – 20th-21st October 2021*



*Annex 3 - Extract from the Environment Agency's Flood Risk from Surface Water Map*



*Annex 4 – Estimated Swanley catchment and location of the Eynsford and Orpington rain gauges*

## Appendix A: Flood Surveys

Table 3 below provides a breakdown of all of the roads that flood surveys were sent to and compares the number of flood surveys per road with the number of responses received.

*Table 3 - Summary of flood surveys*

Location	No. of flood surveys sent	No. of flood surveys received
Almond Drive	6	1
Beech Avenue	49	0
Glendale	40	0
Heather End	14	0
Hibbs Close	42	2
Ladds Way	9	1
Laura Drive	18	4
Leechcroft Avenue	26	3
Lower Road	25	1
Lullingstone Avenue	6	0
Oliver Road	7	1
Overmead	1	1
Sheridan Close	2	1
Sermon Drive	3	1
St Mary's Road	3	0
Strawberry Fields	11	2
Pinks Hill	29	11
Waylands	10	0
West Harold	8	1
<b>Total</b>	<b>309</b>	<b>30</b>

## Appendix B: Flood History

Table 4 below shows the collated flood events from the KCC's flood incident database and Surface Water Management Plans.

*Table 4 - Summary of the historic flood records*

Location	Date of Flooding	Details of Flooding
Button Street / Lawn Close New Barn Road	10/11/2008	Carriageway flooding due to drain blockage.
Archer Way	29/06/2009	Blocked gullies causing external flooding.
Hart Dyke Road / Highlands Hill / Pinks Hill / Waylands / Conifer Way	07/07/2009 - 09/07/2009	Drains blocked after heavy rainfall leading to flooding of carriageways and gardens. Also internal flooding of properties along Hart Dykes Road, Pinks Hill and Waylands.
Cranleigh Drive	03/08/2009	Blocked gully leading to carriageway flooding after heavy rainfall.
The Spinney	13/11/2009	Carriageway flooding.
Edwards Gardens / Goldsel Road	16/11/2009	Heavy flooding across Goldsel Road. One property at Edwards Gardens flooded externally.
Edwards Gardens	30/11/2009	Carriageway flooding and external flooding of properties.
Hilda May Avenue	07/12/2009	Carriageway flooding at the junction of Hilda May Avenue with London Road.
Portswood	26/10/2010	External flooding of properties.
The Spinney	06/01/2011	Drains were blocked leading to flooding of properties along The Spinney.
Edwards Gardens / High Street / London Road / Goldsel Road	17/01/2011 - 18/01/2011	Blocked gullies leading to carriageway flooding, and external flooding along Edwards Gardens.
Goldsel Road	06/07/2011 - 07/06/2011	Carriageway flooding.
Edward Gardens / Goldsel Road	04/11/2011	Carriageway flooding.
Goldsel Road	29/04/2012	Carriageway flooding.
Edward Gardens	14/06/2012	External flooding of a property due to poor drainage.
Lullingstone Avenue	26/09/2012	Carriageway flooding.
Conifer Way	08/10/2012	Blocked soakaways caused approximately 12 cm of flooding externally.
Beechenlea Lane	20/10/2012	Carriageway flooding.

Location	Date of Flooding	Details of Flooding
Button Street	03/01/2012	Carriageway flooding.
Button Street	25/10/2013	Carriageway flooding.
London Road / Beechenlea Lane	04/11/2013 - 05/11/2013	Blocked gullies along Manse Way to London Road. Approximately 8 cm across Beechenlea Lane.
Edwards Gardens / Ladds Way	24/12/2013	Flooding externally along Edwards Gardens and Ladds Way.
Farm Avenue / Beechenlea Lane	01/01/2014 - 02/01/2014	Farm Avenue has soakaways blocked leading to flooding of carriageway. Highway flooding of Beechenlea Avenue.
Pinks Hill / Button Street / Waylands	17/01/2014	8 properties reported to have flooded internally on Pinks Hill, required pumping from KFRS. Carriageway flooding along Button Street and Waylands.
Waylands	01/02/2014	External flooding of 1 property.
Waylands	08/02/2014	Carriageway flooding and external flooding of 1 property.
London Road / Hilda May Avenue	10/07/2014	Carriageway flooding.
Button Street	26/08/2014	Carriageway flooding.
Pinks Hill	13/10/2014	External flooding of properties.
Ladds Way	25/08/2015	Carriageway flooding and external flooding of 1 property.
Button Street	13/11/2015	Carriageway flooding.
Haven Close / Pinks Hill	05/01/2016 - 07/01/2016	Blocked drain externally flooded properties. Carriageway flooding on Pinks Hill.
Hilda May Avenue / Swanley Village Road	11/01/2016	Carriageway flooding.
Church Road	18/03/2016	Carriageway flooding.
Cranleigh Drive	11/05/2016	External flooding of 1 property due to blockage of soakaways.
Ladds Way	01/06/2016	Carriageway flooding and external flooding of 1 property.
Farm Avenue	22/11/2016	External flooding of properties.
St Marys Road	15/08/2018	Flooding of 1 property internally.
High Street	01/11/2018	Internal flooding of properties.
London Road	07/11/2018	Carriageway flooding.

Location	Date of Flooding	Details of Flooding
Goldsel Road / Birchwood Road	13/11/2018 - 14/11/2018	Carriageway flooding.
Birchwood Road	02/12/2018	Carriageway flooding.
Birchwood Road	10/02/2019	Blocked drains leading to road flooding.
The Spinney	04/03/2019	External flooding of properties.
The Spinney	29/03/2019	External flooding of properties.
Pinks Hill / Waylands / Farm Avenue / Sermon Drive / Bourne Way / Azalea Drive / The Spinney / Archer Way / Strawberry Fields / Button Street / West Harold / Leechcroft Avenue / Hibbs Close	11/06/2019 - 12/06/2019	Internal flooding reported along Pinks Hill, Bourne Way, Waylands, The Spinney and Leechcroft Avenue. Reports of 50 cm internally. Properties externally flooded too.
Waylands / Goldsel Road	18 /09/2019 - 19/09/2019	Carriageway flooding and external flooding of properties.
West Harold	26/07/2019	Property internally flooded, 50 cm depth.
Waylands / Swanley Village Road / Pinks Hill / Cranleigh Drive / Goldsel Road / Farm Avenue	20/12/2019 - 24/12/2019	Carriageway flooding reported along multiple roads. 4 properties internally flooding along Pinks Hill.
Waylands	16/02/2020	Carriageway flooding of 20 cm.
Farm Avenue	19/02/2020	Internal flooding of 1 property.
Highland Hills	21/02/2020	Carriageway flooding.
Goldsel Road / Farm Avenue	03/10/2020	Carriageway flooding.
Goldsel Road / Manse Way	14/01/2021	Carriageway flooding.
Waylands / Woodview Road	30/01/2021	Carriageway flooding.