1 Appendix C: Understanding flood risk in Dacorum Borough

1.1 Dacorum Borough

Dacorum Borough covers an area approximately 212km² and has a population of approximately 153,000[1]. There are 25 wards within the borough, the largest of which is Apsley and Corner Hall with a population of approximately 10,200[2]. Other sizeable wards include Bovingdon, Flaunden & Chipperfield, Chaulden & Warners End and Leverstock Green. The Chilterns dominate the north of the borough amongst agricultural land. The southern and eastern areas are urbanised by small villages and hamlets with the two large towns of Hemel Hempstead and Berkhamsted.

1.2 Hydrology

The principal watercourses (Appendix A) in the borough are as follows:

- River Gade (source located in the central band of the borough)
- River Bulbourne (source located near Northchurch)
- River Ver (begins in the grounds of Lynch Lodge, Kensworth Lynch)
- Tring Bourne (minor watercourse located to the north-west)

There are numerous tributaries to these watercourses including Main Rivers, The Grand Union Canal, smaller Ordinary Watercourses and unnamed watercourses. A summary of watercourses within the Borough is provided in Appendix A.

Following the EA's Management Catchments, Dacorum Borough lies within the Thames and Chilterns South catchment in the north-west, and the Colne catchment which forms the majority of the borough. The Thame and Colne are the EA Operational Catchments within the borough.

Average rainfall within the borough at Rothamsted No2 (nearest climate station) indicates average annual rainfall of 712mm which is relatively dry compared to the rest of the UK[3].

1.3 Topography

The topography of the Borough primarily comprises a plateau of elevated land which form the Chilterns to the north and north west of the borough linked with the valley slopes of the Rive Gade and River Bulbourne. The higher elevations of the borough range from 180 and 240 metres AOD (Above Ordnance Datum) with the land occupying the valley floor elevated between 90 and 150 metres AOD. The north-west of the borough towards Long Marston and Tring is low lying agricultural land linked with the Tring Bourne stream, elevated between 65 and 75 metres AOD.

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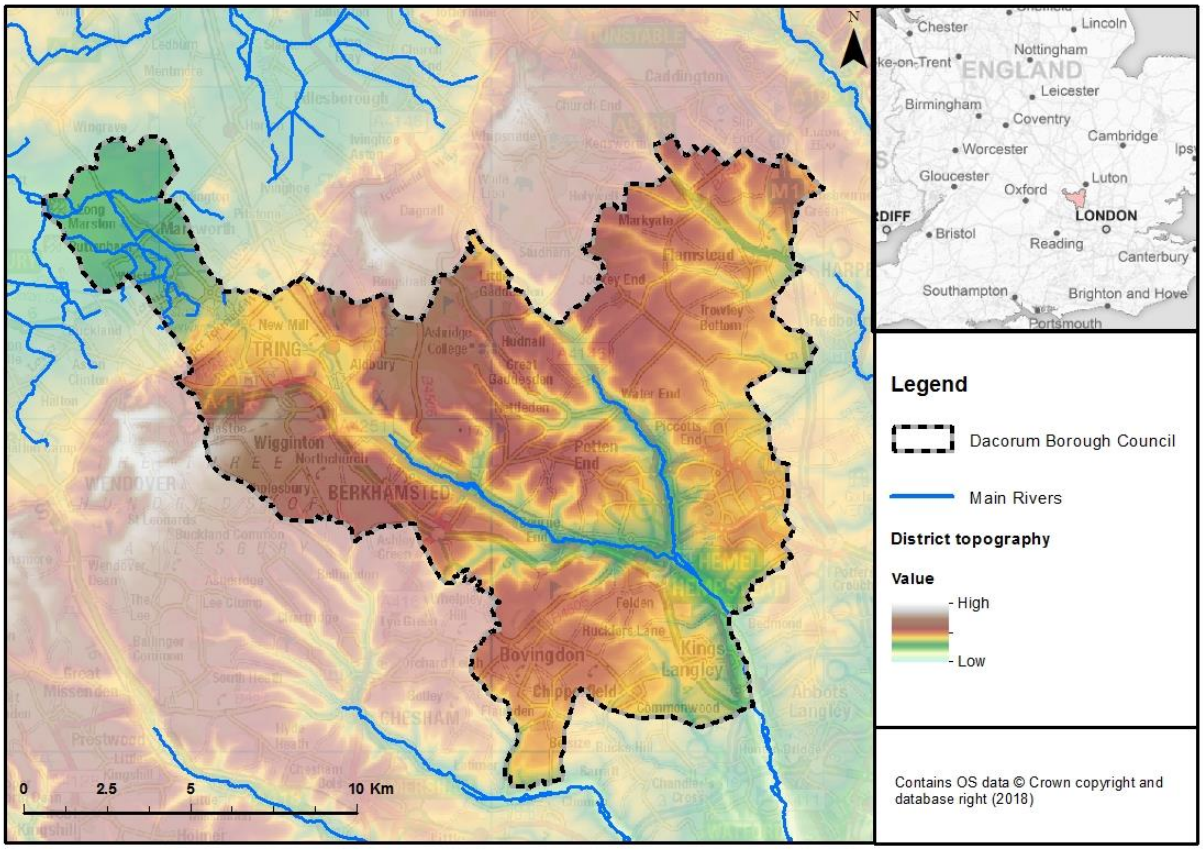
[1] Office for National Statistics (June 2017). *Population estimates for UK, England and Wales, Scotland and Northern Ireland: mid-2016*. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletibu/annualmidyearpopulationestimates/mid2016. Accessed on: 20/02/2018

[2] Office for National Statistics (October 2017). Mid-2016 Population Estimates for 2016 Wards in England and Wales by Single Year of Age and Sex – Experimental Statistics. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/wardlevelmidyearpopulationestimatesexperimental. Accessed on 20/02/2018

[3] The Met Office (2018). *Annual Average Rainfall 1981-2010: Rothamsted No2*. Available online at: https://www.metoffice.gov.uk/public/weather/climate/gcpwmq68n. Accessed on 02/03/2018.

Figure 1-1: Topography of Dacorum



1.4 Geology and soils

The geology of the catchment can be an important influencing factor in the way that water runs off the ground surface. This is primarily due to variations in the permeability of the surface material and bedrock stratigraphy. Dacorum borough primarily consists of one main bedrock geology, that of the White Chalk subgroup. There are three secondary bedrock geologies found within the borough; the Lambeth Group (eastern areas), the Grey Chalk subgroup and the Gault and Upper Greensand Formation to the north-west of the borough.

The White and Grey Chalk Subgroups dominate the borough but are interspersed with areas of the Lambeth Group (clay, silt, sand and gravel) deposits, notably to the east of Hemel Hempstead. The permeable chalk formations indicate that the majority of this area is likely to have a slower response to rainfall and flood volumes.

The borough's superficial (surface) deposits consist of three distinct geologies. Clay-with-flints formation (diamicton) dominates the elevated central and eastern areas of the region, with Alluvium deposits concentrated along the Bulbourne and Gade valley floors. The clay-rich soils will impede drainage at elevated levels with alluvial deposits characterising freely draining soils at the valley slopes. To the north-west of the borough where lowland areas are situated, the Sand and Gravel formation dominate the soils of Tring and Long Marston. Limestone and lime-rich loamy soils are freely draining with the Tring catchment exhibiting slow response to rainfall and flood volumes are likely to be less critical.

1.1 Land use

Beyond the larger conurbations of Hemel Hempstead, Berkhamsted and Tring, the borough is relatively rural in nature, with much of the land used for agricultural practices. The Chilterns AONB occupy much of the north and north-western regions of the borough with areas towards the south and south-east not protected by any landscape designations.

1.2 Flood History

The borough has a number of recorded flood events. Notably, flooding to properties in Long Marston due to Tring Bourne stream, and groundwater flooding in Tring, and fluvial flooding from the River Gade in Hemel Hempstead.

There is limited information regarding historical flooding available for the Rivers Bulbourne or Gade. Based on information from the Environment Agency, Thames Water and Hertfordshire County Council Highways division a detailed listing of known recorded events in the borough and sources of information, is provided in **Error! Reference source not found.**.

The flood incidents that have been identified in the table below are from various sources including backing up of culverts, natural topography of areas (ponding), fluvial flooding and poor land drainage. There has been one Section 19 report undertaken by Hertfordshire County Council within the Dacorum borough at Long Marston, Tring. During the 2013 – 2014 winter there were numerous and serious flood events which required an investigation into the mechanisms for the flood events.

Table 1-1: Recorded flood history in Dacorum

Date	Settlement / location	Severity / description of incident
Unknown	Nettleden Road, Berkhamsted	Road at the crossing with Roman Farm and Nettleden Farm is regularly flooded from groundwater.
1946 and regular flooding	Church Street, Bovingdon	Flooding from surface water drainage occurs at the confluence of Church Street and Green Lane. Attributed to the topography of the area. Flooding in 1946 known as 'The Great Flood of Bovingdon.
Unknown	Delmer End Lane, Flamstead	Groundwater flooding regularly occurs on the road adjacent to Lower Sawpit Wood.
Unknown	Parsons Close, Flamstead	Properties on Parsons Close in Flamstead are frequently flooded due to surface water runoff from the fields to the north.
Unknown	Chequers Hill, Friars Wash	Flooding regularly occurs on Chequers Hill (under the A5). Source is thought to be from surface water and fluvial flooding (River Ver) attributed to the topography of the field.
Unknown	Bede Cottage, Frithsden	Bede Cottage regularly floods from surface water drainage running off the surrounding fields.
2007	Puddephats Farm, Gaddesdon Row	Puddephats Lane is regularly flooded from groundwater
September 2016	Fishery Road, Hemel Hempstead	Property flooding (2 dwellings) and external flooding to properties from the Bulbourne and Gade.

Unknown	Buncefield Lane, Leverstock Green	Buncefield Lane at the crossing with Green Lane in Leverstock Green is impacted by surface water flooding.
1978 (day unspecified)	Long Marston	Village flooded four times, up to 3 feet in depth
31st May 1992	Chipperfield Road, Kings Langley	At least 10 properties flooded due to heavy rain and overland flow.
2nd January 2003	Long Marston	Widespread flooding, Marston Court under water
2003 (day unspecified)	Long Marston	Flooding in Long Marston
1st May 2007	Long Marston, Tring	Medium to heavy rainfall for 48 hours. Source of flooding is not fully understood. Drainage ditch runs through the village next to the main road.
24th December 2013	Long Marston	Flooding on 24/12/2013 and four times between Boxing Day and 07/01/2014
7th January 2014	Long Marston	Widespread flooding
7th February 2014	Long Marston	Widespread flooding that required the Emergency Services.
June & October 1993	Roman Way, London Road, Hicks Road & Church End; Markyate	34 properties flooded due to capacity exceedance at culvert from heavy rainfall in the catchment. Caused flooding downstream at Redbourn.
Unknown	Two Ponds Lane, Northchurch	Surface water flooding occurs on Two Ponds Lane, Tring Road, Boswick Lane and Duswell Lane. Roads are regularly flooded.
27th September 2002	Langdon Street, Tring	Groundwater flooding
9th December 2002	Langdon Street, Tring	Groundwater flooding
4th January & 14th November 2014	Green Lane, Bovingdon	Road flooded from surface water. On average 2ft deep with the deepest areas up to 30cms covering 30ft of area.
7th February 2014	Chapel Lane & Station Road, Long Marston	At least 10 properties flooded internally. Flooding of village due to heavy sustained rainfall and overtopping of Tring Bourne. Flooding also occurred in early January.
7th February 2014	Tring Road, Little Tring, Tring	Groundwater flooding. One property flooded.
8th February 2014	Hogpits Bottom, Flaunden	2 properties flooded internally. Flooding has occurred in 1993, 2009 and 2014.
14th February	Larkspur Close, Hemel Hempstead	History of flooding dating back to early 2000s.

2014		
16th July 2015	Nash Green, Hemel Hempstead	One property flooded due to heavy rainfall.
16th September 2016	Ryder Close, Rymill Close, Eastnor, London Road, & Green Lane; Hemel Hempstead	30 properties flooded, up to 18 inches internal flooding in some properties. Unknown source
16th September 2016	Pix Farm, Bourne End, Hemel Hempstead	Canal overtopping
23rd November 2017	Corner Hall & Longlands, Adeyfield, Hemel Hempstead	Roads completely flooded with surface water making road inaccessible

Figure 1-2: Bedrock geology of Dacorum

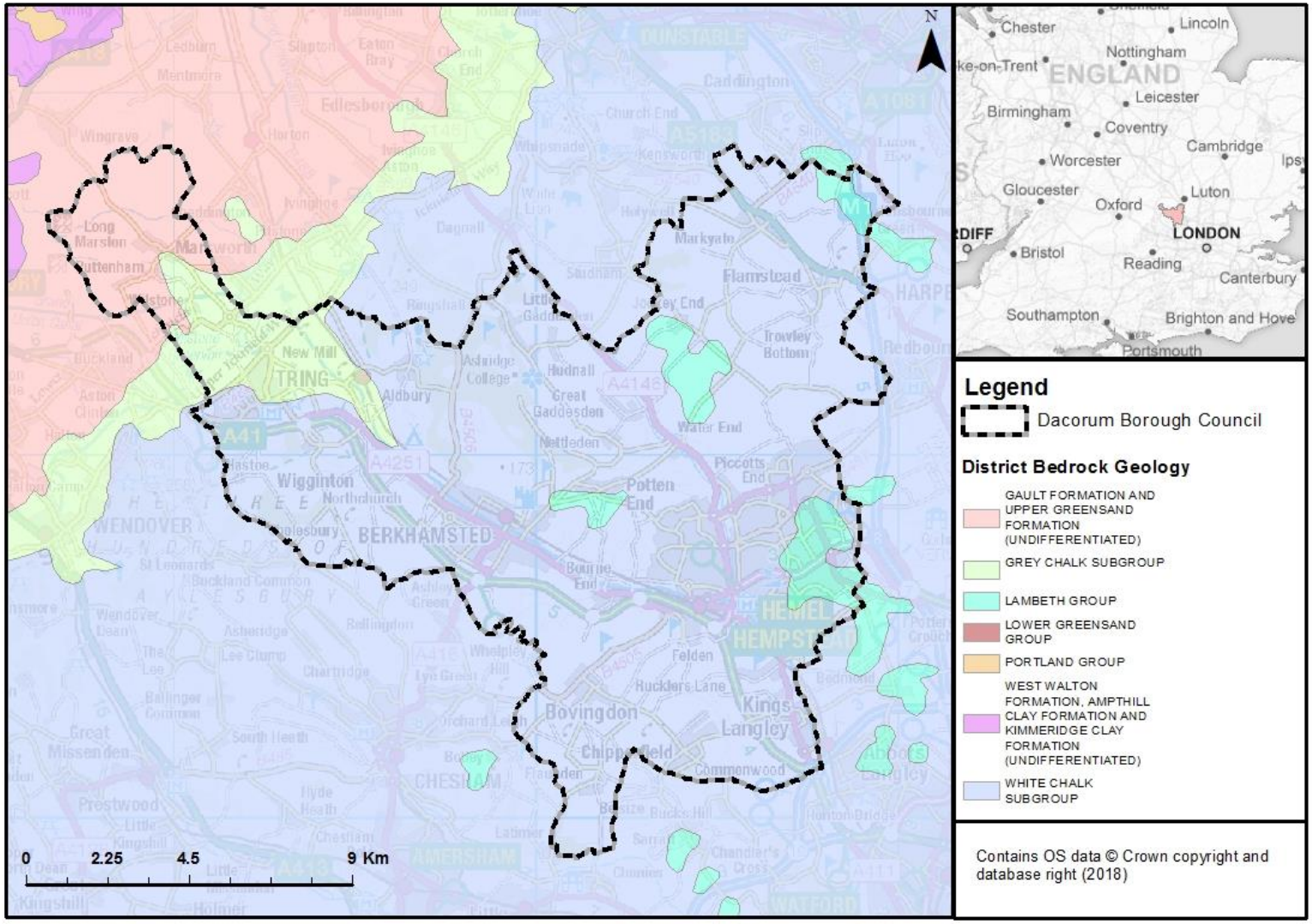
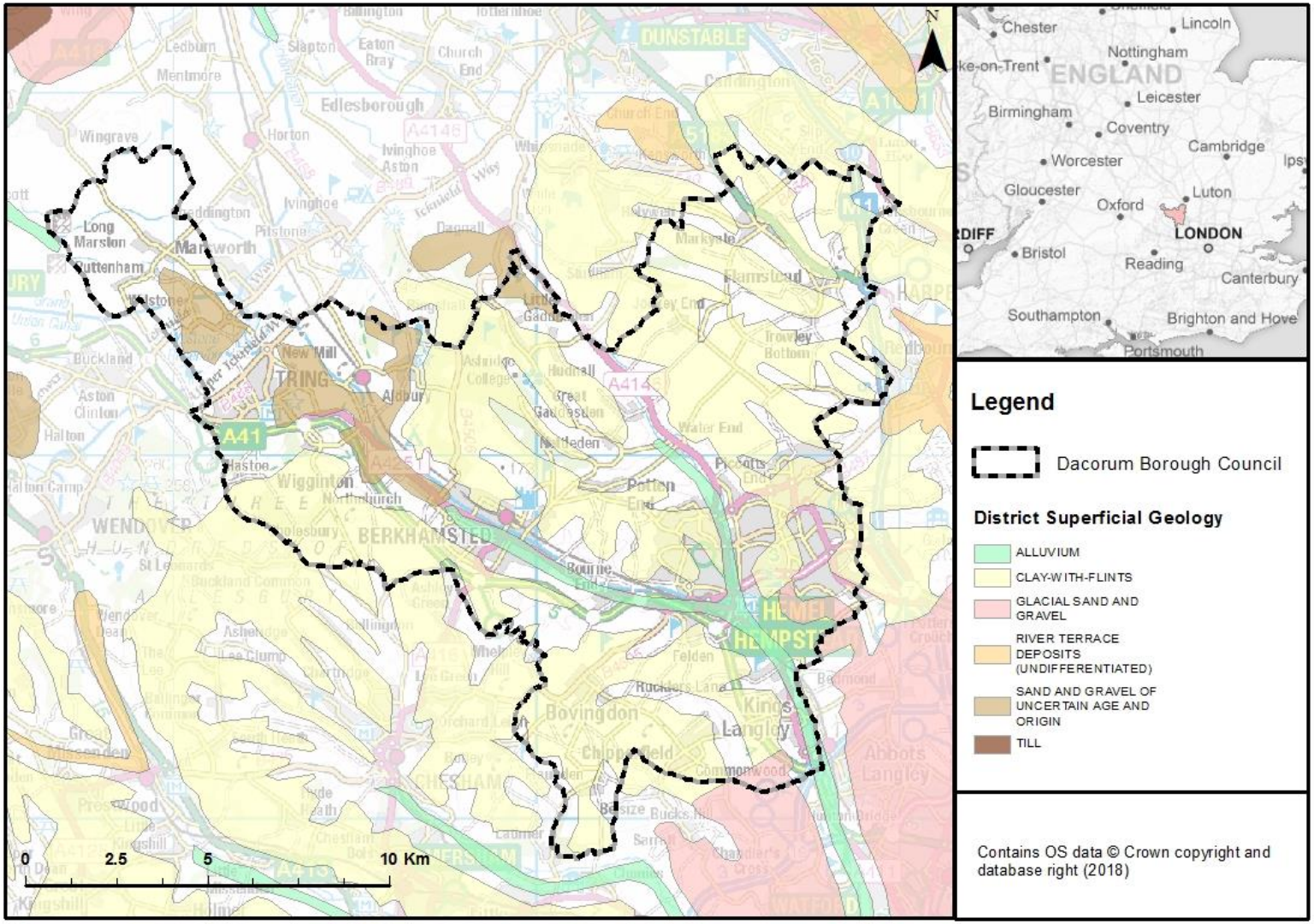


Figure 1-3: Surface geology of Dacorum



1.3 Flood Risk in Dacorum Borough

1.3.1 Fluvial

Fluvial flooding from the Rivers Bulbourne, Gade and Ver is relatively well constrained by the steep topography of the river channels. The extent of fluvial flood risk can be seen in Appendix A.

Eastern Markyate and Friar's Wash are located in Flood Zones 2 and 3 of the River Ver. Localised areas of central Boxmoor, Berkhamsted, Kings Langley and Hemel Hempstead are at risk of flooding from the Rivers Gade and Bulbourne, located in Flood Zones 2 and 3. The watercourses enter a number of culverts and footbridges, posing a risk of blockage and flooding.

An area of frequent flooding from the River Gade was identified in the Gadebridge Park area of Hemel Hempstead by the 2016 River Gade and Bulbourne hydraulic modelling study.

The floodplain becomes more extensive in the north west corner of Dacorum, where three tributaries of the River Thame, the Tring Bourne, Gudgeon Stream and Thistle Brook, form a confluence. The settlements identified at risk during a 1 in 100-year (Flood Zone 3) and 1 in 1,000-year (Flood Zone 2) flood event are Long Marston, Astrope, Gubblecote and to a lesser extent northern Tring.

There are also numerous ordinary watercourses within Dacorum, which can pose a significant local flood risk. These watercourses are not represented by the Flood Zones, and although the RoFSW mapping can provide a proxy for the likely flood extents, the flood risk from ordinary watercourses needs to be assessed as part of a site-specific FRA.

1.3.2 Surface Water

Surface water flood risk in Dacorum largely follows the topography of the Chiltern Hills, forming confined surface water flow paths which drain into the Rivers Gade, Bulbourne and Ver.

Significant flow paths form on steep ground in Hemel Hempstead, flowing east and south eastwards across the town. Large areas of surface water ponding are predicted to form during a on lower ground upstream of roads, including Warners End Road, B487 Queensway and A414 Brakespear Way, during a 1 in 30-year rainfall event and greater storms. However, culverts and other surface water drainage assets are not fully represented within the RoFSW mapping. Therefore, although the structures are likely to restrict the drainage of rainfall beneath the roads, and may cause upstream ponding, the extent of predicted flood risk may be less than identified in the mapping.

More extensive surface water flooding is identified in Tring, where flow paths form in the west and north west of the town during a 1 in 30-year rainfall event and higher return periods, causing ponding on Brook Street, the High Street and surrounding residential areas.

Appendix A provides the surface water flood risk mapping for Dacorum.

1.3.3 Groundwater

Due to the chalk geology of the surrounding Chilterns, there are several areas of Dacorum where groundwater levels lie close to the ground surface, and have led to groundwater flooding. The northwest of the Borough, covering Tring, Wilstone and

Long Marston, is identified as the area of highest flood risk, where groundwater is estimated to lie within 0.025m the ground surface.

Further areas of potential groundwater flood risk are within the chalk valleys of the River Ver at Markyate, the River Gade at Hemel Hempstead, and the River Bulbourne at Berkhamsted.

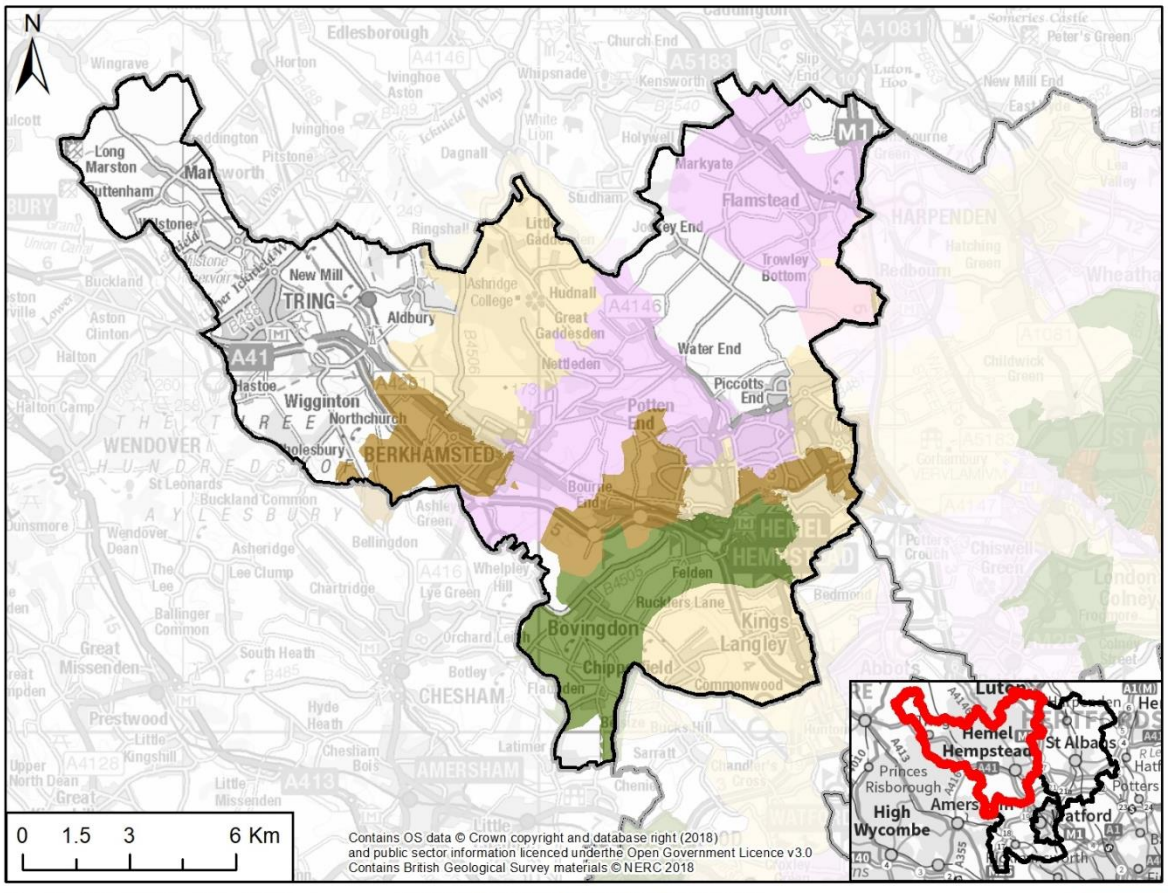
The groundwater flood risk map for Dacorum is provided in Appendix A.

1.3.4 Sewers

Thames Water provided their sewer flooding register for Dacorum, which is detailed below in **Error! Reference source not found.** and in Figure 1-4.

The greatest number of sewer flooding records within a postcode area, 48 in total, is recorded in HP22, which covers the area of Long Marston, Tring and Wilstone. This is an area of higher fluvial, surface water and groundwater flood risk, which suggests that ingress into the sewer system may be an issue in this location. A relatively high number of incidents are also recorded across Hemel Hempstead.

Figure 1-4: Map of sewer flooding incidents recorded on Thames Water register.



South West Hertfordshire Level 1 Strategic Flood Risk Assessment

Table 1-2: Sewer flooding register for Dacorum.

Postcode Area	Coverage	Internal property flooding			External property flooding			Total
		2 in past 10-years	1 in past 10-years	1 in past 20-years	2 in past 10-years	1 in past 10-years	1 in past 20-years	
AL3 6	NE Dacorum (Flamstead, Markyate)	0	0	1	0	0	0	**1**
AL3 7		0	0	0	0	1	0	**1**
AL3 8		0	0	2	1	3	3	**9**
HP1 1	Hemel Hempstead – Bourne End, Boxmoor, Chaulden, Fields End, Gadebridge, Great Gaddesden, Nettleden, Piccotts End, Water End, Warner's End	0	0	0	0	1	3	**4**
HP1 2		0	0	5	1	3	5	**14**
HP1 3		0	0	0	0	1	6	**7**
HP2 4	Hemel Hempstead	0	0	4	0	4	4	**12**
HP2 5	Hemel Hempstead	0	0	1	0	3	2	**6**
HP2 7	Hemel Hempstead	0	1	1	0	2	0	**4**
HP22 5	Long Marston, Tring, Wilstone	0	0	48	0	0	0	**48**
HP3 0	Hemel Hempstead	0	0	1	0	1	15	**17**
HP3 8	Hemel Hempstead	0	0	0	0	0	5	**5**
HP3 9	Hemel Hempstead	0	0	4	0	5	8	**17**
HP4 1	Berkhamsted	0	0	0	1	1	1	**3**
HP4 2	Berkhamsted	0	0	4	0	0	4	**8**
HP4 3	Berkhamsted	0	0	5	1	3	3	**12**
WD4 8	Chipperfield, King's Langley	0	0	0	0	1	3	**4**
WD4 9	Chipperfield, King's Langley	0	0	0	1	0	1	**2**
TOTAL		**0**	**178**	**79**	**5**	**32**	**64**	**358**

1.3.1 Canal

Flooding from the Grand Union Canal poses a residual risk to Dacorum. This is particularly the case within Berkhamsted and Hemel Hempstead, where the canal is perched with numerous interactions between the canal and the Rivers Gade and Bulbourne. Data from the Canal and Rivers Trust identified a minor breach in the canal at Dudswell, north of Berkhamsted in July 2008, and two further breaches caused by failure of a culvert and lock gate east of Wilstone in 1994 and 2006, respectively. As relatively sparsely populated rural areas, there was no known flooding to property.

Further incidents of canal overtopping were reported between 2009 and 2017. These largely occurred west of Wilstone, within Berkhamsted and the Boxmoor and Nash Mills areas of Hemel Hempstead. The only instances of overtopping due to hydrological response of the canal occurred in January 2013 on the Aylesbury arm northwest of Wilstone. The remaining incidents were caused by the incorrect operation of locks by boat users.

1.3.2 Reservoir

There is a residual risk of reservoir flooding in Dacorum, however it is localised, being confined to the north and northwest of the Borough, around Tring Reservoirs and Markyate Flood Storage Area. The settlements at potential risk are identified as Markyate, Wilstone and Long Marston.

However, it should be noted that reservoir safety is closely controlled by operators and regulators, and the likelihood of a flood event due to reservoir breach is low.