Milton Keynes Borough Council

FWMA SECTION 19 REPORT

Flood Event: May 2018

S19-2018-05
OCTOBER 2018

PUBLIC

Milton Keynes **Borough Council**

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CONTENTS

TABLES

FIGURES

Figure 14 – Pipe Burst Cairngorm Gate

APPENDICES

EXECUTIVE SUMMARY

This report sets out the preliminary findings following the 27 May 2018 flood event that occurred within a number of areas of Milton Keynes.

Following the flood event WSP were approached by Milton Keynes Council, to provide technical support, which has consisted of:

- Undertaking an inspection of published flood mapping
- Support during selected site inspections of the flood extents
- Initial appraisal of the storm event, based on available data
- Production of this Flood and Water Management, 2010 (FWMA) Section 19 Flood Investigation Report

MAIN FINDINGS

1.1.1. This FWMA Section 19 report has considered the evidence presented, and based on this evidence, the flood event can be summarised as follows:

- The flooding that occurred was due to a very intense summer storm, with indications that this was in excess of a 1% Annual Probability Event, with a rainfall depth of up to 90 mm.
- The Environment Agency's Flood Map for Surface Water, provides a reasonable representation of the flooding that occurred, with the indicators of flooding occurring within the risk areas, supporting the assumption that the flooding was the result of a significant rainfall event.
- Significant evidence of flooding was observed in the reported areas, including additional properties which, at the time of site inspection, had not notified Milton Keynes Council that they had flooded.
- Reported internal property flooding affected at least 315 houses, the Hospital and a number of business premises.
- Property flooding has tended to occur where the property door thresholds are perpendicular to the local flow routes i.e. the property acts as a barrier to flow, causing the water level to rise sufficiently to exceed the door threshold of the property causing internal flooding. Some evidence of water rising-up through the floor has also been noted.
- Property flooding has also occurred where the driveway between the property and the highway falls towards the property, this is especially true where there is limited, or no kerb height.
- Debris was observed on gully inlets, indicating that the storm event is likely to have mobilised a significant volume of leaf litter and other detritus. It is unclear if this occurred, before, during or

after the event. This may have restricted the functioning capacity of the gullies. On clearing the gully grates, the internal gully was observed to be clear.

- Evidence of sewer surcharging, causing damage to the overlying pavement has been observed, indicating that significant volumes of water were present within the sewer system.

It is concluded that the flooding experienced in Milton Keynes was the result of heavy rainfall, overwhelming the capacity of the drainage network, resulting in surface water flows gravitating towards low points in the local topography causing internal flooding to over 315 residential properties.

2. NON-TECHNICAL SUMMARY

Question	**Answer**
What is the purpose of this Report?	Section 19 of the F&WMA states that on becoming aware of a flood which meets certain pre-determined criteria, the LLFA must undertake a formal flood investigation in order to determine the relevant flood risk management authorities involved and which flood risk management functions have been, or should be taken to mitigate future flood risk. Where an authority carries out an investigation it must publish the results. This report has been prepared to satisfy the requirements of Section 19 of the FWMA.
What has been done?	Milton Keynes Council in partnership with WSP, has undertaken a number of site reviews in areas where residents who have reported flooding. The flood risk maps, published online by the Environment Agency, have been reviewed to understand if the flooding occurred in areas identified as at risk of flooding. Mapping of the sewer infrastructure in the area has also been reviewed. Calculations have been undertaken to determine how rare the rainfall event was likely to have been, that caused the flooding. These calculations have been based on rainfall data captured by the Environment Agency rainfall gauges.
What has been established?	Witness accounts identified that the instances of flooding that occurred were as a result of surface water, i.e. rainfall that couldn't enter local drainage systems. The event occurred so quickly and deposited such a relatively small volume of rainfall across river catchments that fluvial flooding was not a factor in the reported flooding. As the flood instances were related to surface water run-off the Environment Agency has no responsibility or capacity to provide warnings of surface water flooding, they deal with flooding from Main Rivers and the sea only. The properties that experienced flooding during this event are not all identified to be in areas previously believed to be at risk of flooding. Proceeding weather summary? The rainfall event that happened occurred in a very short space of time. A large amount of rainfall fell on the evening of the 27 May. The amount of rain that fell overwhelmed the drainage systems and sadly caused flooding to many people and properties. Most areas that experienced flooding are served by sewer infrastructure but the magnitude of the storm that occurred was too great, even for a drainage system designed to modern standards to have dealt with.
Could it happen again?	Yes. Data suggests that rainfall patterns of large amounts of rainfall falling in short periods are happening more often as a result of climate change. However, the localised nature of the surface water flooding makes it extremely difficult to predict exact localities that could be affected.
What is a 1% Annual Exceedance Probability event?	A 1% flood event equates to the likelihood of flooding in any year, although unlikely multiple storm events of the same return period can occur in any one year. Similarly, just because a 1% flood event occurred in the previous year, does not mean that it will not happen in the following years.
What happens next?	A key finding of this report is the need for Milton Keynes Council, and Anglian Water, to undertake surveys of their drainage pipes, manholes and drainage gullies, to confirm they are all working correctly.
What is Milton Keynes Council doing to manage	A number of potential improvements have been identified. However, these improvements

future flood events?	will need to be designed in detail and assessed before they can be put into action.
What can I (an affected resident) do?	Everyone has their part to play to help reduce the flooding that happens to our properties, things we can do as a community are: **Routine Maintenance** ▪ Making sure people do not use road gullies and ditches as rubbish bins – they can't drain the water as fast as it could if they have rubbish in them; ▪ Make sure grass clippings and garden waste are collected, so they don't flow into our drainage networks ▪ Report blocked road gullies to Milton Keynes Council ▪ Make sure watercourses are kept clear. Small watercourses should be maintained by the property owner, however working on water can be dangerous, so make sure clearance is done safely, if in doubt ask Milton Keynes Council for guidance ▪ Think about what you would do in a flood, do you have a "grab bag" ready if you need to evacuate? Individuals may seek to make their properties flood resistant. There are many companies that can help design and install special equipment to help protect your property **Following a Flood Warning** ▪ Report any blocked road gullies to Milton Keynes Council **During a Flood Event** ▪ Encourage people to be safe and not to drive through flood water, they are putting their car at risk and the flood waves can cause flooding to properties ▪ If safe to do so, take photographs / videos of the flooding ▪ Notify Milton Keynes Emergency Planning Team of flooding, and of any particular safety concerns. ▪ Do not put yourself or others at risk, contact Emergency Services and provide as much information as possible. **Following a Flood Event** ▪ Contact Milton Keynes council to identify if your property has flooded, if possible provide photographs or videos of the flooding. ▪ Consider repairing walls and floors with flood resilient materials to flood minimise damage in the future

3. INTRODUCTION

3.1. BACKGROUND

3.1.1. This document has been produced by WSP on behalf of Milton Keynes Council, in support of the production of a Section 19 Flood Investigation Report, as specified in the Flood and Water Management Act 2010[1] (FWMA).

3.1.2. On the evening of 27 May 2018 significant rainfall in the areas of; Beanhill, Coffee Hall, Lakes Estate, Netherfield, Oldbrook, Stantonbury, Great Linford, Eaglestone, Central Milton Keynes, Downs Barn, Fishermead, Heelands, Neath Hill, Stony Strattford, and Bradwell Common, resulted in flooding of over 315 residential properties, the Hospital, and a number of commercial properties.

3.1.3. Milton Keynes Council, as Lead Local Flood Authority (LLFA), has a responsibility under the Flood and Water Management Act 2010 (FWMA 2010), to undertake flooding investigations, specifically Section 19 states:

Local authorities: investigations

(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.

3.1.4. Milton Keynes Council Flood Incidents Policy is currently in draft format pending full Council approval, a current working draft is presented in Appendix A.

3.1.5. The information provided by Milton Keynes Council identified a distribution of reported flood incidents, as summarised in Table 1, reproduced from data obtained from the emergency planning team (10 July 2018). Figure 1 (Appendix A), provides a reference plan identifying these regions, and the distribution of flooding incidents has been mapped by tallying the number of properties flooded, within a street. Some of the areas affected were verified by WSP through site inspections just after the flood event, from the observations of flood indicators, not all of the reported flooding incidents will have resulted in the ingress of water into the property, and some properties had not notified Milton Keynes of being flooded.

[1] https://www.legislation.gov.uk/ukpga/2010/29/contents

3.1.6. This version of the report is provided as a draft for Public Consultation, Milton Keynes Council would welcome any further data or photographs of the flooding that has occurred.

3.1.7. To date the Emergency Planning team has been made aware of:

- **686 reported incidents of flooding**
- **315 have been confirmed as causing internal flooding**

3.1.8. The Emergency Planning Team data includes information that could identify individual properties, as such the data has been grouped into roads and the cumulative number of flood incidents displayed near to the road centre-point.

3.1.9. Milton Keynes Waste Collection service has kept independent records of properties from which flood damaged items have been collected, these indicate that internal flooding could have occurred to over 50 additional properties.

Table 1 - Distribution of Flood Incidents (reported to the Emergency Planning Team)

Estates	Total	Unclear if internal or external flooding	Internal Flooding
Astwood	1	-	-
Beanhill	106	2	55
Bletchley	22	-	6
Bradville	2	-	-
Bradwell Common	1	-	1
Campbell Park	3	-	-
Cmk	2	-	2
Coffee Hall	241	3	104
Conniburrow	1	-	1
Downs Barn	3	-	2
Eaglestone	6	-	2
Fishermead	13	-	2
Furzton	4	-	-
Galley Hill	1	-	1
Granby	1	-	1
Great Linford	7	-	4
Heelands	1	-	1
Kents Hill	1	-	1
Lakes Estate	11	-	11
Leadenhall	4	-	4
Neath Hill	18	-	16
Netherfield	49	2	31
New Bradwell	6	-	-
Newport Pagnell	25	1	7
Oldbrook	71	1	25
Olney	1	-	-
Peartree Bridge	3	-	2
Pennyland	2	-	1
S. Goldington	-	-	-
Springfield	3	-	1
Stantonbury	5	1	3
Stoke Goldington	54	1	24
Stony Stratford	1	-	1
Tattenhoe	1	-	-
Tinkers Bridge	9	-	4
Tongwell	2	-	-
Various	1	-	-
Willen	1	-	-
Wolverton	1	-	1

3.2. SITE VISIT

3.2.1. WSP staff carried out site visits to the affected areas (as shown in Appendix A) on 30 May, 01 and 12 June 2018. Site visits were undertaken following the flood event, and a walkover was conducted for most of areas that flooded. Indicators of flooding (such as carpets and other household items) being left outside with signs of water damage, rack marks (caused by floating debris adhering to external walls), and wicking on brickwork were noted.

3.2.2. Formal interviews were not conducted, as the focus was to determine the likely extent of flooding by noting the indicators of flooding. The information gathered during the site visits, along with the existing knowledge of Milton Keynes from the Council's Lead Local Flood Officer has contributed to the preparation of this report.

3.2.3. It is envisioned that this report will be updated as more evidence from residents and stakeholders is received.

3.3. LIMITATIONS

3.3.1. The information contained in this document has been compiled for the benefit of Milton Keynes Council officers and contractors, Parish Councils, Anglian Water, and the affected community.

3.3.2. It should be noted that much of the following record is dependent upon observed flooding indicators and anecdotal evidence from Milton Keynes Council officers. Prior to taking any recommendations forward, a feasibility study should be undertaken to confirm the viability of any interventions. Any proposals should be robustly reviewed to ensure that reasonable cost-benefit ratios are achieved, and that the mitigation measures do not adversely impact other properties i.e. by increasing the rate and volume discharged from one area to another.

3.3.3. At this stage investigations regarding the capacity of the drainage network have not been undertaken, this would require intrusive CCTV drainage surveys to be undertaken, and comparison to the statutory drainage asset plans held by Milton Keynes Council, Anglian Water and any third parties affected.

3.3.4. Any data provided to WSP has not been independently validated and has been assumed to be correct and representative of the flood event under consideration.

4. ROLES & RESPONSIBILITIES

4.1. MILTON KEYNES COUNCIL

4.1.1. Under the FWMA 2010, Milton Keynes Council, as the Lead Local Flood Authority (LLFA):

- is responsible for coordinating the management of flood risk from local sources. This includes surface water, groundwater and ordinary watercourses;
- has a duty to investigate and publish reports on flood events (to the extent it considers necessary); and,
- is responsible for compiling and maintaining a register of structures and features that have a significant effect on flood risk.

4.1.2. Milton Keynes Council is also the Highway Authority and has the following powers and duties:

- maintain highways, including ensuring that highway drainage systems are clear and that blockages on the highway are cleared;
- deliver works that they consider necessary to protect the highway from flooding, either on the highway itself or on land which has been acquired by the Highway Authority in the exercising of highway acquisition powers; and
- divert parts of watercourses or carry out any other works on any form of watercourse if it is necessary for the construction, improvement or alteration of the highway or provides a new means of access to any premises from the highway.

4.1.3. The Council also has other related roles in planning and development control, public health, and emergency planning.

4.2. ENVIRONMENT AGENCY

4.2.1. The Environment Agency is responsible for providing a national strategic overview of flooding. The Environment Agency is also responsible for managing flood risk from Main Rivers. The Environment Agency does not have a responsibility for surface water flooding.

4.2.2. The Environment Agency has a key role in providing flood warnings to the public and in protecting and improving the natural environment.

4.2.3. The Environment Agency has permissive powers to reduce flood risk by undertaking work on Main Rivers and flood defence structures.

4.3. ANGLIAN WATER

4.3.1. Anglian Water has responsibility for the public foul and surface water sewer systems in its ownership. Anglian Water is also responsible for treating sewage from its foul network, and to empty and dispose of the contents of their sewers. The Water Company has a general duty (under Section 94 of the Water Industry Act 1991) to provide, extend and improve public sewer systems, ensuring the areas they serve are 'effectually drained'.

4.3.2. Anglian Water must also maintain a register of flooding from sewers. The register records information which is used to apply for investment funds from Ofwat to undertake improvements or repairs to the foul and surface water networks. Investment is agreed with Ofwat on a five year cycle referred to as Asset Management Periods (AMP). The current AMP runs from 2015-2020.

4.4. RIPARIAN LANDOWNERS

4.4.1. Landowners whose property is adjacent to a river, a stream or a ditch are likely to be 'riparian owners'. Riparian owners have a responsibility to maintain the bed and banks of any watercourse within or adjacent to their property, in most cases even if that watercourse is adjacent to a highway, and to ensure there are no obstructions to the natural flow of water.

4.5. PROPERTY OWNERS

4.5.1. Responsibility for protecting property from flooding lies in the first instance with the property owner. Property owners whose home or business premises are located in areas known to be at risk of flooding should consider making their own flood defence preparations. Property owners also have a common law duty to mitigate their losses during a flood event, but without increasing the damage to neighbouring properties.

5. DRAINAGE STANDARDS

5.1. INTRODUCTION

5.1.1. In order to inform the selection of appropriate actions it is necessary to consider the required design performance for drainage systems. Within the UK there is no set level of service that existing drainage assets must achieve, however there a number of inconsistent standards that exist as listed below. UK case law (Marcic V Thames Water[2]) makes it clear that the sewer operator, if operating and maintaining their sewers properly, is not responsible for flooding if caused by a lack of capacity in the system. However, it is useful to assess the performance of the drainage assets against current design guidance, especially for new roads.

5.2. BRITISH STANDARDS

5.2.1. The British Standard for Drain and Sewer systems outside buildings (BS EN 752:2008), states that the 2% AEP event standard should be used for the drainage of vulnerable uses such as underground railways and underpasses.

5.3. DESIGN MANUAL FOR ROADS AND BRIDGES

5.3.1. Under the requirements for the design of new roads in accordance with the Design Manual for Roads and Bridges (DMRB), HA106/04, Drainage of Runoff From Natural Catchments, the manual states (Section 5.3):

- "Highway drainage systems are designed to intercept and remove rainfall from short duration, high intensity events with return periods of 1 year (for no surcharge of piped systems or road-edge channels) or 5 years for no flooding of the carriageway. Flood flows from natural catchments can have durations of several hours so the potential for traffic disruption is greater than that produced by runoff from paved surfaces lasting only a few minutes. For this reason, it is recommended that flow rates from natural catchments without defined watercourses should be assessed for design storms with a return period of 75 years."

5.4. SEWERS FOR ADOPTION

5.4.1. Under the requirements of Sewers for Adoption, 7th Edition new drainage needs to be designed to prevent flooding for the 3.3% rainfall event.

[2] https://publications.parliament.uk/pa/ld200304/ldjudgmt/jd031204/marcic-2.htm

6. CONTEXT & SETTING

6.1. BACKGROUND

6.1.1. The purpose of this section is to present the publicly available information related to flooding within the areas affected.

6.2. TOPOGRAPHY

6.2.1. Appendix B, provides a ground elevation map derived from the Environment Agency's LiDAR data.

6.2.2. The ground elevation map indicates that the areas affected are located on higher ground, with elevations above 90 m Above Ordnance Datum (AOD) being affected.

6.3. GEOLOGY

6.3.1. The British Geological Society provides open source superficial and bedrock geological definitions for the whole of the UK. This data has been used to create the Superficial Geology and Bedrock Geology maps, provided in Appendix B. The types of geological deposits encountered are likely to have a low to moderate infiltration potential, indicating that during high intensity storms, higher rates of surface water run-off are likely to occur, than for high infiltration potential soils.

6.4. ENVIRONMENT AGENCY FLOOD RISK FROM RIVERS

6.4.1. Fluvial flooding, or flooding from rivers, occurs when the capacity of the watercourse is overwhelmed by high flows, resulting in water flowing out of the watercourse banks, causing flooding to adjacent land.

6.4.2. Appendix B, shows the extents of the fluvial (river) flooding predicted by the published Environment Agency Flood Maps. The mapping indicates that the majority of the areas affected are outside of areas identified as being at risk of fluvial flooding. Therefore, it is considered unlikely that flooding from the rivers, was a concern during the flooding.

6.5. ENVIRONMENT AGENCY FLOOD MAP FOR SURFACE WATER

6.5.1. Surface water flooding, or pluvial flooding, occurs when the carrying capacity of the drainage network is unable to cope with the amount of rainfall being generated within an area. Pluvial flooding is normally associated with high intensity summer storm events.

6.5.2. Appendix B, presents the Environment Agency's flood map for surface water, the mapping indicates that within the areas identified as having experienced flooding, surface water flow routes are predicted, and therefore surface water flooding would be expected, during a significant rainfall event.

7. RECORDED FLOOD INCIDENTS

7.1. OVERVIEW

7.1.1. This section provides a summary of the observations from the Site Inspection undertaken; the weather was generally dry with good visibility. The inspections were undertaken from the public highway, using public footpaths.

7.1.2. Following the flood event, the following areas where visited and indicators of flooding where observed at:

- Coffee Hall
- Oldbrook
- Netherfield
- Milton Keynes Hospital
- Winterhill

7.1.3. Note individual properties are not listed as part of this document, and reasonable attempts have been made to remove addresses / number plates from the photographs provided.

7.2. COFFEE HALL

7.2.1. Within Coffee Hall, indicators of surface water flooding was noted within the following roads:

- Daniels Welch
- Elfords
- Garraways
- Jonathans
- St Dunstans
- Hamlins
- Rochfords

7.2.2. The flooding mainly occurred within the southern half of Coffee Hall, with flood depths likely to have increased as the surface water flowed from west to east.

7.2.3. Figure 1 provides a representative photograph of the street layout for this area, it is generally formed of blocks of terraced housing set back from the carriageway, with front gardens, and off-street parking. The area has some amenity tree planting, but the general street scene is mainly hard-paved. Highway drainage gullies tended to be located on the low side at the back of the parking area, the whole road cross-falls to one side.

Figure 1 – Typical Road Layout

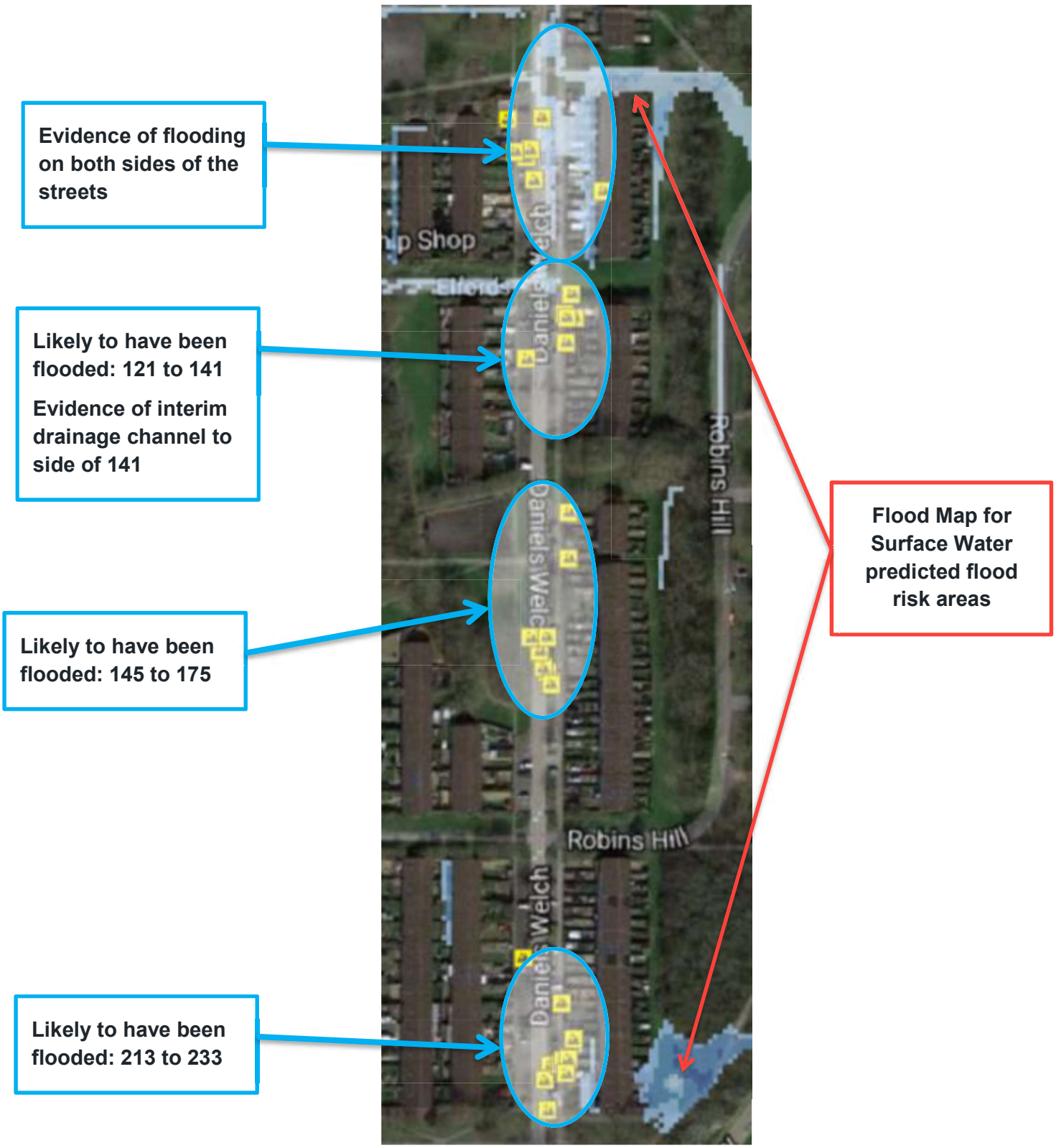
7.2.4. The Site Investigation focused on Daniels Welch, of which there was significant evidence of flooding affecting a number of properties on the left hand side (evidence of carpets having been removed, and placed to dry / be disposed of in the front gardens.

7.2.5. The rack marks indicated that water is likely to have exceeded the door thresholds by around 100 mm to 200 mm, significant variation was observed, with some properties with evidence of water up to the letter box, mid door level. The flood water is likely to have exceeded the level of the damp-proof course, and many of the properties have front facing air bricks. Therefore water ingress into the properties is likely to have occurred. Figure 2 and 3 provide a sample of the types of indicators observed during the site walkover. Figure 4, presents the locations where photographs were taken, and clusters of photographs indicate areas where the greatest number of flooding indicators where observed.

Figure 2 – Indicator of Water Damage Daniels Welch

Figure 3 – Indicator of Water Ingress to Properties

Figure 4 – Observed Flooding Indicator groupings



7.2.6. Along Daniels Welch the flooding has occurred within the low ground at the front of residential properties on the low side of the road.

7.3. OLDBROOK

7.3.1. Flooding within Oldbrook, generally follows the route of a historic watercourse, which is now understood to be integrated within the Public Sewer system maintained and operated by Anglian Water. During the Site Inspections indicators of flooding were observed along the following roads:

- The Boundary
- Oldbrook Boulevard
- Larwood Place
- Verity Place
- Hutton Avenue
- Shackleton Place
- Grace Avenue (pipe burst on Anglian Water Sewer)

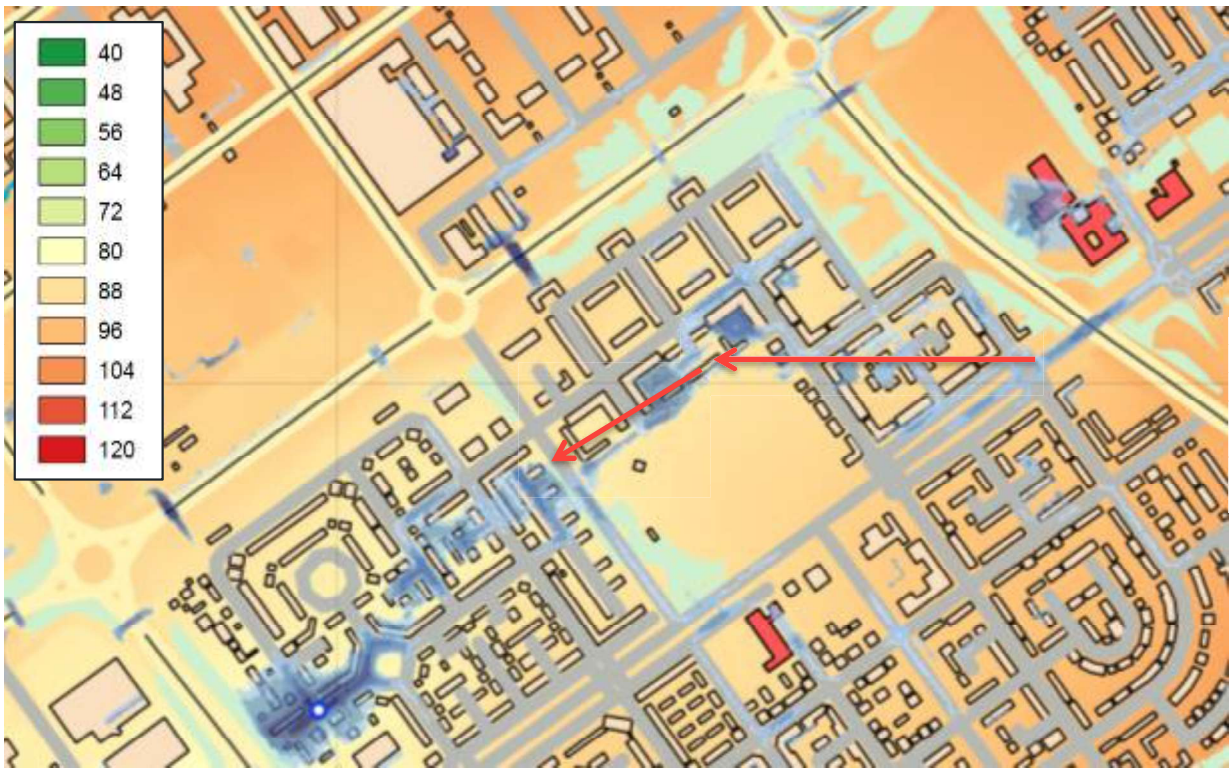
7.3.2. Two main areas of Oldbrook were inspected, the reported property flooding to the east of the area, and the burst sewer at the junction of Kirkstall Place and Grace Avenue.

OLDBROOK EAST

7.3.3. Flooding was inspected around the eastern part of Oldbrook, with evidence of flooding on Larwood Place, Hutton Avenue, Verity Place, and Shackleton Place. Flooding appeared to be related to a flow path from the V7 Saxon Street Overpass, along Larwood Place, down Hutton Avenue, with flooding accumulation of flooding at the roundabout of Hatton Avenue and Shackleton Place, as shown in Figure 7.

7.3.4. Figure 7 shows that the flooding indicators are along the areas predicted to be at risk of flooding, as indicated on the Flood Map for Surface Water. Furthermore, the Flood Map for Surface Water identifies a significant flood extent in the area of the burst pipe. Inspection of DigDat utility information

Figure 5 – Oldbrook flood flow route, flood map for surface water and LiDAR



Environment Agency 1% AEP year surface water flooding

7.3.5. Milton Keynes Council shared video of surface water discharging over the steps adjacent to the V7 Saxon Street, and during the Site Inspection there was evidence of siltation on the footway adjacent to the embankment of the bridge, as shown in Figure 8.

7.3.6. Figures 9 to 11 provide photographs of the indicators of flooding in the area.

Figure 6 – Evidence of Siltation near to Highway Embankment

Figure 7 – Indicators of Flooding Larwood Place

Figure 8 – Oldbrook Indicators of Flooding

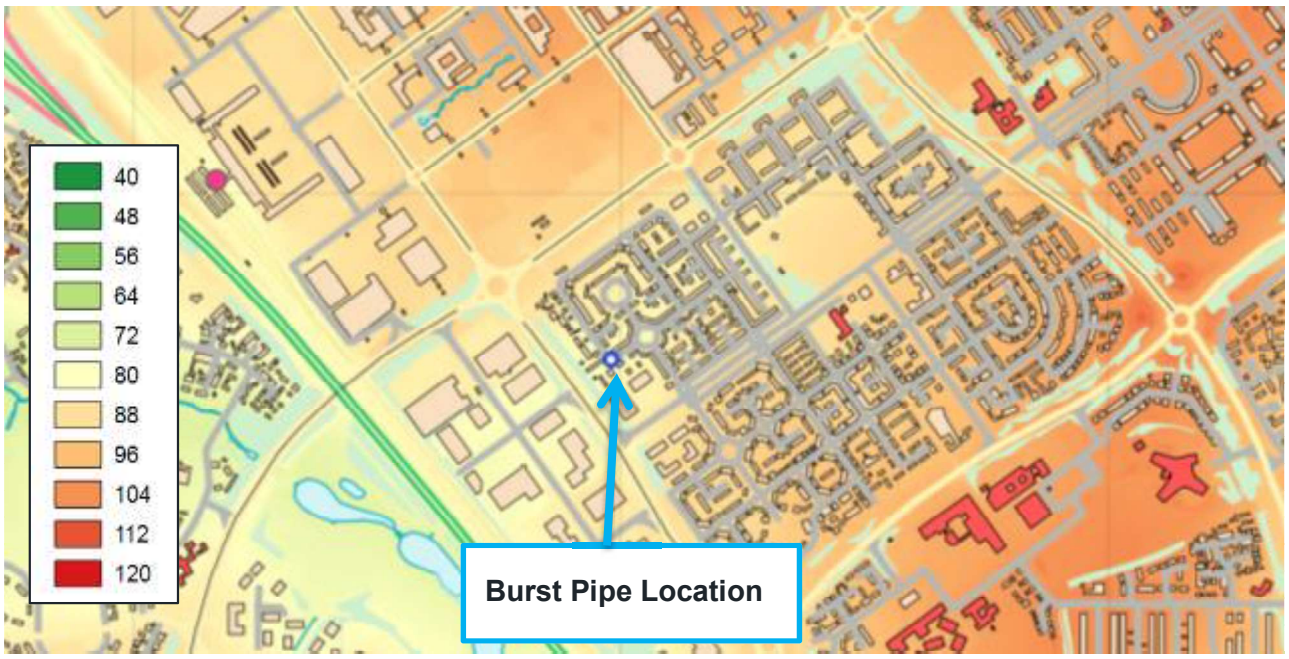
Figure 9 – Indicators of Flooding Shackleton Place

BURST PIPE

7.3.7. Figure 5 below shows the damage caused by a surface water sewer burst pipe. From inspection, of the local topography the chamber that failed is likely to be at the confluence of a number of drainage pipes from higher ground. Figure 6 shows the local ground terrain from LiDAR data.

Figure 10 – Damage caused by surface water burst pipe

Figure 11 –Burst Pipe Location and Local Topography

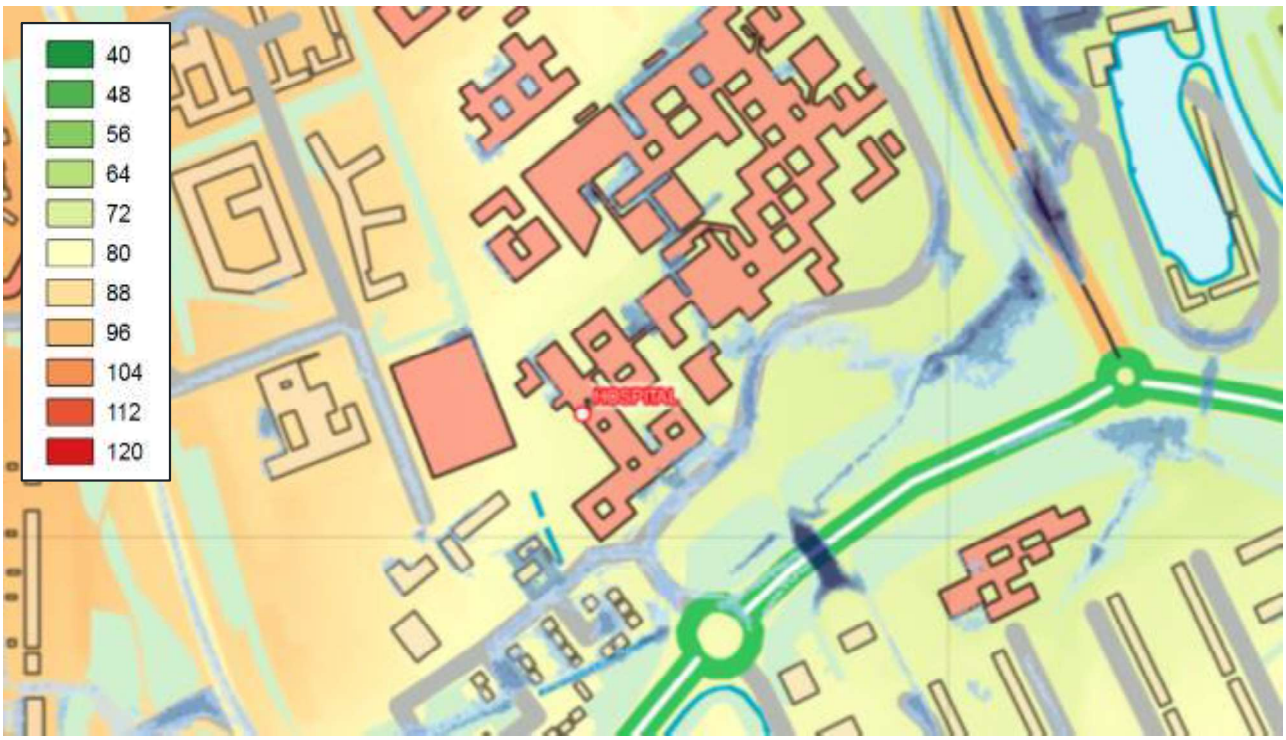


7.4. HOSPITAL

7.4.1. Milton Keynes Hospital was flooded during the event, and from discussions with the Estates Team, flooding of the Hospital has occurred a number of times previously.

7.4.2. Indicators of flooding were noted along the access road from Flemming Drive, around the Hospital. Figure 12 presents the LiDAR data, and Flood Map for Surface Water outline.

Figure 12 – Hospital flood flow route, flood map for surface water and LiDAR



7.4.3. The indicators of flooding generally follow the predicted extents from the Flood Map for Surface Water.

7.5. NETHERFIELD

7.5.1. During the Site Inspection of Netherfield, there were fewer indicators of flooding observed. The properties with indicators of flooding were those with garages and door thresholds below the carriageway and low kerbs. Flooding was observed along the southern portions of the following roads:

- Broadlands
- Farthing Grove
- The Hide
- Farnborough
- Beadlemead
- Langland Road

7.5.2. It is noted that a flow route exists between Netherfield and the Hospital, and therefore the Netherfield catchment is likely to be of significance when considering potential mitigation measures for the Hospital.

7.5.3. Only a preliminary inspection of Netherfield was undertaken, however a number of indicators of flooding were observed. The properties with indicators of flooding were the properties were those with garages and door thresholds below the carriageway and low kerbs.

7.5.4. The Flood Map for Surface Water is provided in Figure 13.

Figure 13 – Netherfield, flood map for surface water and LiDAR

7.6. WINTERHILL

7.6.1. During the Site inspection of Winterhill, there were indicators of flooding observed. These were mainly associated rack marks on the shop fronts, and with pipe bursts of the surface water drainage network, which resulted in damage to the car parking areas.

7.6.2. Flooding was observed:

- Cairngorm Gate retail units (pipe burst on Anglian Water Sewer)

7.6.3. Within the retail park evidence of flooding up to 300 mm deep within the retail units was observed, a number of the stores were in the process of cleaning up the damage, which was across the ground floor areas of the retail units. From the inspection it was noted that flood waters would be impounded by the railway embankment.

Figure 14 – Pipe Burst Cairngorm Gate

7.7. GENERAL OBSERVATIONS

7.7.1. During the Site Inspections a number of road gully covers were observed to be covered by leaves and other detritus, which may have reduced to capacity of the gullies. It is not obvious if the road gully inlets were blocked, before, during, or after the flood event. However, it is reasonable to assume that some of the road gully covers may have been blocked or partially blocked.

Figure 15 – Road Gully covered in leaf litter and detritus, and uncovered (Cairngorm Gate)

7.7.2. The properties that have been affected are generally those located in local topographic depressions, and therefore these may benefit from Property Level Protection (PLP), which can in certain circumstances ameliorate the impacts of flooding. Appendix D provides an outline of PLP.

8. RAINFALL ANALYSIS

8.1.1. The Met Office publishes long term average monthly rain records, split into regions of the UK. Appendix C, provides a summary of this information with the long term monthly average, which indicates that for the Midlands the average monthly rainfall for March, April, and May, are 55, 53, and 59 mm respectively. The values for 2018 were 106, 82, and 57 mm. Therefore in the two months leading up to the flood event in May weather conditions had been wetter than average.

8.1.2. Initial discussions with Milton Keynes Council identified that they had contacted Anglian Water, who reported that their rain gauge had recorded over 90 mm rainfall during the event, within a 1 to 2 hour duration

8.1.3. From discussions with residents of the area, many indicated that the worst rainfall occurred within a 1 to 2 hour period, with different regions experiencing the rainfall at different times. From the information gathered, the course of the storm was generally in a north-westerly direction, tracking over the central urban areas of Milton Keynes.

8.1.4. Rain gauge data has been obtained from the Environment Agency's[3] archive, for the purpose of this Preliminary Report a single nearby rain gauge has been examined (1770 – Woburn Sands), which is in the south east corner of Milton Keynes, as show Appendix A.

8.1.5. Appendix B shows a summary of the rainfall recorded at this gauge, which indicates a number of smaller storms occurred throughout the 27 May 2018, with a larger storm occurring later in the day. The cumulative rainfall for the day was recorded as being 32.4 mm, with no rainfall recorded on the following day. However, the larger single storm consisted of a total of 27.2 mm. It should be noted that the Woburn Sands gauge, is outside of the corridor of the main areas affected, and as such it may not have received the full rainfall depth that occurred in the event.

8.1.6. Using the FEH rainfall parameters (Table 3), centred on Milton Keynes Hospital, obtained from the HR Wallingford Web Service, a Depth-Duration-Frequency Curve has been established, and is presented in Appendix B.

Table 2 – FEH 2013 Rainfall Parameters

Parameters	Values	
Version	"FEH Web Service" (2.0.0.0)	
Exported At	17:21:61	30-05-2018
Rainfall model	FEH 2013	
Calculation type	Design rainfall	
Calculation mode	For a point	
Calculation location	486849	237268
Duration	1	Hours
Fixed duration	no	

[3] http://environment.data.gov.uk/flood-monitoring/archive

8.1.7. Figure 9 indicates that a 90 mm rainfall event, in 24 hours would equate to a return period beyond 0.05% AEP, however, based on consideration of a single storm of 27.2 mm of 30 minute duration, this would equate to a return period of between 5.0% AEP and 3.3% AEP. This analysis has been conducted on a single rain gauge, over a single day. Further rainfall data has been provided by Meniscus[4], who have provided the data outlined in Table 3.

Table 3 – Data Provided by Meniscus

Location on 27th May 2018	Easting and Northing	Rainfall depth	FEH99 Return Period
52°02'02.8"N 0°45'13.2"W – Oldbrook (Verity Place)	485594,238033	67 mm. Duration 1 hours	Return Period 1 in 309 years
52°01'23.3"N 0°44'37.2"W – Coffee Hall (Daniels Welch)	486301,236824	Rain depth 91 mm. Duration 1. 75 hours.	Return Period 1 in 602 years
52°01'15.9"N 0°43'46.5"W – Netherfield (Beadlemead)	487271,236612	Rain depth 84 mm. Duration 1.75 hours.	Return Period 1 in 460 years
52°00'59.6"N 0°44'22.2"W – Beanhill (Neapland)	486599,236097	Rain depth 91 mm. Duration 1.75 hours.	Return Period 1 in 602 years
52°02'35.0"N 0°45'39.4"W – CMK (Civic Offices)	485077,239019	Rain depth 62 mm. Duration 1 hours.	Return Period 1 in 237 years
52°07'59.3"N 0°46'50.1"W – Stoke Goldington (Orchard Way)	483562,249016	Rain depth 97 mm. Duration 1.5 hours.	Return Period 1 in 819 years

8.1.8. Based on the available data, witness evidence, and the indicators of flooding noted, it is considered very likely that the rainfall event experienced was significantly in excess of the 1.0% Annual Probability Event, with some areas affected by rainfall in excess of the 0.5% Annual Probability Event.

[4] http://www.meniscus.co.uk/

9. CONSULTATION WITH RISK MANAGEMENT AGENCY'S

9.1. MILTON KEYNES COUNCIL - HIGHWAYS

9.1.1. An interview was conducted with Milton Keynes Council Highway Team on 17 July 2018, to understand how the Highway Drainage infrastructure performed and to identify any areas of concern.

9.1.2. Under the FWMA, the Highway Authority has the following responsibilities:

- Highways authorities (Highways England and unitary/county councils) have the lead responsibility for providing and managing highway drainage and roadside ditches under the Highways Act 1980. The owners of land adjoining a highway also have a common-law duty to maintain ditches to prevent them causing a nuisance to road users.

9.1.3. The Highways Team have provided significant records of their maintenance actions, including in the areas most affected by the flood events. The team undertakes the maintenance using an asset lead approach, with hotspot areas receiving additional attention.

9.1.4. The Highways Team have stated that since the event they have identified localised areas of concern, and in particular Wolverton Road. They have also identified that they have concerns regarding the effectiveness of perimeter filter drains around open space areas, which were installed during the development of the Milton Keynes.

9.1.5. The Highways Team have identified that in some areas the carrier pipes for the main sewer network change ownership along the network, leading to different levels of maintenance and inspection.

9.1.6. Due to the magnitude of the storm event the Highways Team have indicated that the Highway Drainage system performed well.

9.2. ANGLIAN WATER

9.2.1. A tele-conference was held with Anglian Water on 18 July 2018, the purpose of the interview was to understand how the Public Sewer Surface Water Drainage infrastructure performed and to identify any areas of concern.

9.2.2. Under the FWMA the Sewer Authority has the following responsibilities:

- make sure their systems have the appropriate level of resilience to flooding, and maintain essential services during emergencies
- maintain and manage their water supply and sewerage systems to manage the impact and reduce the risk of flooding and pollution to the environment. They have a duty under Section 94 Water Industry Act 1991 to ensure that the area they serve is "effectually drained". This includes drainage of surface water from the land around buildings as well as provision of foul sewers.
- provide advice to LLFAs on how water and sewerage company assets impact on local flood risk
- work with developers, landowners and LLFAs to understand and manage risks – for example, by working to manage the amount of rainfall that enters sewerage systems
- work with the Environment Agency, LLFAs and district councils to coordinate the management of water supply and sewerage systems with other flood risk management work.

9.2.3. Where there is frequent and severe sewer flooding, sewerage undertakers are required to address this through their capital investment plans, which are approved and regulated by Ofwat. This

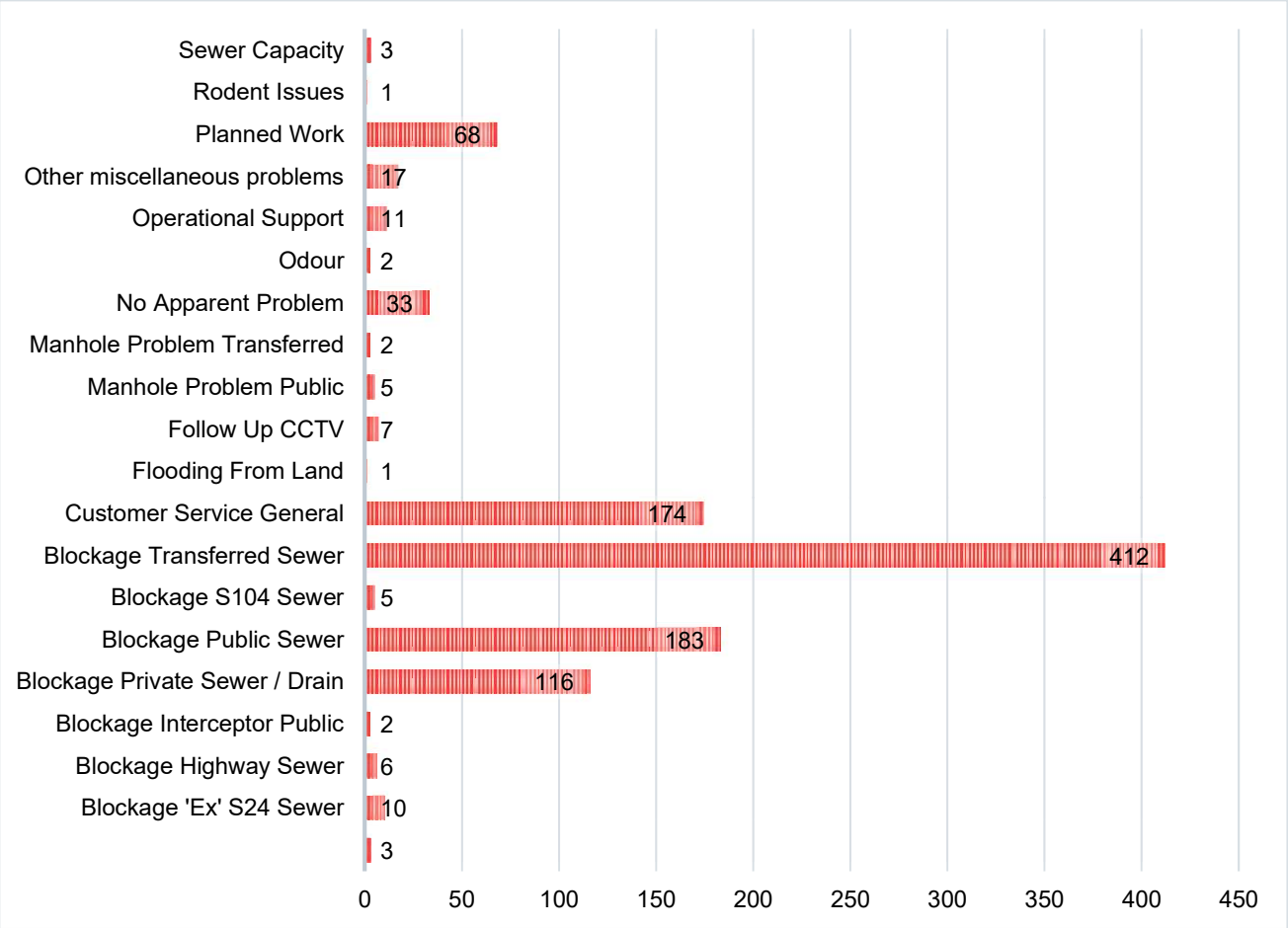
happens every five years through the Price Review process. Water companies have outcome delivery incentives (ODIs) that they agree with customers and partners. All water and sewerage companies have sewer flooding ODIs.

9.2.4. Anglian obtained rainfall data from the Minisucs service and this has been provided to Milton Keynes LLFA, and is discussed in Section 8, of this report.

9.2.5. Anglian Water outlined that undertake maintenance works based on information received which identifies issues with their network, and this is informed by a risk based approach, and technical judgement. They also identified that the planned works are completed as soon as practicable, and are usually started within a few months of the anticipated start date.

9.2.6. Figure 15 provides a graph grouping the drainage related incidents that Anglian Water has attended between 2016 and 2018. The graph indicates that the majority of issues are associated with the sewer network that was transferred to Anglian Water under the Private Sewer Transfer Regulations 2011. These sewers were previously maintained under the responsibility of third parties.

Figure 16 – Anglian Water Incident Attendance (2016 to 2018)



ANGLIAN WATER POST EVENT ACTIONS

9.2.7. Within the area of Beanhill, Anglian Water confirmed that the surface water system has suffered from root ingress, and planned maintenance is in progress. However due to the significant volume

of rainfall that occurred, they consider that if the maintenance had taken place before the storm event, it would have had a negligible impact on the extent of flooding.

9.2.8. Anglian Water are also undertaking a review of the network capacity around Newport Pagnell.

9.2.9. Anglian Water have been made aware that the levels in the lakes rose very quickly, indicating that the wider surface water drainage network that discharges into it, was conveying water rapidly to the lakes.

9.2.10. Although the rainfall that occurred was very significant and locally overwhelmed the strategic drainage infrastructure, Anglian Water consider that the surface water system performed well during the event.

10. RECOMMENDATIONS

10.1. MAIN FINDINGS

10.1.1. This FWMA Section 19 report has considered the evidence presented, and based on this evidence, the flood event can be summarised as follows:

- The flooding that occurred was due to a very intense summer storm, with indications that this was in excess of a 1% Annual Exceedance Probability Event, with a rainfall depth of up to 90 mm.
- The Environment Agency's Flood Map for Surface Water, provides a reasonable representation of the flooding that occurred, and aligned well with the indicators of flooding, supporting the theory that the flooding was the result of a significant rainfall event.
- Significant evidence of flooding was observed in the reported areas, including additional properties which at the time of the site inspection, had not notified Milton Keynes Council that they had flooded.
- Reported internal property flooding affected at least 315 houses, the Hospital and a number of business premises.
- Property flooding has tended to occur where the property door thresholds are perpendicular to the local flow routes i.e. the property acts as a barrier to flow, causing the water level to rise sufficiently to exceed the door threshold of the property causing internal flooding. Some evidence of water rising-up through the floor has also been noted.
- Property flooding has also occurred where the driveway between the property and the highway falls towards the property, this is especially true where there is limited, or no kerb height.
- Debris was observed on gully inlets, indicating that the storm event is likely to have mobilised a significant volume of leaf litter and other detritus. It is unclear if this occurred, before, during or after the event. This may have restricted the functioning capacity of the gullies. On clearing the gully grates, the internal gully was observed to be clear.
- Evidence of sewer surcharging, causing damage to the overlying pavement has been observed, indicating that significant volumes of water were present within the sewer system.

10.1.2. It is concluded that the flooding experienced in Milton Keynes was the result of heavy rainfall, overwhelming the capacity of the drainage network, resulting in surface water flows gravitating towards low points in the local topography causing internal flooding to over 315 residential properties.

10.2. RECOMMENDATIONS

10.2.1. This preliminary report has been based on information available at the time of writing, and further information needs to be obtained before any conclusions can be reached. As such the following next steps are recommended:

- A joint Drainage Service Review should be undertaken, involving Milton Keynes Highway and LLFA functions, Anglian Water, and other stakeholders with drainage assets. This review should seek to rationalise responsibility and maintenance functions.
- Review of street-cleaning / grass cutting operations to reduce the amount of material that could cause blockages to the drainage system.

- Promote the use of Sustainable Drainage Systems, for use on new developments. Milton Keynes to consider replacing off-street car parking areas with attenuating permeable paving, for use on new and existing developments.

GLOSSARY

Term	Definition
Annual Exceedance Probability	The probability associated with a return period. For example an event of a 100 year return period has an AEP of 1/100 or 1%
Critical Ordinary Watercourse	Is a watercourse that is not classified as "main river" but which the Environment Agency and other operating authorities agree is critical because it has the potential to put at risk from flooding large numbers of people and properties
Flood Defences	Artificial structures maintained to a set operational level designed to protect land people and property from Tidal and Fluvial flood sources to an established AEP threshold.
Flood Defence Level	The level required to be achieved by flood defences, usually the design flood level with a freeboard allowance, to account for wave action and modelling uncertainty.
Floodplain	An area of land adjacent to a river or tidal water body that is predicted to become affected by water as the result of a defined flood event.
Flood Source – Fluvial	When flows within watercourses exceed the capacity of the watercourse causing out of bank flows.
Flood Source – Groundwater	When groundwater levels rise above the surface of the ground or sufficiently high to ingress into basements and other below ground structures. Tends to occur at the bottom of a valley in large chalk catchments.
Flood Source – Pluvial	Overland run-off caused when natural and artificial drainage systems do not have sufficient capacity to deal with the volume of rainfall.
Flood Source – Tidal	When sea levels rise above the level of the land or beyond the operational level of flood defences.
Flood Zone	An area defined by the Environment Agency and/or SFRA as being at risk from a specified flood event. The Flood Zone definitions ignore the benefits of flood defence structures.
Flood Zone Map	A map produce by the Environment Agency, or SFRA which designates the flood zones. Site specific FRA usually refine the detail of these maps to provide a more accurate prediction at the Site level.
Flood Zone 1	Low Probability. Land defined as having a less than 0.1% AEP of flooding from tidal and fluvial sources.
Flood Zone 2	Medium Probability. Land defined as having a risk of fluvial flooding between 1% AEP and 0.1% AEP. Or Land defined as having a risk of tidal flooding between 0.5% AEP and).1% AEP.
Flood Zone 3 (A)	High Probability. Land defined as having a fluvial risk of 1% AEP or greater. Or a tidal risk of 0.5% AEP or greater.
Flood Zone 3 (B)	Functional Floodplain. Defined by SFRA's as areas where floodwater is stored during lower AEP events, typically the 5% AEP.
Fluvial Flooding	Flooding caused by a river overtopping its banks, as a result of flows exceeding the rivers capacity.
Freeboard	The difference between the Flood Defence level and the Design Flood level, usually 300mm for fluvial sources and 600mm for tidal sources. But local variations do occur.
LiDAR	*Light Detection And Ranging.* Is an accurate ground terrain model obtained by aerial survey. The typical vertical accuracy is +/- 150 mm, the horizontal spacing of survey points (resolution) is normally 0.5m in city centres, 1m in urban areas and 2m in rural areas.
Main River	Defined on the Main River map and relate to river's on which the Environment Agency have powers to carry out flood defence works on
OS	Ordnance Survey.
Ordinary Watercourse	A watercourse which does not form part of a Main River
Residual Risk	The risk which remains following the use of all risk reduction, mitigation and management options. Or the risk beyond the design AEP event.
SFRA	*Strategic Flood Risk Assessment*
SuDS	*Sustainable Drainage Systems*, which are designed to manage surface water flows in order to mimic the Greenfield run-off from an undeveloped site.

Appendix A

MILTON KEYNES DRAFT S19 POLICY

Draft Flood Investigation Policy

Milton Keynes Council as the Lead Local Flood Authority has a statutory duty to investigate flooding incidents in its area, to the extent that it considers necessary or appropriate. This requirement is set out in Section 19 of the Act.

On becoming aware of a flooding incident, the LLFA must decide whether it is necessary or appropriate to investigate further in order to:

a) Identify which risk management authorities or individuals have flood risk management functions in respect of the flooding (it could be for example the Environment Agency if it comes from main rivers or the sea); and

b) Establish whether that authority or individual has responded or is proposing to respond to the flood.

It is **not** the responsibility of the Investigating Officer to resolve the flooding, however they will investigate the cause and notify any relevant authority. In Milton Keynes, these authorities could include: Milton Keynes Council (including the Highways Department), Anglian Water, the Environment Agency, the Internal Drainage Board and the Parks Trust or landowners.

Upon learning of a flood event within Milton Keynes, the Investigating Officer will follow the established 'Flood Investigations Protocol' whereby it will be determined whether an investigation should be carried out, taking into account the available resources and significance of the event. It is therefore essential to determine what is 'necessary or appropriate' in the context of Milton Keynes.

A formal flood investigation will generally be carried out if one or more of the following occurs:

- Flooding has affected critical infrastructure[1] for a period in excess of three hours from the onset of flooding;
- Internal flooding[2] of a building has been experienced on more than one occasion in the last five years;

The investigation will follow the following process:

- **Step 1.** Flood incident reported to: llfa@milton-keynes.gov.uk

[1] **Definition of critical infrastructure:** Those infrastructure assets (physical or electronic) that are vital to the continued delivery and integrity of essential national services, the loss or compromise of which would lead to severe economic or social consequences, or to loss of life.

[2] **Definition of internal flooding**: A situation in which a building (commercial or residential) has been flooded internally, i.e. water has crossed the threshold and entered the building. This includes;

- Basements and ground level floors of the building;
- Garages/outbuildings if they are integral to the main occupied building. Garages adjacent or separate from the main occupied building are not included;
- Occupied static caravans and park homes. Tents are not included.

- **Step 2.** Review the information provided to determine if the incident meets the threshold for formal investigation. If the incident does not meet the threshold then advice and guidance is provided.
- **Step 3.** If the incident does meet the threshold, then a site meeting is arranged with the affected community and a data collection process undertaken. This will include any photos, video footage and eyewitness statements.
- **Step 4.** A draft Flood Investigation Report (FIR) is written and shared with all relevant Flood Risk Management Authorities (RMAs) for comment and review.
- **Step 5**. Any necessary revisions are made to the FIR and published online.
- **Step 6.** All RMAs and the affected community are notified of the publication.

It is important to note that this is a technical assessment and that it is for the relevant responsible body or persons to assess any recommendations in terms of their legal obligation, resource implications, priority and cost/benefit analysis of undertaking such actions.

Following significant widespread flooding in Milton Keynes, where a number of incidents meet the thresholds for investigation, the investigations will be undertaken on a priority basis. This methodology includes an assessment of; the type or flooding, the impact, what was affected, duration of flooding, whether or not major roads were impassable, whether the flood water was contaminated, the depth of the flood water and the number of times the flooding has occurred.

The Flood Investigation Reports describe the flood incident and aim to determine any contributing factors. The reports explain the roles and responsibilities of those involved, and provide recommendations for future actions.

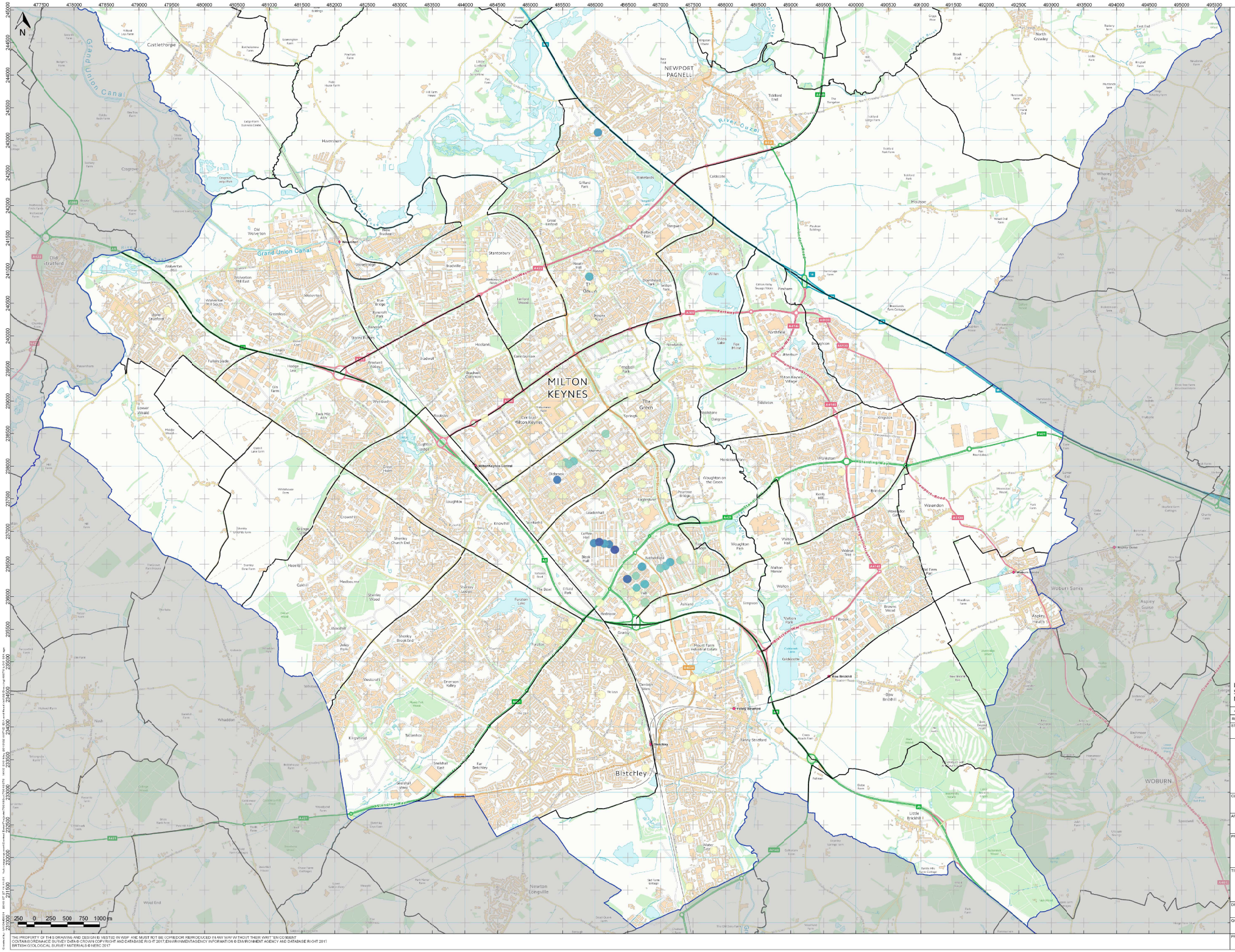
It is for the relevant responsible body or persons to assess each recommendation in terms of the legal obligation, resource implications, priority and cost/benefit analysis of undertaking such action.

The Council will endeavour to undertake and complete a flood investigation report within six months of receipt of a flood incident report form; however this may not be possible following extensive flooding when significant numbers of reports of flooding are received.

Note: The LLFA will not investigate incidents of structural dampness or where basements are affected by groundwater entering through cracks in the basement walls or floors. In the event that the cause of, and the responsibility for addressing the flooding is well understood, no formal investigation will be undertaken. The LLFA will only undertake a flood investigation if the incident is formally reported within 6 months of the flood event occurring.

Appendix B

MAPS



LOCATION OF 20 INCIDENTS ARE NOT SHOWN DUE TO AMBIGUITY OF THEIR NAMED LOCATION

REV	DATE	DRW	DESCRIPTION	CHK	APP
A	27/07/18	OB	FIRST ISSUE	-	SS

STATUS: FOR INFORMATION ONLY

wsp
Mountbatten House, Basing View,
Basingstoke, HANTS, RG21 4HJ
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www.wsp.com

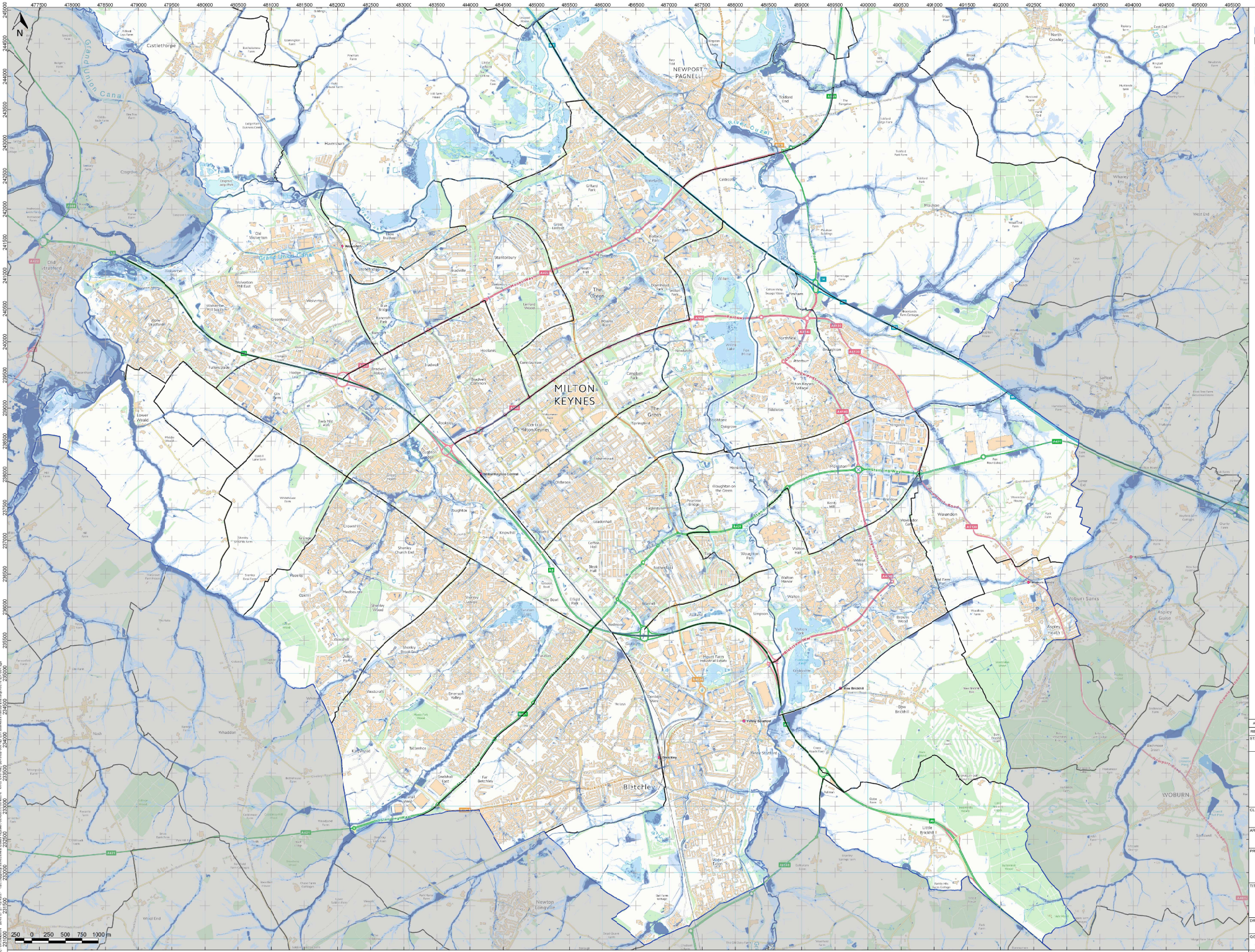
CLIENT: MILTON KEYNES COUNCIL

ARCHITECT: -

PROJECT: MKC S19 MAY 2018

TITLE: LOCATION MAP

DRAWN:	CHECKED:	APPROVED:
QGIS FILE: 48075-LOC-001.qgs	SCALE @A1: 1:25,000	DATE: 27/07/18
PROJECT No: 70048076	DRAWING No: 48075-LOC-001	REV: A



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CLIENT: MILTON KEYNES COUNCIL

ARCHITECT: -

PROJECT: MKC S19 MAY 2018

TITLE: ENVIRONMENT AGENCY RISK OF FLOODING FROM SURFACE WATER

DRAWN:	CHECKED:	APPROVED:

QGIS FILE:	SCALE @A1:	DATE:
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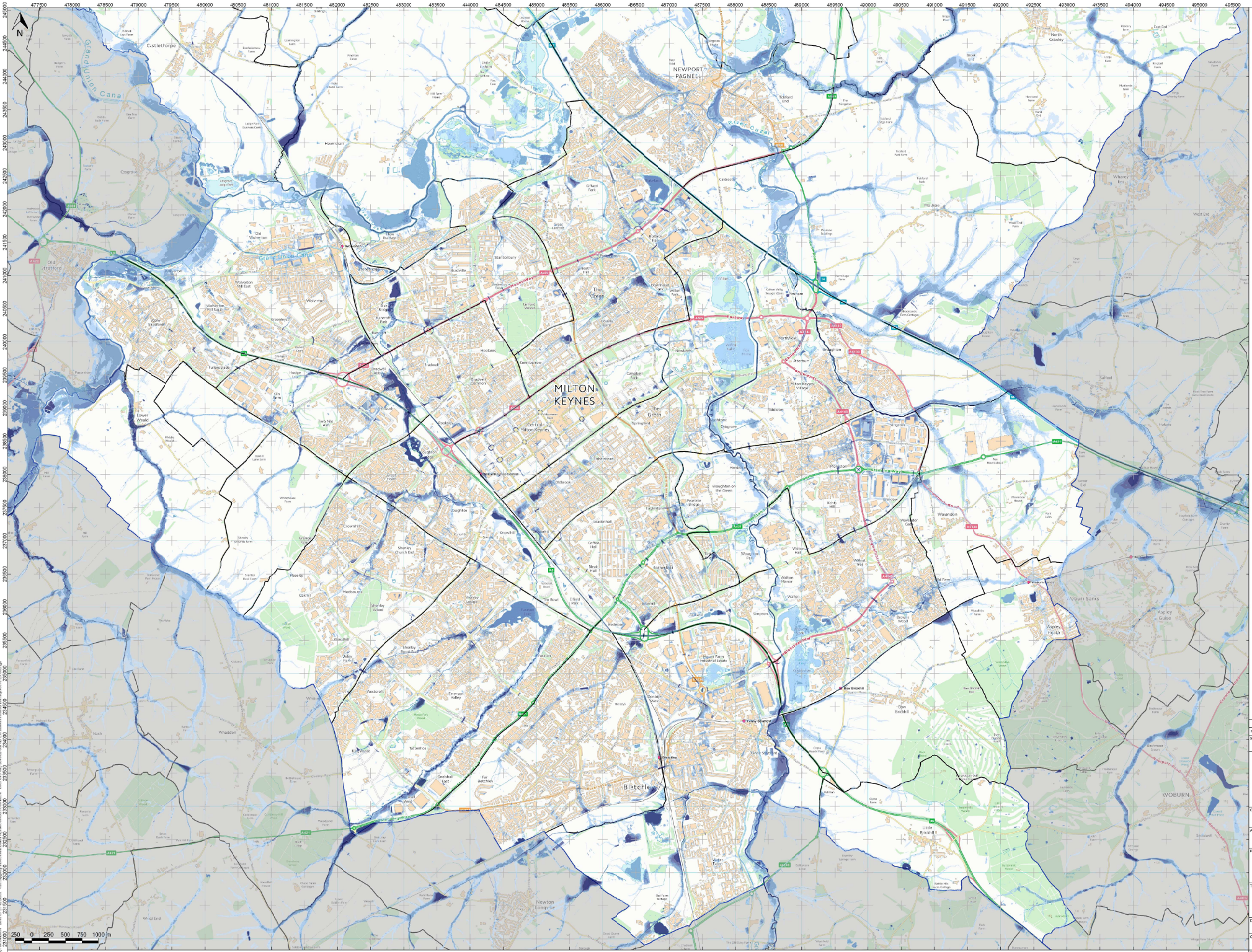

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CLIENT: MILTON KEYNES COUNCIL

ARCHITECT: -

PROJECT: MKC S19 MAY 2018

TITLE: ENVIRONMENT AGENCY 0.1% AEP PLUVIAL FLOOD DEPTH

DRAWN:	CHECKED:	APPROVED:
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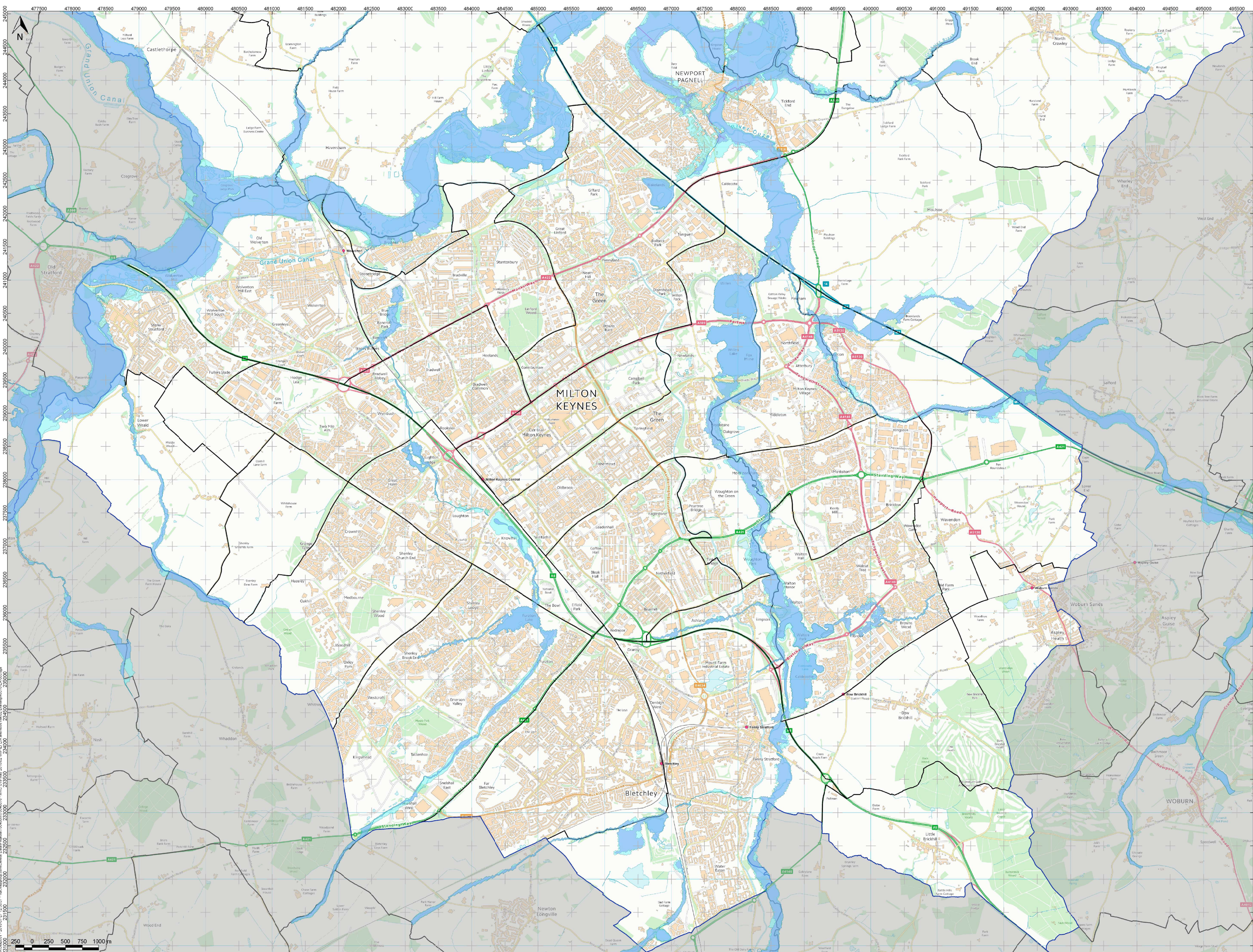

KEY:

- District Borough Unitary Region
- Parish Region

Flood Map For Planning

- Flood Zone 2
- Flood Zone 3
- Spatial Flood Defences

REV	DATE	DRW	DESCRIPTION	CHK	APP
A	27/07/18	OB	FIRST ISSUE	-	SB

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CLIENT: MILTON KEYNES COUNCIL

ARCHITECT: -

PROJECT: MKC S19 MAY 2018

TITLE: ENVIRONMENT AGENCY FLOOD MAP FOR PLANNING

DRAWN:	CHECKED:	APPROVED:
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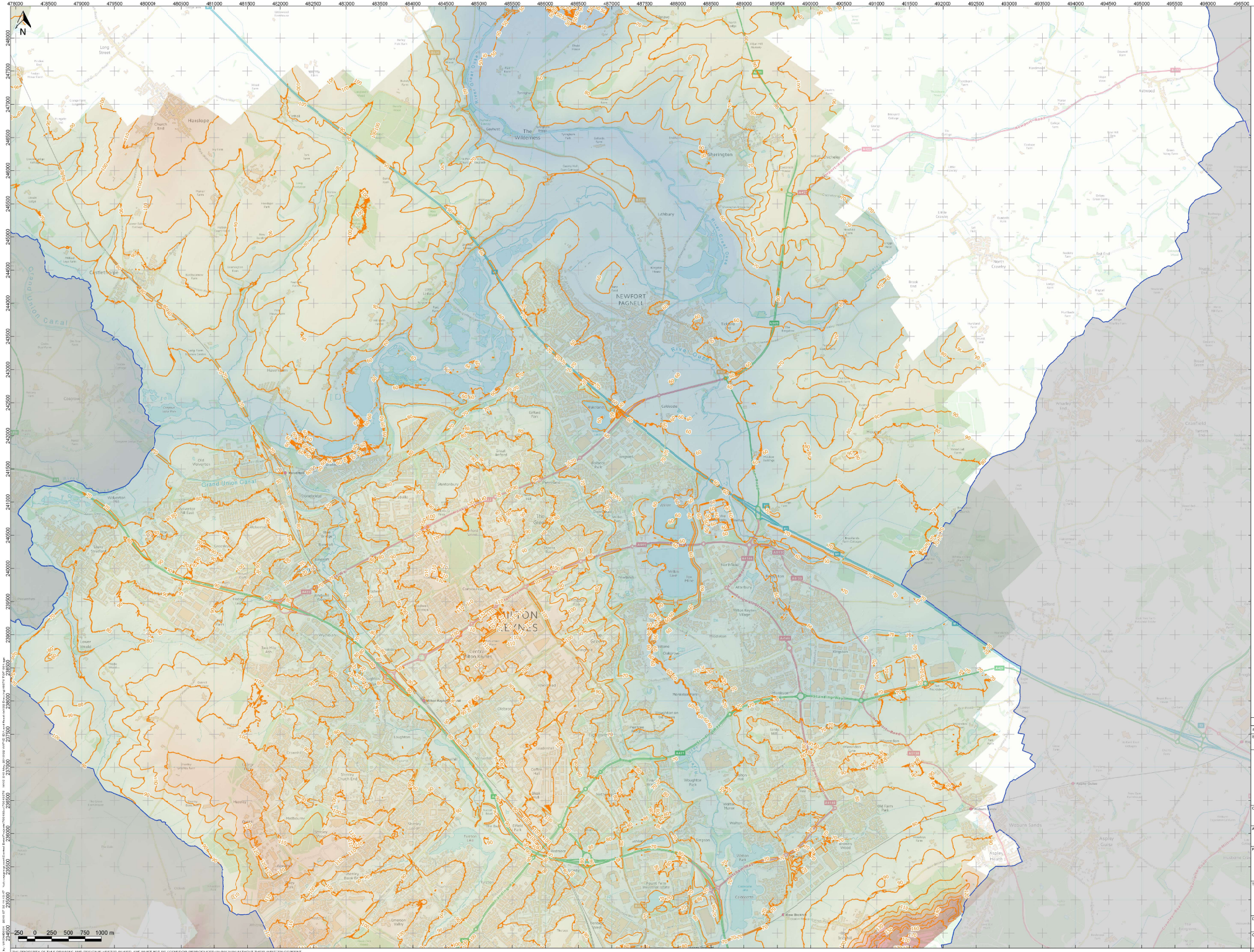
PROJECT No: 70048076	DRAWING No: 48076-EA-003	REV: A



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CLIENT: MILTON KEYNES COUNCIL

ARCHITECT: -

PROJECT: MKC S19 MAY 2018

TITLE: TOPOGRAPHICAL CONTOURS FROM LiDAR

DRAWN:	CHECKED:	APPROVED:

QGIS FILE:	SCALE @A1:	DATE:
48075-TOP-001.qgs	1:25,000	30/07/18

PROJECT No:	DRAWING No:	REV:
70048076	48075-TOP-001	A

KEY:

District Borough Unitary Regon

BGS Superficial Deposits

- Oadby Member — Diamicton
- Stoke Goldington Member — Sand And Gravel
- Head — Clay, Silt, Sand And Gravel
- Glaciofluvial Deposits — Sand And Gravel
- Till — Diamicton.
- Alluvium — Clay, Silt, Sand And Gravel

REV	DATE	DRW	DESCRIPTION	CHK	APP
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CLIENT: MILTON KEYNES COUNCIL

ARCHITECT: -

PROJECT: MKC S19 MAY 2018

TITLE: BRITISH GEOLOGICAL SURVEY SUPERFICIAL GEOLOGY

DRAWN:	CHECKED:	APPROVED:
QGIS FILE: 48076-BGS-001.qgs	SCALE @A1: 1:25,000	DATE: 31/07/18

PROJECT No:	DRAWING No:	REV:
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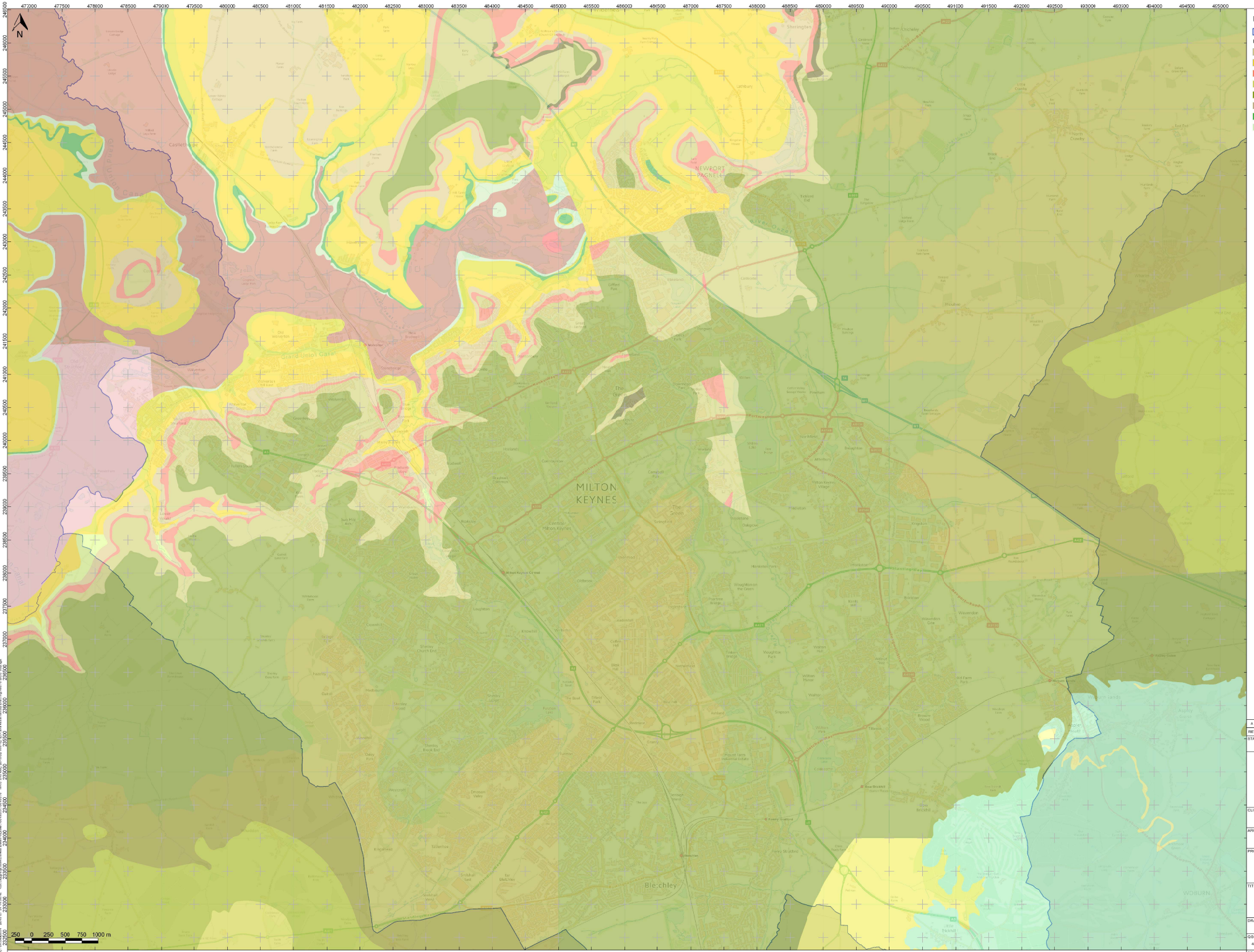

KEY:

- District Borough Unitary Region

BGS Bedrock

- Bilworth Clay Formation Mudstone
- Bilworth Limestone Formation Limestone
- Cornbrash Formation Limestone
- Kellaways Formation Sandstone, Siltstone And Mudstone
- Peterborough Member Mudstone
- Stewartby Member Mudstone
- Wellingborough Limestone Member Limestone
- Stamford Member Sandstone And Siltstone, Interbedded

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CLIENT: MILTON KEYNES COUNCIL

ARCHITECT: -

PROJECT: MKC S19 MAY 2018

TITLE: ERITISH GEOLOGICAL SURVEY BEDROCK GEOLOGY

DRAWN:	CHECKED:	APPROVED:

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PROJECT No:	DRAWING No:	REV:
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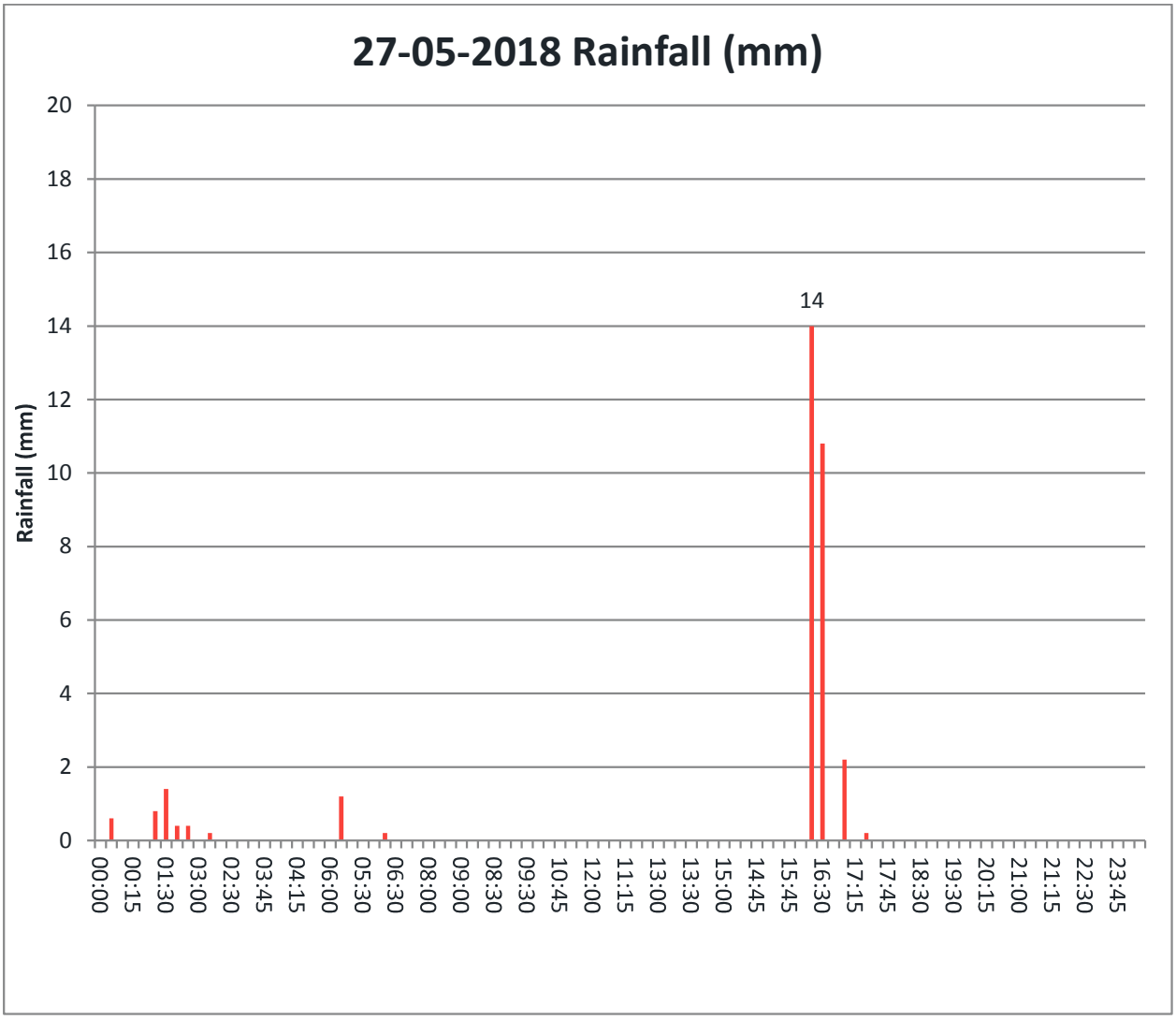
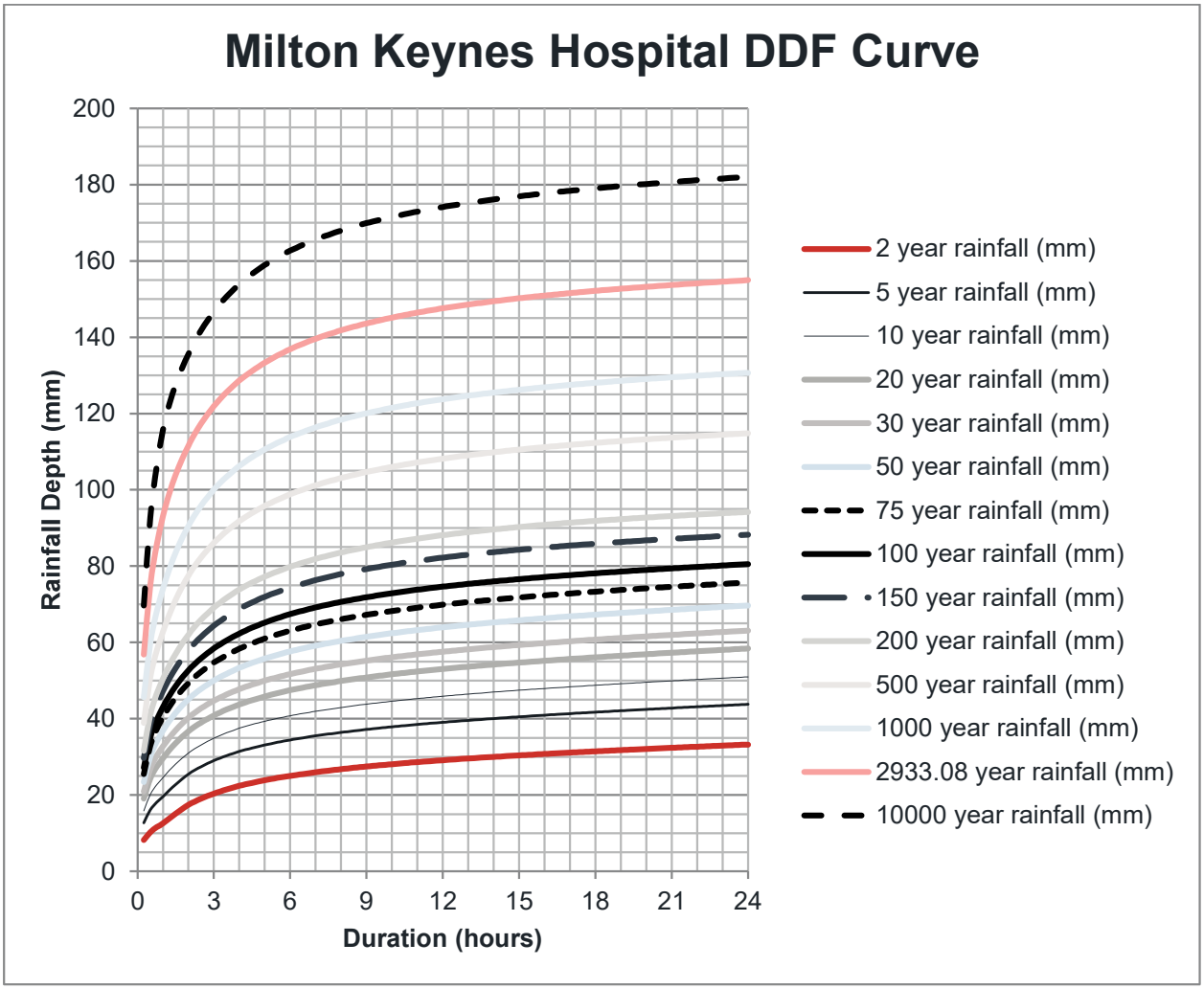
Appendix C

RAINFALL ANALYSIS

Summary of Recorded Rainfall at Environment Agency Gauge

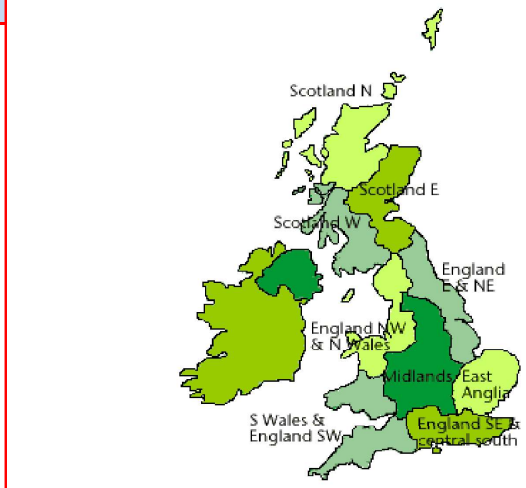


Milton Keynes Hospital DDF Curve



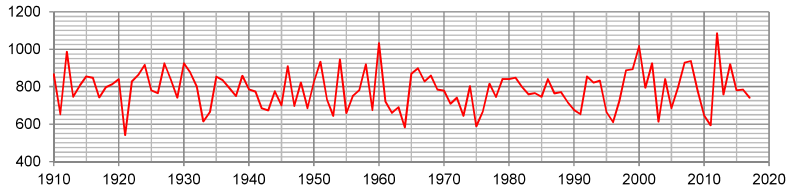
Regional Rainfall Summaries

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		WIN	SPR	SUM	AUT	ANN
1910	72	84	20	62	56	65	70	106	14	78	111	130		---	137	241	202	867
1911	28	53	46	33	35	60	10	50	50	65	82	143		210	113	121	197	653
1912	107	47	103	8	68	118	105	166	33	81	59	94		297	178	388	173	986
1913	103	29	108	91	60	29	28	36	56	94	73	38		226	259	94	222	746
1914	38	58	83	29	42	64	92	52	35	57	94	163		134	154	208	187	806
1915	92	101	29	31	60	32	136	75	29	59	64	149		356	120	242	151	855
1916	42	117	106	39	66	51	50	74	37	110	85	72		308	211	175	231	848
1917	57	26	58	44	68	62	51	148	45	105	45	34		155	170	260	196	743
1918	66	56	33	55	60	25	90	50	164	47	51	100		156	149	164	263	796
1919	102	64	120	52	29	29	71	69	49	64	50	116		265	201	170	164	814
1920	89	47	70	120	70	68	124	34	55	61	33	71		251	259	226	148	840
1921	86	8	43	32	42	11	18	94	32	52	54	69		165	117	124	138	541
1922	95	82	58	75	29	30	114	118	67	21	37	101		246	162	263	125	828
1923	50	135	46	63	61	16	88	75	74	104	69	82		286	171	179	246	863
1924	74	20	30	67	128	58	97	84	93	111	61	93		177	225	239	265	916
1925	62	99	24	57	96	2	63	70	90	93	52	73		254	176	136	235	780
1926	90	65	22	58	78	59	61	62	41	73	135	21		229	158	182	249	766
1927	72	64	71	53	34	97	83	118	122	62	84	65		157	158	298	269	926
1928	137	69	61	32	30	87	42	79	21	122	99	61		272	122	208	242	839
1929	39	18	7	28	48	38	53	57	24	103	169	156		118	83	147	297	741
1930	118	17	65	74	56	40	116	84	100	78	96	81		292	195	240	274	925
1931	57	72	8	95	88	100	96	118	76	24	109	34		210	191	313	209	875
1932	69	8	50	83	146	25	92	53	74	115	53	31		110	279	170	241	799
1933	55	92	68	29	48	54	53	21	43	99	38	13		178	145	128	181	614
1934	66	11	57	63	34	33	43	58	55	57	52	134		90	154	134	164	664
1935	31	80	20	92	26	87	19	46	120	114	133	87		245	138	151	367	854
1936	100	62	53	48	26	97	130	27	84	54	80	73		248	127	254	219	834
1937	99	115	73	70	72	34	69	28	48	74	42	70		287	215	130	164	794
1938	90	26	11	4	60	49	79	84	54	104	92	98		186	75	211	249	749
1939	143	44	48	56	32	52	128	67	27	93	120	50		284	136	246	240	859
1940	71	65	57	65	43	22	90	12	38	100	169	55		187	165	124	306	786
1941	86	78	81	40	59	35	86	103	16	75	77	39		218	180	224	168	774
1942	86	27	54	36	92	16	59	79	43	76	39	78		151	182	154	158	685
1943	126	38	26	32	76	55	37	65	71	61	53	35		241	133	156	185	673
1944	77	40	10	54	36	57	64	73	96	93	121	56		152	100	194	311	777
1945	61	65	25	38	72	75	55	67	48	106	11	78		181	135	197	164	700
1946	71	82	27	44	63	72	60	134	108	28	145	74		231	134	267	282	910
1947	61	48	148	67	57	50	67	13	42	14	63	65		184	273	131	118	696
1948	147	41	31	49	66	79	36	105	67	64	42	97		253	145	219	173	823
1949	37	33	40	64	63	16	61	45	40	127	91	68		167	166	122	257	684
1950	28	128	34	65	51	43	79	100	102	32	116	47		223	150	222	249	824
1951	74	88	103	60	85	30	39	119	60	27	170	79		209	248	188	257	933
1952	68	19	59	54	68	52	28	90	58	100	65	71		166	181	171	223	731
1953	25	46	30	66	52	62	83	78	62	59	51	31		142	148	223	171	644
1954	49	69	62	13	75	82	74	120	72	104	149	79		148	149	276	325	945
1955	65	50	63	30	106	80	21	19	40	49	59	78		194	198	120	148	659
1956	106	20	27	44	19	69	94	142	73	46	25	87		204	90	305	144	752

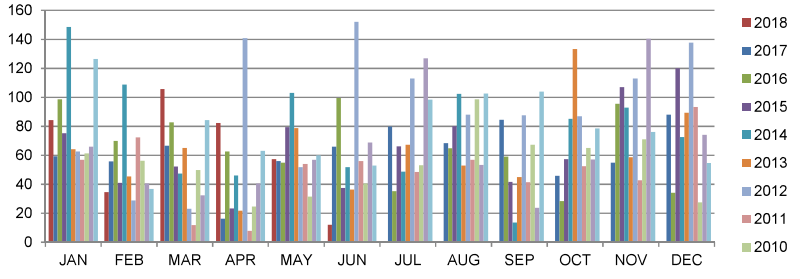
Data source	https://www.metoffice.gov.uk/climate/uk/summaries/datasets
Last Updated	06 July 2018
Regions	

Selected	Midlands											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Maximum	149	141	148	141	146	167	145	166	164	148	170	163
Average	74	56	55	53	59	57	65	72	63	74	77	78
Minimum	12	6	7	4	11	2	10	8	4	14	11	13

Annual Rainfall Summary, Midlands



Monthly Summaries, England South East & Central South, 2008 to 2018



Regional Rainfall Summaries

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		WIN	SPR	SUM	AUT	ANN
1957	52	74	58	7	38	44	99	109	123	54	55	69		212	104	252	232	781
1958	75	111	42	21	70	112	104	77	104	70	48	86		254	133	293	222	919
1959	93	6	57	80	26	37	52	29	4	67	90	134		185	162	118	161	675
1960	128	65	43	34	39	57	99	101	108	148	119	92		327	116	256	376	1033
1961	87	57	11	96	31	34	64	68	60	80	47	87		235	138	166	187	722
1962	83	31	32	66	59	13	50	108	88	26	50	56		201	157	171	164	661
1963	27	21	81	63	42	78	47	78	61	48	126	20		103	185	203	235	691
1964	23	26	87	54	48	69	50	43	24	42	39	79		68	189	161	105	582
1965	79	15	67	53	54	65	91	53	132	25	86	149		173	174	209	243	869
1966	43	111	33	95	66	73	68	97	45	105	69	94		303	195	238	218	898
1967	44	75	49	35	138	33	47	67	80	141	56	64		213	221	147	277	828
1968	70	36	48	62	78	75	110	58	126	70	69	59		170	188	243	265	860
1969	74	65	68	55	125	44	58	76	34	14	103	70		197	248	178	151	785
1970	87	72	57	80	21	44	59	86	47	43	146	37		229	159	189	236	778
1971	90	29	56	55	45	85	41	108	25	69	72	34		156	156	234	166	709
1972	85	64	72	53	67	67	55	36	44	30	75	93		183	193	157	149	741
1973	36	36	21	64	75	68	99	49	58	46	42	51		166	160	215	146	645
1974	95	82	39	10	33	62	69	81	112	71	94	56		229	82	212	276	803
1975	86	27	73	59	36	15	61	43	71	27	48	45		169	167	119	145	589
1976	52	34	38	16	63	17	25	31	142	120	50	81		131	117	74	311	669
1977	82	141	58	48	45	96	16	92	29	47	85	76		304	151	204	162	816
1978	90	57	62	42	38	61	76	61	51	14	45	148		224	142	198	110	745
1979	68	54	109	63	114	30	26	81	32	57	70	137		270	286	137	159	840
1980	67	83	89	16	29	111	60	91	61	108	71	57		287	133	261	240	840
1981	52	53	129	63	80	38	35	53	126	89	54	78		162	272	126	268	848
1982	60	33	93	24	32	133	28	82	70	72	95	76		171	150	244	237	798
1983	79	30	54	107	110	22	43	27	88	63	42	94		185	271	92	193	759
1984	113	51	55	9	58	44	18	62	103	73	126	54		258	122	124	301	765
1985	56	28	49	60	71	96	61	85	28	45	66	101		138	181	241	139	746
1986	107	17	65	82	79	37	42	114	17	76	94	112		225	225	193	187	841
1987	24	45	75	60	41	112	55	60	53	132	64	44		181	176	227	249	765
1988	123	53	86	34	52	46	118	71	47	68	39	36		220	172	234	153	771
1989	34	67	67	90	25	55	42	45	36	82	50	127		136	182	141	167	718
1990	106	110	20	31	18	61	28	37	42	90	47	85		344	69	126	180	676
1991	75	48	59	62	11	80	71	21	55	54	76	42		209	132	172	184	653
1992	59	33	68	55	58	45	86	118	83	73	113	64		133	181	249	269	854
1993	86	10	17	82	77	64	76	44	100	75	60	132		160	175	184	235	822
1994	95	67	71	56	56	25	41	55	113	70	75	109		293	183	121	258	832
1995	130	86	53	21	47	15	29	8	97	38	65	77		325	122	52	199	665
1996	45	66	38	47	44	29	36	68	23	65	95	55		188	130	133	182	611
1997	12	88	23	27	75	119	46	85	28	59	88	75		155	125	249	175	724
1998	95	17	83	116	24	118	39	46	82	140	60	70		187	223	202	281	888
1999	114	42	67	69	62	75	21	98	104	78	47	116		225	198	195	229	894
2000	37	77	32	137	72	42	53	55	114	144	142	115		230	241	150	399	1018
2001	51	81	71	94	54	37	69	75	67	116	46	33		247	219	181	229	794
2002	66	116	38	45	75	46	93	63	30	126	116	110		215	157	203	272	925
2003	65	28	33	41	66	67	64	16	29	48	70	86		203	140	147	147	613

Regional Rainfall Summaries

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		WIN	SPR	SUM	AUT	ANN
2004	98	41	41	87	43	52	61	155	51	121	47	44		224	171	268	219	841
2005	42	45	48	62	38	55	62	54	63	96	66	56		131	147	170	224	684
2006	22	42	77	44	104	17	51	85	76	95	83	100		120	225	153	254	796
2007	92	85	55	9	113	167	145	41	38	41	64	78		277	176	353	144	929
2008	126	37	84	63	60	53	98	103	104	78	76	55		241	207	254	258	937
2009	66	41	32	40	57	69	127	53	24	57	141	74		161	129	249	221	781
2010	61	56	50	25	32	41	53	99	67	65	71	28		191	106	192	203	647
2011	57	72	12	8	54	56	48	57	41	53	43	93		157	74	161	137	594
2012	63	29	23	141	52	152	113	88	88	87	113	138		185	215	353	287	1085
2013	64	46	65	22	79	36	67	53	45	133	59	89		247	166	157	237	759
2014	149	109	47	46	103	52	49	103	14	85	93	73		347	196	203	192	921
2015	75	41	52	23	79	38	66	80	42	57	107	120		189	155	184	206	781
2016	99	70	83	63	55	100	35	65	59	28	96	34		289	200	199	183	785
2017	59	56	67	16	56	66	80	68	85	46	55	88		149	139	214	185	741
2018	84	35	106	82	57	12								207	245			

Appendix D

PROPERTY LEVEL PROTECTION

PROPERTY LEVEL PROTECTION

Introduction

The purpose of this document is to make residents and building owners aware of a selection of Property Level Protection (PLP) measures which could be used to ameliorate the impacts of flooding within a building. This document is provided for information only, and does not constitute a recommendation for a particular product or approach.

It is important that anyone considering the use of PLP, seeks professional advice and ensures that the installation and materials used are warrantied and guaranteed.

PLP are the measures by which individual properties can be protected from the impacts of flooding. They generally comprise of a combination of flood resistance and flood resilience measures. Flood resistance involves keeping water out of a property using a variety of barriers for doors, windows and pipes. Flood resilience is the modification of a property such that it can withstand the effects of flooding. This can be achieved by using appropriate materials and furnishings, and by raising services above likely flood levels.

Types of products

A variety of products are available to protect all areas of potential water ingress into a property including doors and windows, brickwork and sewage systems.

Types of product include; anti flood doors, door barriers, anti-flood airbrick replacements or covers, non-return valves and sumps and pumps.

Available Products and Services

The Blue Pages (http://bluepages.org.uk/) is an independent flood directory set up by the National Flood Forum (https://nationalfloodforum.org.uk/). It provides a substantial list of the various products and services available in relation to protecting individual properties from flooding.

The most common methods of providing PLP are formed of a combination of the following devices:

1. Air Brick Protection - http://bluepages.org.uk/listing-category/air-brick-protection/
2. Demountable Flood Barriers - http://bluepages.org.uk/listing-category/demountable-flood-barriers/

A key issue with the Demountable Flood Barriers are the need to deploy the barriers before the flood event occurs, this can be difficult to achieve on private residents, particularly in areas at risk of surface (rainfall) water flooding. An alternative is to construct a permanent flood barrier at the rear door by raising the threshold, provided that it is suitably sealed and maintained to prevent the ingress of water to any sub floor void (if present). In general 'passive' flood defence systems such as this are preferable to a 'reactive' solutions (such as demountable flood barriers) as they don't require anybody to be present during a flood event to ensure that they are put in place.

GENERAL OBSERVATIONS

Following our work as an expert witness on cases relating to the failure of property level protection features, we recommend that a single supplier is used for the survey, design and installation of any protection measures residents and building owners choose to install. This would ensure that purchasers have a single point of contact should the product(s) fail during a flood event, offering a much better chance of recourse. We have observed difficulties of establishing responsibility for the failure of property level protection measures in the past when separate firms have supplied and installed various products at a single property.

If residents or building owners employ a firm to design the protection for a property then said firm should design their system to protect against a flood event of a particular magnitude (i.e. to protect against a flood which is likely to happen, on average, once every 100 years for example). This would be preferable to simply installing the protection up to or just above the level to which flooding has previously occurred, as a larger flood event could occur at any time. Specifying a magnitude of event also means purchasers have recourse should flooding occur during events of a lower magnitude.

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