URS

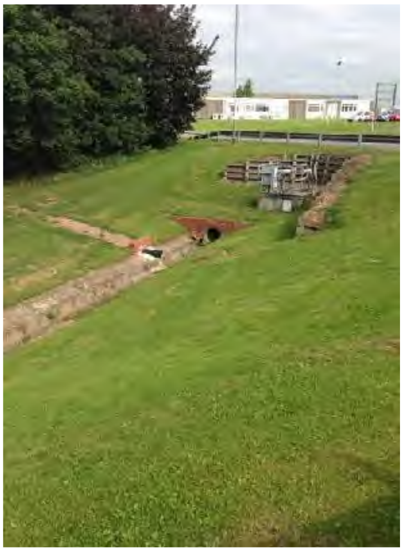
Diseworth and Long Whatton Catchment Study

FINAL REPORT

January 2014

Prepared for:
Leicestershire County Council

UNITED KINGDOM & IRELAND



REVISION SCHEDULE					
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1 INTRODUCTION

1.1 Background

The villages of Diseworth and Long Whatton have suffered from fluvial flooding a number of times in recent years, most recently in November 2012. The main risk of fluvial flooding in the villages is considered to be from Diseworth Brook, Long Whatton Brook and their associated tributaries.

Leicestershire County Council (LCC) commissioned URS Infrastructure & Environment UK Limited (URS) to undertake a study of the flooding that has occurred in Diseworth and Long Whatton. The study will determine the flooding mechanisms involved; including the contribution that runoff from East Midlands Airport (EMA) may have on flood risk within the catchment.

1.2 Study Aims and Objectives

The aim of this study is to undertake an investigation into the flooding that has occurred in the villages of Diseworth and Long Whatton, identifying potential contributing factors and mechanisms by which flooding occurs.

The study is considered sufficient to provide LCC with the information required to establish what potential mitigation measures may be most appropriate to reduce the future risk of flooding, and what further investigation may be required.

The objectives of this study are to:

- Collate and review all information, including available data relating to historic flooding (notably the events which occurred in November 2012 and November 2000);
- Delineate the local contributing catchments;
- Undertake an initial analysis of the flows generated by the contributing catchments;
- Assessment of the capacity of the surface water attenuation basins at East Midlands Airport;
- Assessment of the control mechanisms and operating regimes of the surface water attenuation basins at East Midlands Airport;
- Determination of the mechanisms of flooding.

1.3 Stakeholder Engagement

The following stakeholders have been contacted through the course of this study:

- Leicestershire County Council Flood Risk Management Team;
- North West Leicestershire District Council;
- Environment Agency;
- East Midlands Airport;
- Local Residents of Diseworth and Long Whatton.

1.4 Data Collection and Review

As part of undertaking the study, data has been collated from a number of different sources and includes:

- Ordnance survey mapping used to assist with delineating catchments;
- Flood Estimation Handbook CD-ROM used to identify hydrological features and further assist with delineating catchments;

- Rainfall data (provided by the Environment Agency and the University of Nottingham) used to develop rainfall profiles for the November 2012 events;
- Information on historical flooding events obtained by reviewing Environment Agency reports, correspondence to Leicestershire County Council from local residents, newspaper articles and eye witness accounts from local residents;
- Drainage information for East Midlands Airport reviewed to understand the operation of the various surface water attenuation reservoirs and the potential impact that discharges from these reservoirs may have on flows in the local watercourses.

2 CATCHMENT STUDY AREA

2.1 Overview

The villages of Diseworth and Long Whatton are situated in North West Leicestershire to the west and east of the M1 motorway (Junction 23a) respectively. Diseworth is situated approximately 1 km south of East Midlands Airport and Long Whatton approximately 3 km south east of East Midlands Airport.

The location of both villages is shown on Figure 2-1.

Figure 2-1: Location Plan

2.2 Topography and Land Use

Diseworth is situated within the valley of Diseworth Brook which drains the area to the north and west of the village, including East Midlands Airport. Topography within the catchment draining to Diseworth ranges from 90mAOD on the plateau, where East Midlands Airport is situated, falling away to 60mAOD in Diseworth village itself. Land-uses in the catchment are a combination of rural to the immediate north and west, with East Midlands Airport situated in the northern part of the catchment.

Downstream of Diseworth, Long Whatton is situated on the southern side of the valley of Long Whatton Brook. Long Whatton Brook drains the Diseworth Brook catchment along with the long ribbon shaped Westmeadow Brook catchment to the south west. Topography within the catchment draining to Long Whatton ranges from 150 mAOD in the headwaters of the Westmeadow Brook catchment, falling away to 50 mAOD in Long Whatton. Land-uses in the catchment are predominantly rural to the south west, however as with the Diseworth Brook catchment, East Midlands Airport is situated in the northern part of the catchment.

2.3 Catchment Overview

Figure 2-2 shows the approximate extents of the Diseworth Brook and Long Whatton catchments, and indicates the three individual surface water catchments draining East Midlands Airport via a series of surface water attenuation basins. Details of the surface water attenuation basins are included in Section 3.

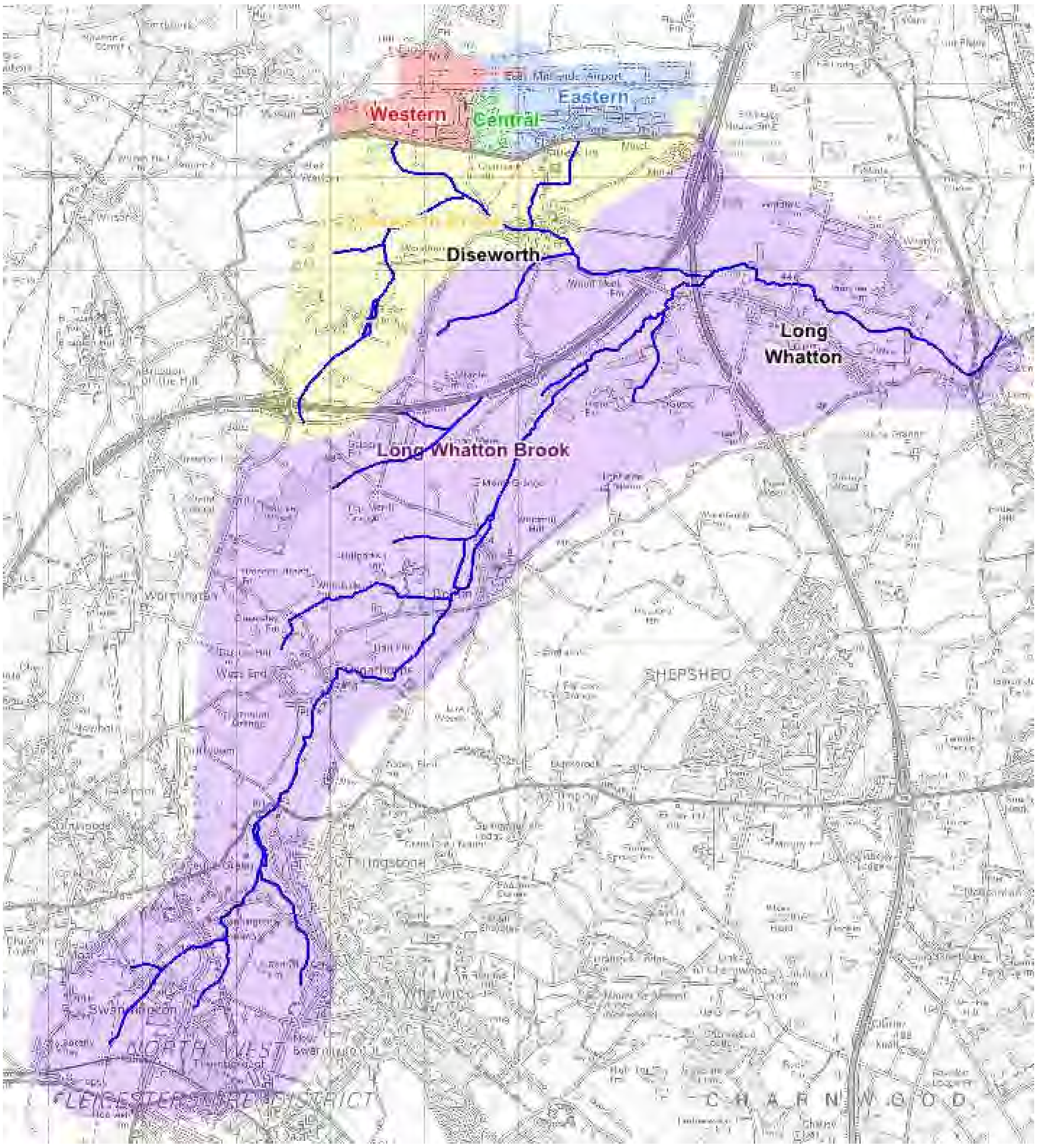

Figure 2-2: Catchments

In total, the Diseworth Brook catchment as far downstream as Diseworth covers an approximate area of 10.0 km^2, of which 6.9 km^2 is considered to be a natural catchment. The remaining 3.1 km^2 is drained via the surface water attenuation basins at East Midlands Airport.

The Long Whatton catchment as far downstream as Long Whatton covers an approximate total area of 32.0 km^2. Excluding the Diseworth Brook catchment, the remaining Long Whatton catchment covers an area of approximately 22.0 km^2.

2.4 Flow Estimates

An assessment of potential flows generated by the Diseworth catchments (excluding East Midlands Airport) and the Long Whatton Brook catchment (upstream of the confluence with Diseworth Brook) has been undertaken using the Revitalised Flood Hydrograph (ReFH) method. Where appropriate, the catchments have been delineated into sub-catchments, which are indicated on Figure 2-3.

A summary of the modelling output is included in Appendix A.

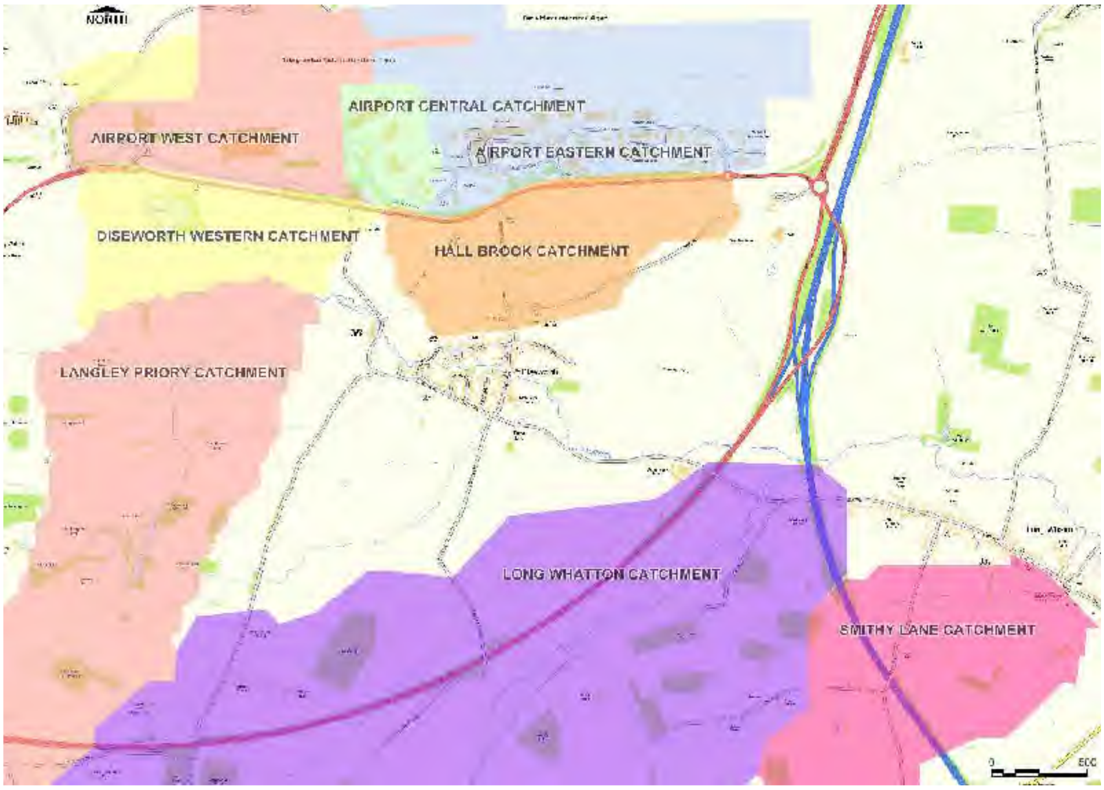

Figure 2-3: EMA Catchments

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The peak flows for selected storm events are shown in Table 2-1 below. The discharges from East Midlands Airport are discussed in Section 3.

TABLE 2-1: REFH DESIGN STORM FLOWS (M^3/S)						
Catchment	**2 year**	**5 year**	**20 year**	**50 year**	**100 year**	**100year+CC**
Diseworth Western*	0.4	0.5	0.7	0.8	1.0	1.2
Langley Priory	1.0	1.4	1.9	2.4	2.8	3.4
Long Whatton	4.3	5.6	7.6	9.2	10.7	12.8
Hall Brook*	0.4	0.5	0.7	0.9	1.0	1.2
Smithy Lane	0.7	0.9	1.3	1.6	1.9	2.3

* an areal reduction has been applied to the Diseworth Brook catchment to remove the area covered by East Midlands Airport. Also, the URBEXT value for the catchment has been reduced to 0.00. All other catchment descriptors have not been changes

3 EAST MIDLANDS AIRPORT SURFACE WATER DRAINAGE SYSTEM

3.1 Site Visit

A site visit of East Midlands Airport was undertaken by a senior member of the URS Flood and Water Management Team in August 2013. The site visit included visiting key areas within the airport and discussions in relation to the operation of the surface water attenuation basis at the airport. Photographs of key features were taken and these are presented in this report.

The surface water attenuation system at East Midlands Airport is used to manage surface water from the majority of the impermeable catchment surfaces within the operational areas of the airport (i.e. aprons, runway, taxiways roads, car parks and buildings). The airport area is divided into three distinct catchments and these are shown on Appendix C.

Each of the three catchments (central, eastern and western) are served by two surface water attenuation basins, a larger winter basin and a smaller summer basin.

Photographs of each of the basins are included as Photograph 3-1 to Photograph 3-6.

Photograph 3-1: Central Catchment 'Summer' Basin

Photograph 3-2: Central Catchment 'Winter' Basin

Photograph 3-3: Eastern Catchment 'Summer' Basin

Photograph 3-4: Eastern Catchment 'Winter' Basin

Photograph 3-5: Western Catchment 'Summer' Basin

Photograph 3-6: Western Catchment 'Winter' Basin

3.2 Operating Regimes

The purpose of the dual (summer/winter) systems are to allow runoff from the airport to be managed in a manner that does not cause pollution of local watercourses. During the winter months (typically November to March) when temperatures can drop to around or below freezing, areas of the airport including aircraft are treated with a de-icing agent to prevent accumulations of ice. Due to its composition, the de-icing agent significantly increases the Biological Oxygen Demand (BOD) of the surface water runoff generated from the impermeable areas. As such, during winter conditions when the airport has been treated for ice the surface water runoff is unsuitable for discharging into the local watercourses.

The dual system allows runoff to be routed into the relevant winter basin (dependent upon the catchment). Flows entering the central and eastern winter basins are then pumped to the western winter basin where it undergoes aeration to reduce the BOD level. Surface water held in the western winter basin is then pumped to the River Trent (at a maximum rate of 0.025 m^3/s) where the river flow sufficiently dilutes the runoff and prevents adverse environmental damage arising from the residual BOD.

The routing of runoff into either the winter basin or summer basin is determined by an automated monitoring system which measures the BOD of the runoff. This takes place within flow division chambers (FDC) which are located upstream of the Central, Eastern and Western reservoirs. The FDC is able to detect elevated BOD levels and determine if the runoff requires treatment and if so is routed into the winter reservoir. If the BOD level of the runoff is low enough such that it does not require treatment, the runoff is routed into the relevant summer basin (dependent upon the catchment) and subsequently discharged into the local watercourses. The limiting BOD level has been consented by the EA.

Each winter basin has an emergency overflow which conveys water over a spillway and into the respective summer basin. The summer basins in turn have emergency overflows which discharge water directly into the local watercourse once the basin is full. Both the western and the eastern basins are classified as reservoirs under the Reservoirs Act (1975) and therefore undergo regular inspections by qualified Reservoir Panel Engineers, which include inspection of the embankment dams, overflows and outfalls.

3.3 Discharge Rates

Each of the summer basins have a gravity outlet to allow the structure to discharge water into the local watercourses. The Environment Agency's permit to discharge only covers water quality not quantity. The outfall rates and consented discharges for each of the structures have been determined through discussions with the East Midlands Airport operations team.

A summary of the outfall arrangements for each of the basins is outlined in Table 3-1.

TABLE 3-1: STORAGE RESERVOIR OUTFALL ARRANGEMENTS			
Storage Reservoir	**Pipe Outlet Size**	**Discharges into**	**Maximum Discharge**
Central Winter	Not reported (pumping main)	Western Winter Reservoir	0.21 m^3/s
Central Summer	450 mm diameter	Local Watercourse (via secondary reservoir) leading to Diseworth Brook	0.26 m^3/s
Eastern Winter	Not reported (pumping main)	Western Winter Reservoir	0.18 m^3/s
Eastern Summer	800 mm diameter	Hall Brook	1.50 m^3/s
Western Winter	225 mm diameter (pumping main)	River Trent	0.025 m^3/s
Western Summer	450mm diameter	Diseworth Brook	0.35 m^3/s

Winter Conditions

The central and eastern winter basins discharge to the western winter basin via a pumped and gravity channel arrangement, with a maximum discharge rate of 0.21 m^3/s and 0.18 m^3/s respectively.

The outlet from the western winter basin connects to the River Trent through a 225 mm diameter pumping main. Effluent is pumped (at a maximum rate of 0.025 m^3/s) to the river when the BOD level exceeds limits set by the EA that prevent it from being discharged into Diseworth Brook.

During a significant event, should the capacity of the western winter basin be exceeded, then this would overflow into the adjoining western summer basin and discharge to the Diseworth Brook catchment at a maximum rate of 0.35 m^3/s. Should the capacity of the western summer basin also be exceeded then this would discharge via the emergency overflow to prevent uncontrolled overtopping of the basin. From the EMA records of the November 2012 event, this emergency overflow was not in operation at any time during the event.

Summer Conditions

The central summer basin discharges via a 450 mm pipe and discharges into a secondary basin, which also receives inflow from two land drains serving adjacent agricultural land. The discharge from the central summer basin to the secondary basin is reported by EMA to be 0.26 m^3/s and is controlled by the diameter of the outfall pipe. No engineering drawings have been provided by EMA to enable the maximum discharge rate to be verified.

The eastern summer basin discharges to Hall Brook via an 800 mm outlet and is reported by EMA to have a maximum discharge of1.50 m^3/s. No engineering drawings have been provided by EMA to enable the maximum discharge rate to be verified.

No flow recording equipment is fitted to the central or eastern summer basin outlets. A water depth monitor is in use however on the eastern summer pond.

The western summer basin discharges via a 450 mm diameter pipe at a maximum rate of 0.35 m^3/s as noted above and there is telemetry installed at the outlet to monitor flows and water depths.

In the event of an extreme rainfall event resulting in the storage capacity of any of the three summer basins to be exceeded, then, as designed, the basins would overspill.

Therefore under normal (non-extreme) summer conditions the maximum combined discharge from the central and western summer basins (which discharge into the same reach of Diseworth Brook) would be 0.61 m^3/s, with the maximum discharge from the eastern summer basin being 1.50 m^3/s.

3.4 Basin Capacities

An Environmental Information Statement (included in Appendix B) detailing the surface water management at the airport provides indicative storage volumes for each of the storage basins.

The eastern winter and summer basins have a combined capacity of 28,000 m^3. The central winter basin has a capacity of 9,000 m^3. No storage capacity information is provided for the central summer basin. The western winter reservoir has a capacity of 63,000 m^3, whilst the western summer reservoir has a capacity of 18,500 m^3.

4 FLOOD SOURCES AND MECHANISMS

4.1 Background

The most recent flooding event in Diseworth and Long Whatton occurred in November 2012 when several localities including a number of properties suffered flooding. During the month of November the Midlands region was subject to unusually unsettled weather punctuated with periods of heavy rainfall which worsened through the month. Rainfall was particularly heavy during the latter half of the month with net rainfall in the nine-day period between 19th November 2012 and 27th November 2012 exceeding the monthly November average. The Centre for Ecology and Hydrology newsletter bulletin provides a more detailed description of the rainfall during November 2012 and is included in Appendix D of this report.

As part of the study URS acquired rainfall data for the period for November 2012. The rainfall data was provided from a gauging station located at The University of Nottingham, Sutton Bonington Campus, approximately 4 miles to the east of the study area. The hourly rainfall profile for late November 2012 is included in Figure 4-1.

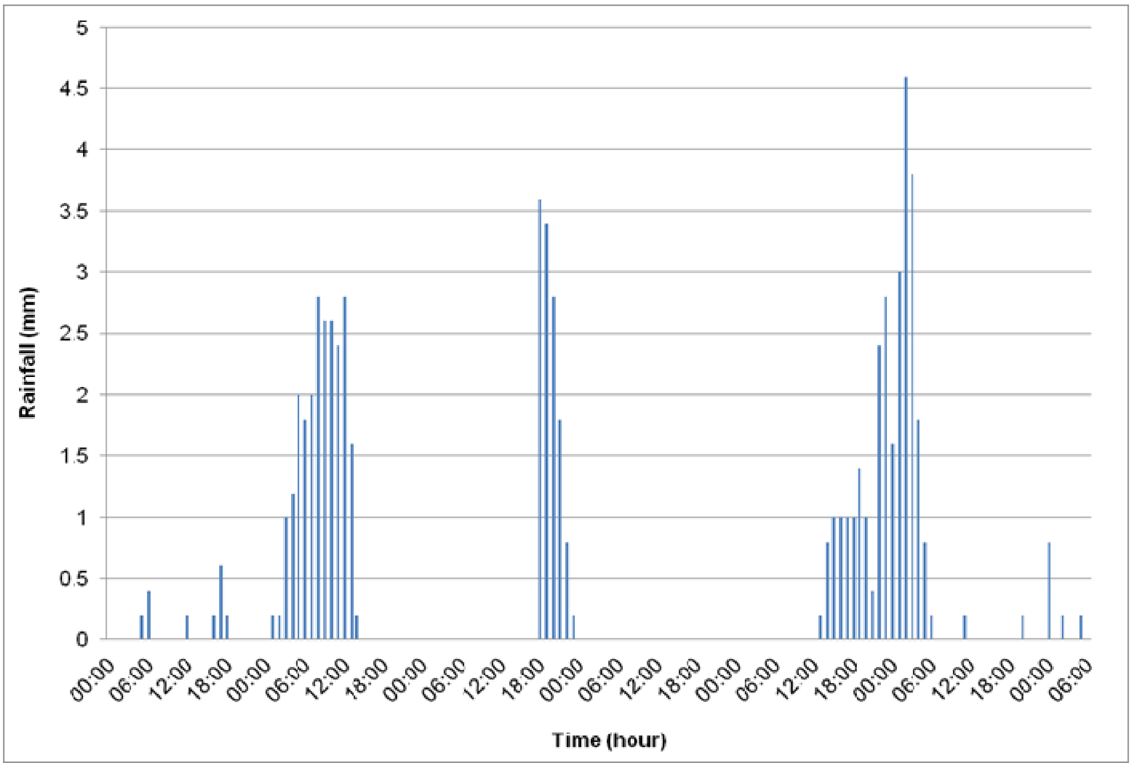

Figure 4.1: Rainfall Profile from 00:00 on 20/11/12 to 06:00 on 27/11/12

The rainfall profile indicates that three separate rainfall events occurred during the period 20th November 2012 to 27th November 2012. As a result of the successive heavy rainfall the Diseworth and Long Whatton catchments became saturated. Rather than infiltrating into the ground, rain falling on the ground surfaces effectively ran off into watercourses. This would have caused water levels in the watercourses to respond very rapidly to the onset of rainfall.

In Leicestershire, main rivers were recorded as being at 'notably high' or 'exceptionally high' levels with extensive and frequent flooding of floodplain areas throughout November. Several localities in the North Leicestershire region suffered fluvial flooding. BBC news articles from the 25th November 2012 and 26th November 2012 stated that the EA had forecast 'imminent' flooding across the county, with North Leicestershire being particularly likely to suffer widespread flooding.

Historic flooding has also occurred in Diseworth and Long Whatton in early November 2000. Several properties suffered flooding and this prompted the EA to undertake an investigation of the flooding that had occurred for North West Leicestershire District Council. The report stated that the region had suffered an unusually large amount of rainfall during early November 2000, and this was the primary cause for the widespread flooding across the area, including Diseworth.

The EA report concluded that the flooding was caused by the relatively large flows from Diseworth Brook and Long Whatton Brook being unable to pass through constrictions in the channel such as bridges and culverts. The report also concluded that poor maintenance of the river channel and land directly adjacent to the river channel was a contributing cause. This was reportedly due to large debris such as branches reducing the capacity of the river channel. Poor alignment of the river channel was also listed as a potential contributing factor.

The report examined the operation of the surface water attenuation basins at East Midlands Airport during the flood event. The report concluded that the western basins had helped alleviate the flooding by attenuating and redirecting flows to the River Trent, therefore reducing flows into the local watercourses. The report also concluded that the basins had not exceeded their permitted discharges.

4.2 Site Specific Flood Mechanisms

Four localities are reported to have suffered flooding during the November 2012 events, these were:

- Shakespeare Close in Diseworth;
- Hallgate in Diseworth;
- Mill Lane, Main Street and Crawshaw Close in Long Whatton;
- County Bridge Mobile Home Park

A site visit was undertaken in September 2013, which included a visit to each of the locations which had suffered flooding. The site visit provided an insight of the location of potential causes of flooding to be determined. An account of the likely flood mechanism for each location is outlined below.

Shakespeare Close in Diseworth

Prior to flowing into the village, Diseworth Brook is culverted beneath the road adjacent Wartoft Grange. The culvert consists of a 900 mm circular culvert that extends approximately 10 m beneath the roadway. Having flowed through the culvert the watercourse continues to flow south east towards the village.

As it flows into Diseworth from the west, Diseworth Brook enters a 60 m long culverted section which conveys the brook beneath ‘The Bowley’. The culvert consists of a 2 x 1000 mm pipes and is fitted with an informal trash screen on the upstream entrance (Photograph 4-1). At the site inspection both pipes were observed to be clear.

Photograph 4-1: Upstream view of the Bowley culverts

The area immediately upstream of the culverts is an area of relatively wide channel measuring approximately 3 m from bank top to bank top (Photograph 4-2). Upon exiting the culvert, the watercourse narrows down to a width of around 2m from bank top to bank top. As a result, through the reach adjacent to Shakespeare Close the profile of the channel changes from being wide and shallow to being very narrow and still quite shallow. Photograph 4-2 and Photograph 4-3 demonstrate the difference in channel profile between the upstream and downstream lengths.

Photograph 4-2: View looking upstream from culvert

Photograph 4-3: View downstream towards constriction adjacent to flooding location at Shakespeare Close

During the flood event in late November 2012 the runoff flow rates would have been significantly increased due to the saturated conditions within the catchment. During the event, the flow being conveyed by the watercourse downstream of the Bowley culverts exceeded the capacity of the channel causing inundation to the area on the left bank. This in turn caused flooding to properties at Shakespeare Close.

Based on observations made during the site visit and in consideration of design flow rates, the principal cause of flooding at the location is considered to be the geometry of the channel, specifically the constriction as the brook negotiates the reach adjacent to Shakespeare Close.

Hallgate in Diseworth

The flooding at Hallgate was caused by Hall Brook which rises to the north of Diseworth and includes the Eastern Area of East Midlands Airport. The watercourse also drains the envelope of farmland situated between the village and the airport. As such, the flooding that occurred at this location is not associated with Diseworth Brook that caused flooding at Shakespeare Close.

At times during the winter months, when runoff at the airport is being pumped to the River Trent, Hall Brook does not receive discharge from the eastern basin. This has been reported to be the case in the November 2012 event. The flows in Hall Brook during this event were therefore generated by runoff from the farmland to the north of the village. The saturated nature of the catchment would have resulted in an increased amount of runoff, causing an increase in peak flows. The increase in peak flows was sufficient for the watercourse to exceed its channel capacity and cause flooding to neighbouring property.

Mill Lane, Main Street and Crawshaw Close in Long Whatton

The village of Long Whatton is located around 200m south of Long Whatton Brook. The brook flows from west to east parallel to the northern extent of the village. According to Ordnance Survey mapping, the village is sited at a higher topography of around 44mAOD along Main Street. This was confirmed during the site visit in September 2013.

It is understood that the flooding of properties at Main Street and Mill Lane in November 2012 was caused by the unnamed watercourse which drains approximately 1.5 km^2 of farmland to the south-west of the village. In order to flow past Main Street the watercourse is culverted beneath the road. Having flowed beneath the road the watercourse continues to flow south eventually discharging into Long Whatton Brook. The culvert below the road consists of a 450 mm pipe which extends diagonally under the roadway, for a length of around 50 m.

The site visit in September 2013 included discussions with a number of local residents who were able to describe the mechanism by which flooding of the road resulted in several properties becoming flooded. The flooding appears to have been caused by 'backing up' of the culvert beneath the road, which caused flooding to the adjacent farmland upstream. Flows coming off the fields caused flooding to occur along Main Street which overtopped the kerbs and flooded adjoining properties on the north side (shown in Photograph 4-4) which are set down below the road level. The floodwater also affected a low area at the corner of Main Street and Mill Lane. Having flooded the lower lying land at Mill Lane, the floodwater caused flooding of the properties on Mill Lane. The floodwater also extended into Crawshaw Close flooding several properties.

It is understood that a relatively new brick headwall (photograph 4-5) has been built at the downstream end of the culvert, adjacent to the footpath. It is reported that this brick wall prevented flows from returning to the watercourse channel, and exacerbated the flooding. It is also reported by local residents that the road levels on Main Street have been raised several times as a result of resurfacing (no scarifying first), which has reduced the kerb height over the years. This has increased the likelihood and frequency of floodwater overtopping the kerb and inundating adjacent properties.

Photograph 4-4: View west along Main Street

Photograph 4-5: View across Crawshaw Close

Further flooding was reported approximately 1 km to the east of the junction at Mill Lane and Main Street. The brook flows from west to east at this point and it is understood that the flooding at this location in November 2012 was caused by the Long Whatton Brook. The brook at this location drains around 31 km^2 of land, most of which is farmland.

During the flood event in late November 2012 the runoff flow rates would have been significantly increased due to the saturated conditions within the catchment. During the event, the flow being conveyed by the watercourse downstream of the Mill Lane culvert exceeded the capacity of the channel causing inundation to the low lying areas. Based on observations made during the site visit and in consideration of design flow rates, the principal cause of flooding at this location is considered to be the geometry of the channel and volume of water. Photographs 4-6 and 4-7 below compare the water levels at the same point in the watercourse both during typical winter flow conditions and at the time of the 2012 flood event.

Photograph 4-6: Long Whatton Brook in Typical Winter Flow Conditions

Photograph 4-7: Long Whatton Brook During Flooding in November 2012

County Bridge Mobile Home Park

The County Bridge Mobile Park is located approximately 900m to the east of Mill House on Zouch Road. The Park is situated between Long Whatton Brook to the north and Zouch Road to the south. According to Ordnance Survey mapping, the Park is sited at a topography of around 37mAOD. It is understood that the flooding at the Park in November 2012 was also caused by the Long Whatton Brook which at this point drains approximately 32 km^2 of land, most of which is farmland.

During the event, the flow being conveyed by the watercourse downstream of the Mill Lane is believed to have exceeded the capacity of the channel. The watercourse will also have been constricted by the brick arch culvert shown in Photograph 4-8 below.

Photograph 4-8: Brick Arch Culvert

This in turn caused localised flooding to the carriageway. It has been reported from residents that the ditch adjacent to Zouch Road was also partially blocked which wasn't able to accommodate the additional surface water. In consideration of the observations made during the site visit and the design flow rates, the principal cause of flooding at the location is likely to have been the geometry of the channel and volume of water.

5 POTENTIAL MITIGATION OPTIONS

In order to potentially reduce flood risk in Diseworth and Long Whatton, initial 'high level' mitigation options have been identified based on the known flooding sources and mechanisms and these include:

(A) **Amendments to the operating regime of the basins at East Midlands Airport** – EMA should look to minimise discharges to watercourses during significant storm events on the catchment by diverting flows into the winter reservoirs to act as storage basins. When utilising the storage capacity of the basins in this way, the option of pumping additional flows to the River Trent should be considered as part of the measure.

(B) **Channel works to improve capacity and conveyance** – Improving the capacity of watercourses through either undertaking channel widening schemes and/or undertaking routine channel maintenance could be further considered.

(C) **Flood storage area(s)** – The provision of a flood storage area(s) upstream of the village of Diseworth is a potential option for reducing peak flows and reducing the risk of flooding through the village.

Sustainable Development and Catchment Drainage Betterment Planning Policies – North West Leicestershire District Council as the Local Planning Authority should, through their planning policies promote sustainable development and "Betterment" of surface water drainage within the catchment including promoting best practice in the management of land use to reduce rapid runoff into watercourses from fields and developments. This would include ensuring that all future development and redevelopment demonstrates the surface water is disposed of in a sustainable manner that will reduce surface water runoff rates.

Further to the above engineering based solutions, should cost benefits not support such schemes, non-engineering solutions may need to be considered. Such solutions may include measures such as:

- Increased community awareness,
- Development of a Local Community Flood Plan,
- Changes to maintenance regimes,
- Flood proofing of properties at risk.

6 SUMMARY

There are three separate sources of flooding in the villages of Diseworth and Long Whatton which are caused flooding to properties in November 2012:

- Fluvial flooding from Hall Brook;
- Fluvial flooding from Diseworth Brook;
- Fluvial flooding from the small watercourse upstream of Main Street, Long Whatton.

The flooding mechanisms from these sources have been established based on anecdotal evidence of historic flood events and available data.

The East Midlands Airport has a system that regulates discharges to the watercourse to rates agreed with the EA. The airport does not appear to have been a factor in the flooding of Diseworth in the 2012 flood event.

Initial 'high level' options have been identified that may assist with reducing flooding in the village;

Discussions should be held with LCC, key stakeholders and local residents to determine preferred options to take forward for further consideration;

The feasibility of the preferred options will need to be confirmed by hydrological analysis and hydraulic modelling. Hydraulic modelling will also be required at the design stage for most options and WFD assessments for works on channels, or that impact on flows.

APPENDIX A – SUMMARY OF THE REFH MODELLING

APPENDIX B – AIRPORT SURFACE WATER CATCHMENTS

APPENDIX C – EMA ENVIRONMENTAL STATEMENT

APPENDIX D – NOVEMBER 2012 HYDROLOGICAL REPORT