M42 Junction 6 Improvement
Scheme Number TR010027
Volume 6
6.10 Flood Risk Assessment

Regulation 5(2)(e)

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

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Infrastructure Planning

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The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

M42 Junction 6 Improvement

Development Consent Order 202[-]

6.10 Flood Risk Assessment

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Executive summary

This Flood Risk Assessment (FRA) forms part of the Development Consent Order (DCO) application for the M42 Junction 6 Improvement Scheme (the Scheme), and has been prepared in accordance with the requirements of Regulation 5(2)(e) of The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009.

The Scheme comprises a series of road improvements proposed by Highways England to address congestion and journey reliability issues at Junction 6 of the M42 motorway in Birmingham.

This report assesses the risks of all forms of flooding to and from the Scheme, and demonstrates how these flood risks would be managed, taking climate change into account as not to increase flood risk elsewhere.

The assessment has been prepared by Highways England in accordance with the requirements of the National Policy Statement for National Networks (NPSNN), the scope of which has been consulted upon with Solihull Metropolitan Borough Council (SMBC) and the Environment Agency (EA).

The assessment has identified that the majority of the Scheme would be located within Flood Zone 1, with some parts to the north of M42 Junction 6 located within Flood Zones 2 and 3 in the locality of Hollywell Brook.

As the Scheme would extend the M42 motorway over Hollywell Brook (classified by the EA as a Main River), a process of hydraulic modelling was undertaken to establish its flood zone extents and capacity. This established that the channel of the brook does not over top its banks in the 1% Annual Exceedance Probability (AEP) event or 1% AEP plus 50% allowance for climate change event.

The assessment confirmed that the land adjacent to Hollywell Brook is located in Flood Zone 1 rather than Flood Zone 3. Accordingly, the risk of flooding from Hollywell Brook was considered to be low and therefore compensatory storage in this area is not required.

The assessment also confirmed that the risk of flooding from surface water, drainage infrastructure and artificial sources is low.

Accounting for the delivery and implementation of mitigation measures incorporated into the design of the Scheme to capture and attenuate surface water runoff, the assessment has recorded that there is low risk on-site or off-site impacts would occur from the Scheme in relation to flood risk.

1 Introduction

1.1 Background

1.1.1 Highways England is the Government-owned company responsible for the operation, maintenance and improvement of England's motorways and major A-roads. It is proposing to implement the M42 Junction 6 Improvement Scheme (the Scheme) to address congestion and journey reliability issues at Junction 6 of the M42 motorway in Birmingham.

1.1.2 The Scheme comprises a series of improvements to the strategic and local road networks, the objectives of which are to: promote the safe and reliable operation of the road network; increase the capacity of the junction; improve access to key businesses; and support economic growth.

1.1.3 Highways England has applied for a DCO under Section 37 of the Planning Act 2008 [REF 1-1] to obtain authorisation to construct the Scheme. The application will be examined by an appointed Examining Authority, who will make a recommendation to the Secretary of State for Transport as to whether the DCO should be granted or refused.

1.2 Overview of the flood risk assessment process

1.2.1 The National Policy Statement for National Networks (NPSNN) [REF 1-2], in line with the National Planning Policy Framework (NPPF) [REF 1-3] and the accompanying Planning Practice Guidance (PPG) covering flood risk and coastal change [REF 1-4], states that development proposals with an area greater than 1 hectare (ha) or located in an identified area of flood risk should be accompanied by a Flood Risk Assessment (FRA) that identifies and assesses all forms of flooding to and from the development.

1.2.2 This policy framework identifies that an FRA should demonstrate how these flood risks will be managed so that a development remains safe throughout its lifetime, taking into account the vulnerability of the development and the potential impact of climate change on risk.

1.2.3 Further details regarding the policy framework covering FRA is presented in Chapter 5 EIA methodology and consultation.

1.3 Purpose of the report

1.3.1 This FRA has been undertaken and reported in accordance with national policy [REF 1-2, REF 1-3] and PPG [REF 1-4] to establish the baseline flood risk conditions associated with the area within which the Scheme would take place, and identify the extent to which these conditions would alter as a result of its construction and operation.

1.3.2 The content of this report draws upon information gathered as part of the Environmental Impact Assessment of the Scheme, and should be read in conjunction with the Environmental Statement [**TR010027/APP/6.1, 6.2 & 6.3**].

1.3.3 The outcomes of this FRA have been used to influence the engineering and environmental design of the Scheme, the preliminary design of which is presented within Appendix A of this document.

2 The Scheme

2.1 Location and elements

2.1.1 The Scheme would be implemented within an area broadly defined by M42 Junction 7 to the north, Birmingham Airport and Catherine-de-Barnes to the west, Middle Bickenhill and Hampton in Arden to the east, and M42 Junction 5 to the south.

2.1.2 A more detailed description of these proposals is as follows:

M42 Junction 5A

2.1.3 A new junction (M42 Junction 5A) is proposed approximately 1.8km south of M42 Junction 6. This dumbbell junction would comprise two roundabouts immediately north of Solihull Road, each positioned either side of the M42 motorway and connected by a new bridge over the M42. The new junction would have south facing slip roads only, enabling M42 northbound traffic to exit the M42 motorway and join a new mainline link road, and traffic travelling from the new mainline link road to join the M42 motorway in a southbound direction.

2.1.4 The existing Solihull Road overbridge would be demolished and rebuilt on a slightly modified alignment to accommodate the new slip roads.

Mainline link road and the local road network

2.1.5 A new 2.4km long link road (the mainline link road) would connect M42 Junction 5A with the A45 at Clock Interchange, replacing the existing connection between Catherine-de-Barnes Lane and Clock Interchange. The mainline link would be predominately positioned in cutting to minimise visual and environmental impacts on Bickenhill and the surrounding countryside.

2.1.6 Catherine-de-Barnes Lane would be realigned between Birmingham Dogs Home and Clock Interchange, and the existing connection to Clock Interchange would be closed.

2.1.7 A new roundabout (Barber's Coppice roundabout) to the east of Birmingham Dogs Home would provide access to the northbound carriageway of the mainline link road, nearby properties and the Warwickshire Gaelic Athletic Association sports facility (referred to by the users as Páirc na hÉireann). From Barber's Coppice roundabout, the realigned Catherine-de-Barnes Lane would pass over the mainline link road on a new bridge. The existing T-junction with Shadowbrook Lane would be realigned to the north of its current location.

2.1.8 North of Barber's Coppice roundabout; Catherine-de-Barnes Lane, St Peters Lane and Clock Lane would provide local access only, with no direct access onto the A45.

2.1.9 A new roundabout (Bickenhill roundabout) located to the west of Bickenhill village would connect Catherine-de-Barnes Lane to St Peters Lane, and the mainline link road southbound off-slip. From Bickenhill roundabout, Catherine-de-Barnes Lane would connect to Clock Lane via a new overbridge crossing the mainline link road, and to St Peters Lane, via a modified T-junction.

A45 and Clock Interchange

2.1.10 The mainline link road would connect to the A45 via a reconfigured Clock Interchange roundabout, which would be widened to have three lanes, new traffic signals, and improvements to slip roads joining the interchange. On the approach to the Clock Interchange from the new mainline link road, a segregated left turn lane would enable traffic to join the A45 and head westbound. Spurring off the northbound carriageway of the mainline link road, prior to the junction at Clock Interchange, a new free flow slip road would allow road users to connect to the existing link leading to Airport Way; allowing direct access to Birmingham Airport and the National Exhibition Centre (NEC).

2.1.11 The existing segregated lane from Bickenhill Lane to the A45 eastbound would be closed. Works would also be undertaken to realign and widen Bickenhill Lane, immediately north of Clock Interchange.

M42 Junction 6 free flow links

2.1.12 A free flow link for A45 eastbound to M42 northbound traffic would be constructed on the north-west quadrant of the junction, with an underpass constructed beneath the existing NEC access. To facilitate construction of this link, a sloped abutment on the existing East Way overbridge would be replaced with a retaining wall.

2.1.13 A free flow link from the M42 southbound to A45 eastbound would be constructed on the north-eastern quadrant of the junction. The existing connection to East Way would be modified through the introduction of a new slip road and roundabout to maintain access from the M42 southbound to the NEC.

2.1.14 The slip road from the A45 eastbound to the Middle Bickenhill loop would be closed, and the Middle Bickenhill loop connecting East Way with the settlement of Middle Bickenhill would be upgraded to provide two-way access.

2.1.15 The existing M42 northbound to A45 westbound free flow link would be closed to traffic, and the M42 northbound off-slip road would be improved to accommodate four lanes of traffic and provide network resilience.

Modifications to the M42 motorway

2.1.16 Modifications would be undertaken to the M42 between Junctions 5 and 7 to alter the location and spacing of several emergency refuge areas (ERAs), and to accommodate the additional signing, gantries and road markings required by the new road layout.

Modifications to the Warwickshire Gaelic Athletic Association

2.1.17 The mainline link road would sever the existing access to the Warwickshire Gaelic Athletic Association from Catherine-de-Barnes Lane, and would require land currently used for sports pitches. Modifications would be made to reconfigure the access and the layout of the affected pitches using adjacent land to the south of the facility, in order to secure its continued operation and viability.

2.2 Landtake and accommodation works

2.2.1 Land currently subject to a range of uses would be permanently taken to accommodate the engineering, drainage and environmental components of the Scheme, and temporarily for construction purposes.

2.2.2 New tracks, gated accesses and an accommodation overbridge across the mainline link road (to the south east of Barber's Coppice roundabout) would enable landowners, residents and businesses to continue to access their property and land interests.

2.3 Road signage, markings, barriers, lighting and surfacing

2.3.1 New road signage and markings would be installed across the Scheme. Barriers would be installed on new and improved sections of road, with the appropriate type of road surfacing applied to new and improved sections of road depending on local conditions.

2.3.2 The new junctions on the M42 and Clock Interchange would be lit, and some slip roads and local road junctions would be partially lit.

2.4 Earthworks and drainage

2.4.1 A combination of earthworks cuttings and embankments would be used to reduce the environmental impact of the Scheme, and to achieve the desired levels to connect into the existing road network.

2.4.2 Drainage infrastructure comprising kerb drains, gullies, filter drains, reed bed systems, pumping stations, underground storage tanks, culvert extensions and swales would be installed to capture, direct, store, treat and discharge carriageway run-off into drainage networks maintained separately by Highways England and SMBC.

2.4.3 Several new access tracks would be formed to allow drainage infrastructure to be inspected and maintained.

2.5 Landscaping and boundary treatments

2.5.1 Measures comprising improved grassland, trees, hedgerows and scrub planting would be used to: integrate the Scheme into the local landscape; create and enhance ecological habitats; screen new road infrastructure in existing views; provide visual interest to road users; and compensate for vegetation loss.

2.5.2 Boundaries created or altered by the Scheme would predominantly be demarcated using wooden post and rail fencing and hedgerows.

2.6 Non-motorised user provisions

2.6.1 Measures comprising footpaths, cyclepaths, underpasses and bridge crossings would be implemented at locations throughout the Scheme to enable the continued movement of non-motorised users on routes affected by temporary or permanent closures and diversions.

2.6.2 Enhancements would also be made to existing routes and facilities, including the relocation of existing bus stops affected by the Scheme.

2.7 Construction

2.7.1 Construction of the Scheme is anticipated to commence in 2020. Works would be undertaken in sequential phases to reduce the extent and duration of disruption to residents, businesses and road users, and would be completed in 2024.

2.7.2 Temporary construction compounds would be established at several locations across the Scheme to provide equipment and materials storage, welfare facilities and parking for contract staff. The main compound would be located north of Bickenhill village, to the immediate south east of Clock Interchange. A number of smaller compounds would be formed along the mainline link road and at other locations requiring specific works or activities.

2.7.3 The construction phase would require the use of different equipment and machinery suited to the location and nature of the works to be undertaken. Enabling works undertaken prior to the main construction activities would include: the diversion of utilities; the demolition of a small number of existing buildings and structures; vegetation clearance; the stripping and storage of top soil; and the formation of temporary fencing and accesses.

2.7.4 Activities during the main construction phase would comprise: traffic management; earthworks; carriageway formation and realignment; the erection of structures; and the installation of supporting infrastructure. Restoration works would be carried out to return areas of land used temporarily to their former condition and use, upon completion of the works.

2.8 Future maintenance

2.8.1 The future maintenance of the Scheme would be undertaken on a routine basis, and following any major incidents or extreme weather events. Typical activities would include the inspection and repair of barriers and signage, carriageway repairs, renewal of road markings, maintenance of highway verges and boundaries, landscape management, and the inspection and maintenance of road drainage infrastructure.

3 Site information

3.1 Study area

3.1.1 The following sections provide an overview of the existing topographical, land use and surface water features and conditions within a study area comprising all land within the Scheme's Order Limits, extending outward to approximately 1km, and their relationship to key infrastructure and works included within the Scheme design.

3.1.2 Information relating to the existing conditions has been obtained using a combination of desk-based and site-based methods, supplemented by dialogue with relevant consultees, as described in Chapter 5 EIA methodology and consultation.

3.2 Topography and land use

3.2.1 Topographic data obtained from Ordnance Survey (OS) mapping confirmed that the area is very gently undulating with all elevations being between 90m and 120m above ordnance datum (AOD), and that valleys with low gradients surround the various watercourses.

3.2.2 To the north of the study area the elevation is 10m AOD at Park Farm to the north of Middle Bickenhill. The land gently slopes down to Hollywell Brook (approximately 85m AOD) which is orientated west-east, roughly parallel with the A45. The land rises from the watercourse towards Diddington Hall (100m AOD) to the south of the A45. The elevation then declines south towards Shadow Brook at around 95m, which also flows west to east. The land rises to 98m AOD to the east at Siden Hill Wood southeast of Hampton in Arden. To the west the land rises to 120m AOD at Hampton Lane Farm, east of Catherine-de-Barnes. To the south of the study area the land rises to 120m AOD at Eastcote.

3.2.3 Land use is predominantly arable agriculture to the east of Solihull. The northern extent of the Scheme's Order Limits border Birmingham NEC and Birmingham Airport, including related facilities such as hotels, car parks, fuel stations and landscaping associated with Pendigo Lake. A railway line crosses the A45 south of Birmingham International Railway Station, west of M42 Junction 6.

3.2.4 Key settlements within the study area include Middle Bickenhill, Bickenhill and Catherine-de-Barnes.

3.3 Surface water features

3.3.1 An initial site visit and walkover was undertaken on 26 October 2017 in dry conditions.

3.3.2 Based on observations taken on this visit and data obtained from OS mapping, the following surface water bodies were identified within the study area:

a. River Blythe – Main River;

b. Hollywell Brook – Main River;

c. Shadow Brook – Main River;

d. Low Brook – Main River;

e. Tributary of Shadow Brook – Ordinary Watercourse;

f. Tributary of Low Brook – Ordinary Watercourse;

g. Grand Union Canal (Solihull to Birmingham);

h. Pendigo Lake;

i. Coleshill and Bannerly Pools;

j. Several unnamed small ponds; and

k. Several unnamed field drains and ditches.

3.3.3 Main Rivers are a statutory type of watercourse in England and Wales, usually comprising larger streams and rivers but also include some smaller watercourses[1].

3.3.4 In England, Main Rivers are designated by the Department for Environment, Food and Rural Affairs (DEFRA) and works that can affect the flow in them are controlled through water activity permits for flood defence enforced by the EA.

3.3.5 Similarly, consent may be required for certain works that may affect the flow in Ordinary Watercourses (i.e. all watercourses that are not Main Rivers) from the Lead Local Flood Authority (LLFA), which in this case is SMBC.

3.3.6 The attributes of the surface water features identified in the study area are described below.

River Blythe

3.3.7 The southern extents of the M42 motorway are included within the Scheme's Order Limits and cross the River Blythe, south of Friday Lane at grid reference SP 18602 79488.

3.3.8 The southern extents are located approximately 500m to the north of the River Blythe, and works within this section would focus on the modification and installation of emergency refuge areas, gantries and signage.

3.3.9 There are existing outfalls from the M42 motorway to the Blythe at this river crossing location; however, these outfalls are not proposed to be modified or utilised by the Scheme.

Hollywell Brook

3.3.10 Hollywell Brook flows east out of Pendigo Lake at the NEC. It is culverted under the M42 motorway parallel to the A45, and has two standing water bodies connected to the brook downstream of the lake. It meets the River Blythe approximately 2.2km downstream at SP 21390 83923.

3.3.11 As the brook flows out of Pendigo Lake the channel is very straight, with steep embankments either side of the channel. This is likely to have been linked to the straightening of the channel during NEC development works.

[1] The Main River designation for Hollywell Brook and Shadow Brook begins immediately downstream of the M42 motorway.

3.3.12 The channel of Hollywell Brook itself is approximately 3m wide and the culvert beneath the M42 motorway is circular and is approximately 3m in diameter.

3.3.13 Downstream of the culvert, the channel narrows to around approximately 1.5m wide as it crosses a fallow field. The brook is culverted through two pipes of approximately 1m width at Middle Bickenhall Lane.

Shadow Brook and its tributary

3.3.14 Shadow Brook flows in a north-easterly direction from its source northeast of Catherine-de-Barnes, to meet the River Blythe at Stonebridge Golf Club at SP 21612 82541. Upstream of the M42 motorway the brook comprises a series of agricultural drains along field boundaries that were completely dry and overgrown with low energy flows during the site visit. The ditches are approximately 1m wide. It is thought that the true source of the brook is likely to lie downstream of the M42 motorway with the drains acting as more recent extensions to the brook.

3.3.15 Shadow Brook was also observed further downstream where it crosses Shadowbrook Lane through a concrete pipe culvert approximately 1m wide. The channel width is approximately 1.5m wide.

3.3.16 A tributary of Shadow Brook, which is an ordinary watercourse, flows from just to the east of the junction of Shadowbrook Lane and Catherine-de-Barnes Lane in a north-easterly direction to meet Shadow Brook at SP 20640 82243. The source is mapped by OS as being immediately north of Shadowbrook Lane at the south of the southwestern unit of the Bickenhill Meadows Site of Special Scientific Interest (SSSI). Here, lateral drainage ditches from the road coalesce and flow north beneath the caravan park site and emerge at the southern border of the SSSI. There is a pond on the opposite (south) side of Shadowbrook Lane to the mapped source of the stream, which collects water from adjacent road and agricultural drainage.

3.3.17 On the initial site visit the watercourse was dry, but on subsequent visits (18 January 2018, 28 February 2018 and 2 May 2018) the watercourse was flowing freely. The watercourse is very straight and possibly originated as an agricultural drainage ditch. The watercourse was around 0.5m wide and 3-4cm deep during the site visit.

3.3.18 OS mapping suggests that the connectivity of the pond (located on the opposite (south) side of Shadowbrook Lane) to the stream on the opposite side of the road is via culverted section beneath the road; however, this was not visible during the site visits due to thick, overgrown vegetation. Significant amounts of standing water were observed in the ditches adjacent to the culvert after heavy rainfall, indicative of impeded flow through the culvert.

3.3.19 As the watercourse flows into the Bickenhill Meadows SSSI boundary it is culverted under a grassed land bridge through a pipe of around 400mm diameter. Upstream the culvert is partially buried and may cause impoundment of flow under very high discharge conditions. However, the stream is not considered significant enough in size to cause widespread out of bank events across the grasslands and woodland, and when consulted, Natural England and Warwickshire Wildlife Trust were not aware of any widespread flooding at the site resulting from out of bank stream flows.

Low Brook and its tributary

3.3.20 Low Brook rises to the east of Damson Parkway at SP 16721 81124, approximately 1.4km west of the Scheme's Order Limits. It flows in a generally northeast direction towards Birmingham Airport, where it is culverted beneath the runway. It emerges north of the airport and flows through Marston Green before meeting Hatchford-Kingshurst Brook at SP 17155 86349. At its closest location to the Scheme, Low Brook is approximately 640m from the Scheme's Order Limits at Clock Lane.

3.3.21 The tributary of Low Brook has its source 340m west of Catherine-de-Barnes Lane at SP 18212 82011, which is the southern boundary of the northwest unit of the Bickenhill Meadows SSSI. It flows directly north through Bickenhill Meadows SSSI and an arable agricultural field, before being culverted beneath the A45. The watercourse then flows northwest to its confluence with Low Brook at SP 17833 82957.

3.3.22 As the watercourse flows north it widens out into a marshland area of 4-5m width temporarily, with little discernible surface water flow, before reverting to a well-defined stream of up to 2.5m width which has generally good floodplain connectivity within Bickenhill Meadows SSSI.

3.3.23 As the watercourse leaves Bickenhill Meadows SSSI, it flows north through an arable field following the field boundaries with incised banks up to 1.5m deep. Several other agricultural drains join with this tributary at the north of the field as it approaches the A45.

Grand Union Canal

3.3.24 The Grand Union Canal crosses the B4102 around 800m west of the Scheme's Order Limits at Catherine-de-Barnes. At Catherine-de-Barnes the canal is aligned north-west to south-east. Topographical investigation using LiDAR shows that the canal is located upslope of the Scheme, with a further raised topographic mound located between the Scheme's south western extents and the canal, which during normal flow would prevent flow between the two (as the canal would not receive surface water, groundwater flows from the Scheme, or highway discharges).

Pendigo Lake

3.3.25 Pendigo Lake is an ornamental lake within the grounds of the NEC, located within 400m of the Scheme's Order Limits, and from which Hollywell Brook flows. The lake itself is around 3m deep and around 65,000m^2 in area, and is used for angling.

Coleshill and Bannerly Pools

3.3.26 There are three large pools at the north eastern extent of the study area, referred to as Coleshill and Bannerly Pools. These features are located between the M42 motorway and Packington Lane, and are designated as a SSSI, covering a combined area of 37.6ha. OS mapping indicates that there is no connectivity to upstream waterbodies and, although they are within the study area, they are located over 1.6km north of any highway improvement works proposed as part of the Scheme, and can be discounted from further consideration in the assessment.

Unnamed ponds

3.3.27 There are a number of small ponds scattered across the study area, notably seven small ponds surrounding Woodhouse Farm and a relatively large pond at Diddington Hall, located to the southeast of M42 Junction 6. The majority of ponds in the area do not receive an inflow from, or discharge to a watercourse as far as can be established from OS mapping, with the exception being those previously mentioned along Hollywell Brook, and an online pond on Low Brook east of Elmdon to the south of A45.

Unnamed field drains and ditches

3.3.28 A small stream/ditch rises just south of the A45 east bound slip road to Junction 6, and flows north through a culvert (which is to be extended) at SP 19541 83039, and ultimately discharges to Pendigo Lake. This was observed at the northern side of the A45 as it leaves the culvert and flows between two NEC car parks, and may have been the original headwaters of Hollywell Brook prior to the construction and landscaping of Pendigo Lake. This is a very straight and heavily engineered channel with a width of around 1m and only 4-5cm water depth observed during the site visit.

3.3.29 Further downstream this watercourse is culverted below ground before discharging into Pendigo Lake.

3.3.30 There are a number of other field drains within the study area, the most significant of which comprise the following:

a. an unnamed drain north of Park Farm which flows east from the existing M42 (SP 199 844) towards an unnamed waterbody near Church Farm Barn, which then flows southeast to the River Blythe. This watercourse passes through disused workings (Packington Landfill Site) to the north of Little Packington;

b. four unnamed drains to the north of Bickenhill at Clock Interchange;

c. four field drains to the east of Woodhouse Farm;

d. several artificial drains associated with Barston Sewage Treatment Works at SP 192 799; and

e. several field drains and ditches less than 300m west of Bickenhill, which coalesce with the tributary of Low Brook and ultimately meet Low Brook to the south of Birmingham Airport.

4 Legislative and policy framework

4.1 Legislation, policy and guidance

4.1.1 A summary of the legislation, policy and guidance documents relevant to, and considered within, the assessment is presented in the following sections.

4.2 European Union directives

4.2.1 The European Union (EU) Floods Directive [REF 4-1] makes provision for the assessment of flood risk, mapping its potential impact and planning measures to reduce potential and significant flood risk.

4.3 National legislation

4.3.1 The objectives and requirements of the Floods Directive [REF 4-1] are met through the following UK legislation:

a. Water Act 2014 [REF 4-2];

b. Flood and Water Management Act 2010 [REF 4-3];

c. Land Drainage Act 1991 [REF 4-4]; and

d. The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 [REF 4-5].

4.4 National policy

National Policy Statement for National Networks

4.4.1 NPSNN [REF 1-2] paragraphs 5.90 - 5.115 specifically apply to flood risk and how impacts on the water environment affect the decision making process.

4.4.2 The NPSNN states that when determining an application, the Secretary of State should be satisfied that flood risk will not be increased elsewhere, and only consider development appropriate in areas at risk of flooding where it can be demonstrated that the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location; and development is appropriately flood resilient and resistant, including safe access and escape routes where required, and that any residual risk can be safely managed, including by emergency planning. Priority is given to the use of Sustainable Drainage Systems (SuDS).

4.4.3 In preparing a FRA the applicant should:

a. consider the risk of all forms of flooding arising from the project (including in adjacent parts of the United Kingdom), in addition to the risk of flooding to the project, and demonstrate how these risks will be managed and, where relevant, mitigated, so that the development remains safe throughout its lifetime;

b. take the impacts of climate change into account, clearly stating the development lifetime over which the assessment has been made;

c. consider the vulnerability of those using the infrastructure including arrangements for safe access and exit;

d. include the assessment of the remaining (known as ‘residual’) risk, after risk reduction measures have been taken into account and demonstrate that this is acceptable for the particular project;

e. consider if there is a need to remain operational during a worst case flood event over the development’s lifetime; and

f. provide the evidence for the Secretary of State to apply the Sequential Test and Exception Test, as appropriate.

National Planning Policy Framework

4.4.4 The NPPF [REF 1-3] contains statements relating to water resources and flood risk. Key statements within sections 11 and 14 relate to:

a. an acknowledgement that undeveloped land can function as flood risk mitigation;

b. directing development away from areas with a high risk of flooding; and

c. assessing flood risk and applying the Sequential Test to meet the challenges of climate change, flooding and coastal change.

Planning Practice Guidance: Flood risk and coastal change

4.4.5 PPG relating to flood risk and coastal change [REF 1-4] provides guidance for local planning authorities on assessing the significance of water environment effects of proposed developments. The guidance highlights that adequate water and wastewater infrastructure is needed to support sustainable development.

The Sequential Test and Exception Test

4.4.6 The overall aim of the Sequential Test is to steer new development to Flood Zone 1. Where there are no reasonably available sites in Flood Zone 1, projects can consider reasonably available sites in Flood Zone 2. If there is no reasonably available site in Flood Zones 1 or 2, then national networks infrastructure projects can be located in Flood Zone 3, subject to the Exception Test. If the development is not essential transport infrastructure that has to cross the area at risk, it is not appropriate in Flood Zone 3b, the functional floodplain where water has to flow and be stored in times of flood.

4.4.7 For the Exception Test to be passed:

a. it must be demonstrated that the project provides wider sustainability benefits to the community that outweigh flood risk; and

b. a FRA must demonstrate that the project will be safe for its lifetime, without increasing flood risk elsewhere and, where possible, will reduce flood risk overall.

4.4.8 Both elements of the test have to be passed for development to be allocated or permitted.

Development and flood risk vulnerability

4.4.9 The NPPF [REF 1-3] considers the vulnerability of different forms of development to flooding and classifies proposed uses accordingly. As mentioned in Chapter 2 Site and surroundings, the Scheme would comprise junction improvements. Based on Table 2 'Flood risk vulnerability classification' of the PPG [REF 1-4], proposed junction improvements are considered as 'Essential Infrastructure' under the heading "*Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk*".

4.4.10 The PPG [REF 1-4] illustrates a matrix which identifies which vulnerability classifications are appropriate within each flood zone - this is presented in **Table 4.1**.

Table 4.1: Flood risk vulnerability and flood zone classification

Flood risk vulnerability classification	Essential infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	✓	Exception test required	✓	✓
Zone 3a	Exception test required	✓	×	Exception test required	✓
Zone 3b 'functional floodplain'	Exception test required	✓	×	×	×

Key: ✓ Development is appropriate × Development should not be permitted

4.4.11 Based on the classification shown in **Table 4.1**, the Scheme use (comprising of Essential Infrastructure) is considered appropriate in Flood Zones 1 and 2 and may be appropriate in Flood Zone 3a and 3b, providing the development can satisfy the requirements of the Exception Test.

Exception Test

4.4.12 The Scheme would cross local watercourses and small, localised areas of land classed as Flood Zone 3 associated with Hollywell Brook.

4.4.13 In line with Part 1 of the Exception Test, the Scheme would provide wider sustainability benefits to the community as follows:

a. the 'Road Investment Strategy: for the 2015/16 – 2019/20 Road Period' (RIS1) [REF 4-6], published 12/03/2015, indicated the project as a committed new scheme first announced in Autumn Statement 2014, stating that the Scheme is a "*comprehensive upgrade of the M42 Junction 6 near Birmingham Airport, allowing better movement of traffic on and off the A45, supporting access to the airport and preparing capacity for the new HS2 station*";

b. the Scheme forms part of a much larger Government/High Speed 2 (HS2) Growth Strategy being developed with local partners to maximise the economic benefits of HS2;

c. the Scheme would help facilitate significant economic growth in the area given that it would lie at the heart of an area of dynamic growth, surrounded by a unique mix of existing and proposed major assets serving both the local and wider economy. Junction 6 is the gateway to Birmingham Airport, Birmingham International Network Rail Station, the Birmingham NEC, the National Motorcycle Museum and National Conference Centre, Birmingham Business Park and Jaguar Land Rover;

d. in addition to the committed growth in the area, HS2's Birmingham Interchange station is anticipated to be operational by 2026, and SMBC has ambitious plans to accommodate mixed use development at the UK Central Hub area. Collectively these developments will continue to add significant demand to the highway network and increase dependence on M42 Junction 6; and

e. current congestion and journey reliability issues on the M42 motorway and at M42 Junction 6 present a significant constraint to future investment and economic growth. Without infrastructure investment to improve Junction 6, a major investment opportunity of national significance could be lost.

Flood risk assessments: climate change allowances

4.4.14 The EA publication Flood Risk Assessments: Climate Change Allowances [REF 4-7] provides catchment/region specific uplift factors for peak fluvial flow and peak rainfall intensity across three future scenarios:

a. total potential change anticipated for the '2020s' (2015 to 2039);

b. total potential change anticipated for the '2050s' (2040 to 2069); and

c. total potential change anticipated for the '2080s' (2070 to 2115).

4.4.15 Within each of the three scenarios, the estimates for peak fluvial flow can be further divided into Central, Higher Central and Upper End and the peak rainfall intensity can be further divided into Central and Upper End; the specific scenario chosen is reflective of a development's vulnerability and potential to impact flood risk elsewhere.

4.4.16 Climate change is discussed further in the assessment in Chapter 15 Climate.

Sustainable drainage systems guidance

4.4.17 Paragraph 5.111 of the NPSNN [REF 1-2] encourages developers to include SuDS in their proposals where practicable to manage surface water drainage.

4.4.18 SuDS provide a way to attenuate runoff from a site to the rate agreed with the EA to avoid increasing flood risk, and also have an important role in reducing the quantities and concentration of diffuse pollutants found in the runoff.

4.4.19 Current best practice guidance on the planning for and design of SuDS treatment is provided by the following documents:

a. DEFRA published non-statutory guidance on the use, design and construction of SuDS [REF 4-8];

b. The SuDS Manual (C753) [REF 4-9]; and

c. Design Manual for Roads and Bridges (DMRB): Volume 4, Section 2, Part 1 – Vegetated Drainage Systems for Highway Runoff [REF 4-10]; and

d. DMRB: Volume 4, Section 2, Part 3 – Surface and Sub-surface Drainage Systems for Highways [REF 4-11].

4.5 Local planning policy

Solihull Local Plan

4.5.1 The Solihull Local Plan [REF 4-12] sets out the main challenges the borough faces with regards flood risk and climate change:

a. CHALLENGE F – Climate Change - vi. Risk of increased surface water flooding in urban areas. The objectives include:

i. ensure that new development does not increase, and where possible reduces risks such as flooding; and

ii. ensure new development, and where possible existing communities have resilience to the effects of future climate change.

b. CHALLENGE L – Water Quality and Flood Risk - i. Poor or moderate quality of the Borough's main water bodies, the Rivers Blythe and Cole and their tributaries, and increasing risk of flooding associated with new development. The objectives include i) minimising the risk of flooding by avoiding development in high risk areas wherever possible, ii) reducing flows to rivers during periods of high intensity rainfall, and iii) ensuring that new development is designed so as to minimise surface water flooding risks.

4.5.2 Relevant borough wide policies with specific regard to flood risk and surface water management that have been considered in the assessment comprise:

a. Policy P9 Climate Change;

b. Policy P11 Water Management; and

c. Policy P15 Securing Design Quality.

North Warwickshire Borough Council

4.5.3 The north eastern extents of the assessment study area extend into the jurisdiction of North Warwickshire Borough Council.

4.5.4 The North Warwickshire Local Plan [REF 4-13] was formally submitted to the Secretary of State in March 2018 for independent examination. Regard has been given to the following policies in the assessment:

a. Policy LP31 Development Considerations; and

b. Policy LP35 Water Management.

4.6 Other policy and guidance

SMBC Level 1 and Level 2 Strategic Flood Risk Assessment

4.6.1 SMBC's Level 1 Strategic Flood Risk Assessment (SFRA) [REF 4-14] and Level 2 SFRA [REF 4-15] provide a high level overview of the various flood risks to the borough of Solihull.

4.6.2 Both documents have been used in the assessment to inform the level of flood risk to the Scheme.

SMBC Local Flood Risk Management Strategy

4.6.3 SMBC, as the LLFA, is responsible for leading and coordinating local flood risk management, including flood risk from ordinary watercourses, surface water, and groundwater.

4.6.4 SMBC's Local Flood Risk Management Strategy [REF 4-16] provides an overview and assessment of local flood risk, and sets out objectives and processes as to how Solihull Council will manage and reduce this risk.

4.6.5 Reference has been made in the assessment to the information and objectives contained in this local strategy.

5 Flood risk assessment methodology

5.1 Scope of the assessment

5.1.1 The scope of the assessment has involved a number of key tasks, using a combination of desk-based research, site surveys and modelling to establish the baseline conditions of the area within which the Scheme would be progressed, and to identify and assess potential flood risk.

Identification of potential sources of flood risk and consultation

5.1.2 A review of existing information relating to the flood risk existing flood risk conditions and potential changes in flood risk as a result of the Scheme from all sources (fluvial and tidal, surface water, artificial sources, groundwater and sewer flooding) was undertaken, using the data sources presented in **Table 5.1**.

Table 5.1: Summary of data sources

Purpose	Data Source	Comments
Identification of Hydrological Features	1: 25,000 scale OS mapping	Identifies the area within which the Scheme would be progressed, and local hydrological features.
Historical Land Use and Hydrological Features	Historic OS maps dating back from 1888-present [REF 5-3]	Identifies historical land use change and hydrological features over the last 130 years.
Identification of Existing Flood Risk	Topographical survey and LiDAR data (see Appendix B)	Provides existing Site levels. LiDAR data provides a Digital Elevation Model containing the ground level of a particular point.
	EA Indicative Flood Zone Map (see **Figure 6.1**)	Identifies fluvial/ tidal inundation extents and historical flooding.
	EA Flood Inundation Mapping and Risk of Flooding from Surface Water [REF 5-4]	Provides information on the risk of flooding from reservoirs (artificial sources) and surface water.
	EA Consultation undertaken in September 2017 (see Appendix C)	Information from the EA on existing Flood Risk.
	SMBC Level 1 Strategic Flood Risk Assessment (SFRA) [REF 4-14]	Assesses flood risk across the SMBC boundary. Includes flood risk from fluvial/tidal, sewers, overland flow and groundwater.
	SMBC Level 2 SFRA [REF 4-15]	
	SMBC Local Flood Risk Management Strategy (LFRMS) [REF 4-16]	
	SMBC Preliminary Flood Risk Assessment (PFRA) [REF 5-5]	
	British Geological Survey (BGS) records [REF 5-6]	Provides details of the geological environment.
	Hollywell Brook Capacity Assessment & Modelling Report (see Appendix D)	Hydraulic modelling of Hollywell Brook was undertaken to determine flood zone extents and the channel capacity of the watercourse.
Identification of Historical Flooding	EA Consultation (see Appendix C)	Provides details of historical flooding.
	SMBC Consultation (see Appendix E)	
	SMBC SFRAs [REF 4-14, REF 4-15]	
	SMBC PFRA [REF 5-5]	

Purpose	Data Source	Comments
Details of the Scheme	Preliminary design (see Appendix A)	Provides the engineering layout of the Scheme.

5.1.3 A review of the Scheme's Order Limits (illustrated in Appendix A) against current OS 1:25,000 scale mapping identified that the Scheme would cross the following watercourses:

a. Hollywell Brook;

b. Shadow Brook;

c. a tributary of Shadow Brook; and

d. a tributary of Pendigo Lake.

5.1.4 The review also identified two additional watercourses, the River Blythe and Low Brook, located within 1 km of the Scheme's Order Limits.

5.1.5 Site surveys of these watercourses were undertaken on the following dates to supplement the information obtained through desk study:

a. 26 October 2017;

b. 18 January 2018;

c. 28 February 2018; and

d. 2 May 2018.

5.1.6 A review of the EA's Indicative Flood Zone Map (see **Figure 6.1**) and the related Flood Zone definitions presented in **Table 5.2**, as reproduced from the PPG [REF 1-4], was undertaken to identify the relationship between the Scheme and areas identified as being at risk of flooding.

Table 5.2: EA flood zone definitions

Flood Zone	Definition	Probability of Flooding
Flood Zone 1	Land that has a low probability of flooding (less than 1 in 1,000 annual probability of river or sea flooding (<0.1% AEP)).	Low
Flood Zone 2	Land that has a medium probability of flooding (between 1 in 100 and 1 in 1,000 annual probability of river flooding (0.1-1% AEP), or between 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.1-0.5% AEP)).	Medium
Flood Zone 3a	Land that has a high probability of flooding (1 in 100 year or greater annual probability of river flooding (>1% AEP), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5% AEP)).	High
Flood Zone 3b (Functional Floodplain)	Land where water has to flow or be stored in times of flood based on flood modelling of a 5% AEP event (1 in 20 chance of flooding in any one year) or greater, or land purposely designed to be flooded in an extreme flood event (0.1% AEP).	Very High

5.1.7 A review of the relationship between the Scheme and these Flood Zones indicated that:

a. the majority of the Scheme would be located within Flood Zone 1, which is considered to have a low risk of flooding; and

b. small areas of land in proximity to the points at which the Scheme would cross the four identified watercourses are located within Flood Zone 2 and Flood Zone 3, which are of medium and high risk to flooding respectively.

5.1.8 Hollywell Brook is shown to be located within Flood Zone 2 and 3 i.e. at a medium and high risk of fluvial flooding respectively, on the EA Flood Map for Planning (**Figure 6.1**). A review of channel capacity and topographic information indicated that the flood map for planning did not provide a realistic representation of flood zones. Therefore hydraulic modelling was undertaken of Hollywell Brook to define channel capacity and flood zones (see Appendix D in this document). This was progressed to determine baseline flood zone extents, the capacity of the watercourse and, based on the modelling outputs, the volume of land that may be required for flood compensation as a result of the Scheme's extents extending into the floodplain (Flood Zone 3).

Consultation

5.1.9 Consultation was undertaken with SMBC and the EA in relation to flood risk, and to identify their requirements for the management of any risk identified.

5.1.10 Details of consultation undertaken with the EA in September 2017 are presented in Appendix C.

5.1.11 Details of consultation undertaken with SMBC in October 2017 are presented in Appendix E.

Assessment of flood risk and identification of mitigation measures

5.1.12 The assessment of flood risk to the Scheme was undertaken for both the existing and post-development conditions, taking into account climate change.

5.1.13 Based on the outcomes of the assessment, and where required, mitigation measures were developed and incorporated into the design of the Scheme to ensure the Scheme and its users would be safe for the lifetime of the development, and to meet the requirements of the NPSNN [REF 1-2].

5.1.14 The consideration of tidal flooding from sources including the sea and estuaries was scoped out of the assessment, due to the distance from the Scheme to the nearest coastline.

6 Flood risk

6.1 Fluvial flooding

6.1.1 Flood risk areas and the crossing locations of the watercourses identified in Chapter 2 Site and surroundings are assessed in detail in the following sections.

River Blythe

6.1.2 The River Blythe is a Main River, and land immediately surrounding river is classified as Flood Zone 2 and 3 i.e. at a medium and high risk of flooding respectively.

6.1.3 The southern extent of the Scheme boundary crosses the River Blythe, but the nearest improvement works are to take place over 400m to the north, with the crossing itself unaffected.

6.1.4 Given the distance of this watercourse and the topography of the land, the assessment has identified that the Scheme would be at low risk of flooding from the River Blythe.

Hollywell Brook

6.1.5 Hollywell Brook is classed as a Main River immediately downstream of the M42 crossing, and the land surrounding Hollywell Brook is shown to be located within Flood Zone 2 and 3 i.e. at a medium and high risk of fluvial flooding respectively, on the EA Flood Map for Planning (see **Figure 6.1**).

Shadow Brook and tributary of Shadow Brook

6.1.6 Shadow Brook (Main River) from downstream of the M42 motorway originates in the central area of the Scheme's Order Limits.

6.1.7 Upstream of the M42 motorway, the adjacent land is classed as Flood Zone 1 i.e. at low risk of fluvial flooding. East of the M42 motorway, the adjacent land is classified as Flood Zone 3 i.e. at high risk of fluvial flooding.

6.1.8 The tributary originates west of the M42 motorway by Shadowbrook Lane, before flowing north east where the stream is culverted. Land directly adjacent to the tributary and the wider area is located entirely within Flood Zone 1 i.e. at low risk of fluvial flooding.

6.1.9 Existing M42 crossings of Shadow Brook and its tributary are maintained and no changes are proposed to these. The tributary of Shadow Brook is located beyond the Scheme's Order Limits, and the assessment has concluded that there would be minimal effect on fluvial flood risk in the tributary as a consequence of the Scheme.

Low Brook

6.1.10 Low Brook is an ordinary watercourse, and the extent of Low Brook within close proximity to the Scheme is mainly located within Flood Zone 1 i.e. at low risk of fluvial flooding.

6.1.11 Low Brook drains away from Clock Interchange, and as such the assessment has recorded that the risk of fluvial flooding from Low Brook would not alter as a result of the Scheme.

Small watercourse beneath A45 to Pendigo Lake

6.1.12 A small unnamed ordinary watercourse flows north from the A45 by the western arm of M42 Junction 6. This watercourse is culverted beneath the A45, and originates from Wyckhams Close. The watercourse continues in an open channel until it is culverted beneath highway infrastructure.

6.1.13 It is assumed the watercourse discharges into Pendigo Lake via a culvert.

6.1.14 Land directly adjacent to the tributary and the wider area is located entirely within Flood Zone 1 i.e. at low risk of fluvial flooding.

6.1.15 A culvert extension in the location of the A45 is proposed within the design of the Scheme; the impact of this extension on flood risk is considered in Chapter 7.

Flooding history

6.1.16 The EA has no record of fluvial flooding; however, the Level 2 SFRA [REF 4-15] indicates historic fluvial flood events have been recorded as having impacted critical infrastructure including Birmingham International Airport, the NEC and the A45.

6.1.17 Based on this information, it cannot be confirmed if land associated with the Scheme was affected during these events.

6.1.18 The preliminary flood risk assessment (PFRA) [REF 5-5] notes that there are historic records of Low Brook flooding, the extents of which include the A45 and the boundary of Birmingham Airport.

Flood defences

6.1.19 There are no EA raised flood defences located in proximity to the Scheme.

Modelled in-channel flood levels

6.1.20 The Scheme would cross small, localised areas of land classed as Flood Zone 3 associated with Hollywell Brook as it passes beneath the M42 motorway to the north of M42 Junction 6.

6.1.21 As the EA has no modelled flood water levels for the watercourses within, and in proximity to, the Scheme's Order Limits, hydraulic modelling of Hollywell Brook (see Appendix D) was undertaken. In summary, this determined that:

a. the channel does not exceed capacity in the 1 in 100 year event plus 50% allowance for climate change;

b. the capacity of the channel is sufficient to retain flow associated with a 1 in 100 year event plus 50% allowance for climate change event, and as such the land surrounding the channel is not located in Flood Zone 3 as suggested on the EA Flood Map (see **Figure 6.1**); and

c. as the Scheme would not encroach into an area designated as Flood Zone 3, there is no requirement to provide flood compensatory storage mitigation along Hollywell Brook.

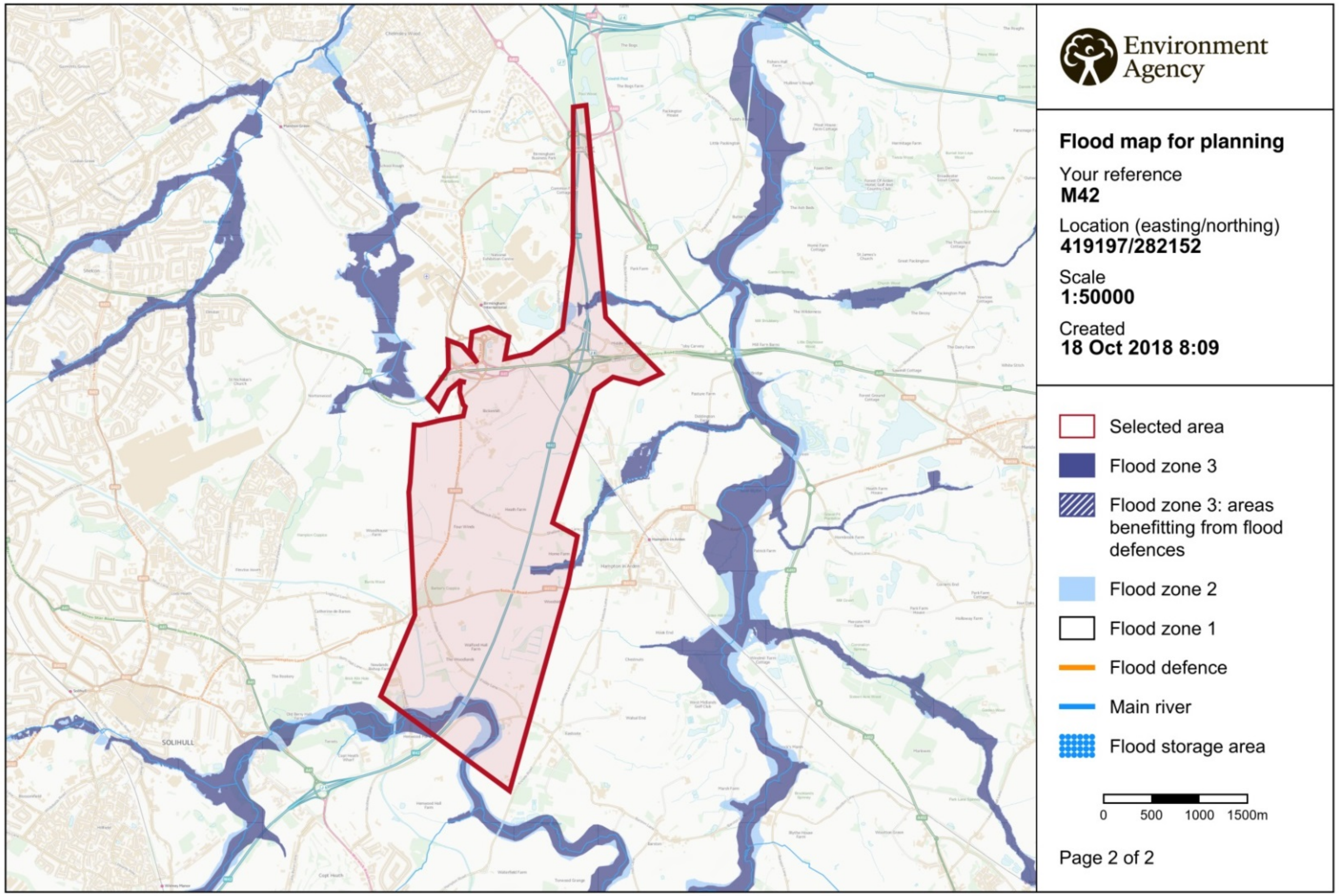

Figure 6.1: EA flood map for planning

6.2 Surface water (overland flow)

6.2.1 Overland flow results from rainfall that fails to infiltrate the surface and travels over the ground surface. This is exacerbated where the permeability of the ground is low due to the type of soil and geology (such as clayey soils) or urban development with impermeable surfaces.

6.2.2 The LFRMS [REF 4-16] states:

"There are multiple causes of surface water flooding including overland flows, inundation of the sewerage system and overtopping of drainage ditches. As such surface water flooding cannot be separated from ordinary watercourse flooding. In Solihull, surface water flooding is most common on highways and agricultural land where the associated drainage network becomes overwhelmed. Surface water flooding has been the most significant flooding issue within the Borough, and has been particularly concentrated towards the west where the urban areas are located".

6.2.3 The EA published the Risk of Flooding from Surface Water (RoFSW) flood maps in December 2013 and these are available online (Long Term Risks of Flooding Maps) [REF 5-4]. The maps indicate areas at risk from surface water flooding, when rainwater does not drain away through the normal drainage systems or soak into the ground, but instead lies on or flows over the ground. The map shows that the majority of the Scheme is considered to be at 'very low' risk of flooding from surface water. The EA define 'very low risk' as an area that has a chance of flooding that is less than 0.1% AEP in any given year.

6.2.4 Areas at low (considered to have a chance of flooding between a 1% AEP and 0.1% AEP in any year), medium (considered to have a chance of flooding between a 33.3% AEP and 1% AEP) and high risk (considered to have a chance of flooding greater than 33.3% AEP) of flooding are located in proximity to the Scheme. These are predicted to be associated with topographical low spots throughout the area, causing surface water to pond or reflective of the location of local watercourses and drainage ditches.

6.2.5 The PFRA [REF 5-5] states that rural and permeable areas are considered to be at low risk of surface water flooding, and it is not believed that the consequences of flooding are likely to be significant.

6.2.6 Based on the information above the risk of flooding from overland flow is considered to be low.

6.3 Artificial waterbodies

6.3.1 Artificial flood sources include raised channels, such as canals, or storage features such as ponds and reservoirs.

6.3.2 The Reservoir Act 1975 [REF 6-1] defines a large reservoir as one that holds over 25,000 cubic metres (m^3) of water, although this is expected to be reduced to 10,000m^3 under a review into the safety legislation and regulation of reservoirs, and is expected to be phased in by the EA once this comes into effect under the Flood and Water Management Act [REF 4-3].

6.3.3 Pendigo Lake, located approximately 300m west of the proposed crossing point of the Scheme with Hollywell Brook, is classified as a reservoir on the EA online Long-term Risk of Flooding map [REF 5-4]. The map indicates that the Scheme would not be located in an area at residual risk of flooding from structural failure or breach of Pendigo Lake, as flood waters would be contained west of the M42.

6.3.4 The strategic flood risk assessment (SFRA) [REF 4-14] states that investigation into the history of the reservoir did not uncover any records of breach or overtopping.

6.3.5 The Grand Union Canal is an artificial waterbody located west of the junction of Catherine-de-Barnes Lane and Solihull Road, which falls under the jurisdiction of the Canals and Rivers Trust. Given the local topography and its distance from the Scheme, no flood risk from this source is predicted.

6.3.6 There are a number of ponds within the study area; however, the risk of flooding from these ponds is expected to be localised and would not pose a significant flood risk to the Scheme.

6.3.7 Based on this information, the current risk of flooding from artificial sources is considered to be low.

6.4 Groundwater flooding

Geology

6.4.1 British Geological Survey [REF 5-6] mapping indicates that the bedrock underlying the Scheme's Order Limits consists predominantly of Sidmouth Formation Mudstone. There are some areas of Branscombe Mudstone Formation (Mudstone), notably to the northeast of the site and around Catherine-de-Barnes. Arden Sandstone Formation (Sandstone, Siltstone, Mudstone) is found in small patches including at the NEC, the immediate east of Bickenhill and south of Catherine-de-Barnes.

6.4.2 Superficial deposits are generally sparse in the area, but there are small scattered patches of glaciofluvial deposits (sands and gravels), and this is more widespread around Catherine-de-Barnes. Alluvium is found in the immediate vicinity of the larger watercourses.

Hydrogeology

6.4.3 The superficial aquifer designation is a mixture of non-classified and Secondary A aquifer. The designated areas are mainly around the NEC, Catherine-de-Barnes and Hampton in Arden, with other small patches scattered over the site.

6.4.4 Secondary A aquifers are defined as "permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers" [REF 6-2].

6.4.5 The underlying bedrock, including the Sidmouth Mudstone and Branscombe Mudstone Formations, are classified as Secondary B aquifers.

6.4.6 Secondary B aquifers are defined as “predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering”. These are generally the water-bearing parts of former non-aquifers. [REF 6-2].

6.4.7 The Cranfield Soil and Agrifood Institute Soilscapes website [REF 6-3] indicates the area is underlain by slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils.

6.4.8 The groundwater vulnerability zones around the area of the Scheme are mainly minor aquifer high [vulnerability] and minor aquifer low [vulnerability].

6.4.9 There are no groundwater source protection zones within the study area.

6.4.10 **Figure 6.2** illustrates the EA mapped superficial aquifer designation, and **Figure 6.3** illustrates the EA mapped bedrock aquifer designation.

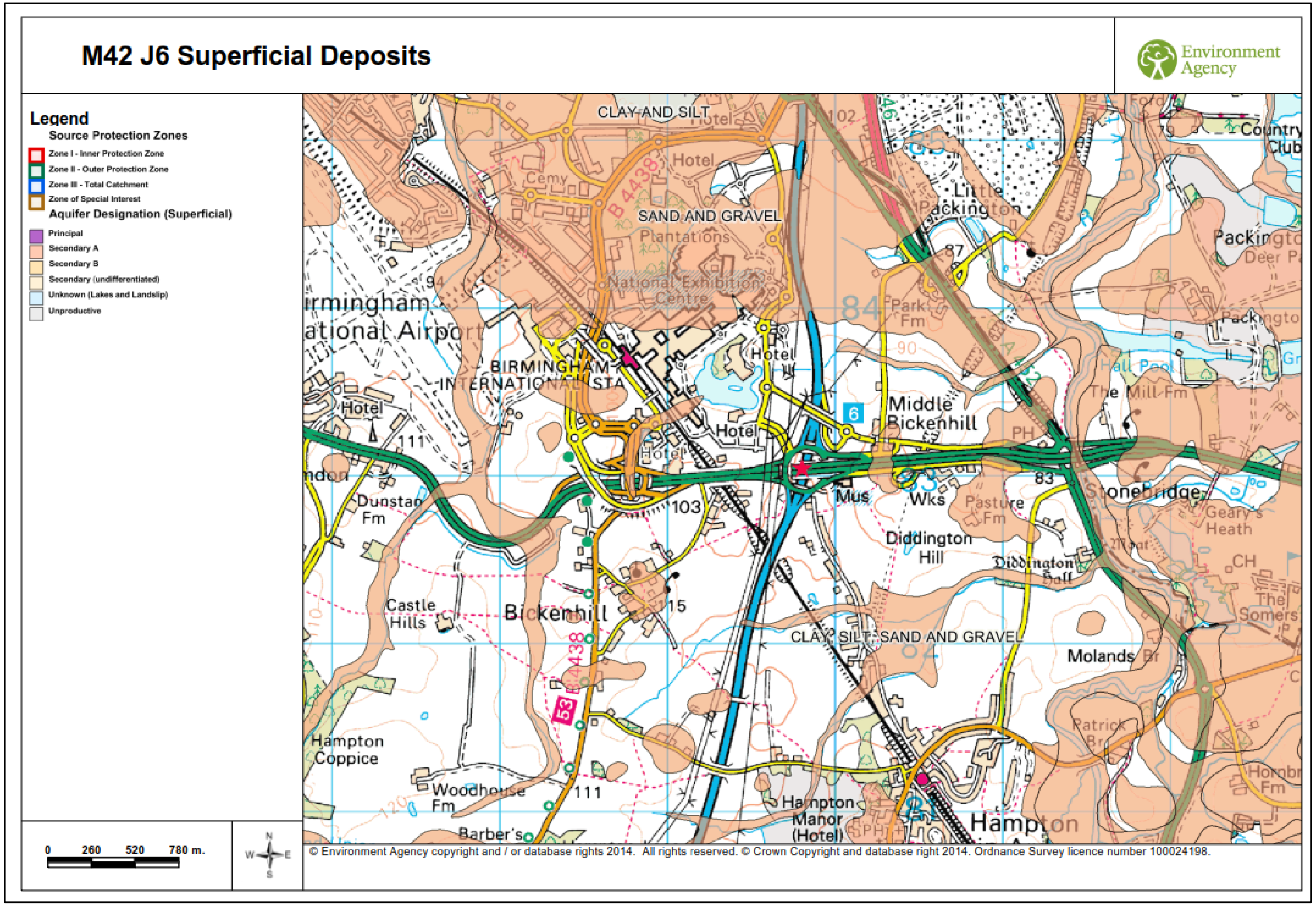

Figure 6.2: Superficial aquifer designation

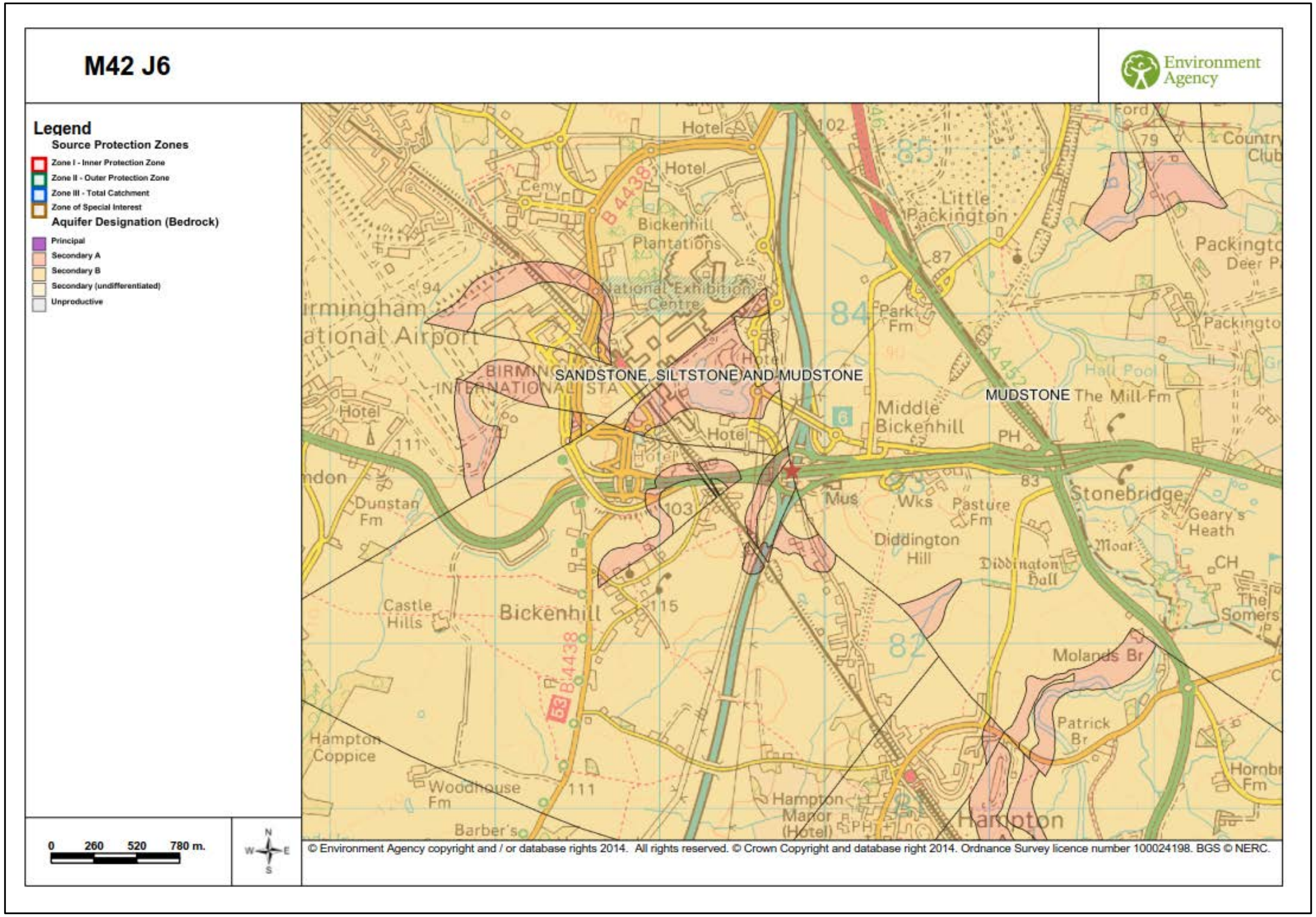

Figure 6.3: Bedrock aquifer designation

Groundwater levels

6.4.11 Borehole records collected from ground investigations historically undertaken during the development of the M42 motorway in the 1970s and 1980s recorded that groundwater was generally encountered within 10m of the ground surface adjacent to the M42 at Junction 6.

6.4.12 Borehole records available at the north western corner of the Bickenhill Meadows north west SSSI unit showed depth to groundwater of 6.75m in 1978 (reference SP18SE/511), and the borehole log indicates sand and gravel pockets within clay to a depth of 4.7m. Another borehole approximately 0.13km to the south of Bickenhill Meadows SSSI had a depth to water of 3.0m, also in 1978 (reference SP18SE/510).

Groundwater flooding

6.4.13 The SFRA [REF 4-14] states there are no known problems with flooding from groundwater within the borough of Solihull.

6.4.14 The ‘Areas Susceptible to Groundwater Flooding’ maps provided by the EA to inform the PFRA [REF 5-5] have been used to identify areas where geological and hydrogeological conditions show that groundwater might emerge. This information is shown as a proportion of 1km grid squares where there is potential for groundwater emergence. The data does not show where flooding is likely to occur, but instead is used at a strategic level to indicate areas for further investigation.

6.4.15 The dataset presented in the PFRA [REF 5-5] indicates that land to the north of A45 and M42 Junction 6 is located in an area with >= 50% <75% risk of groundwater emergence whilst the Scheme to the south of A45 and M42 Junction 6 is located in an area with < 25% risk of groundwater emergence.

6.4.16 Considering the susceptibility data and the lack of flooding shown in historic flood records, the Scheme is classified as being at low flood risk from groundwater sources.

6.4.17 Groundwater may be encountered during construction of the Scheme. Should groundwater emergence occur, standard construction mitigation measures would be implemented by the contractor to reduce the risk of flooding, as presented in the Outline Environmental Management Plan [**TR010027/APP/6.11**].

6.5 Drainage and sewer infrastructure

6.5.1 Sewer and surface water flooding are often interconnected; insufficient drainage capacity in the sewer network can result in extensive surface water flooding and, by the same rationale, large volumes of surface water can overload the public sewers, causing the sewer network to back up, surcharge and ultimately flood.

Existing drainage

6.5.2 The existing greenfield catchments drain to various named and unnamed watercourses, including Shadow Brook, located towards the southern section of the dual carriageway. There is no record of sub-surface land drainage within the existing fields.

6.5.3 The existing slip roads on the approach to and leaving M42 Junction 6 are kerbed with gullies and are the main method for draining the carriageway.

6.5.4 Sections of the M42 motorway carriageway within the Scheme's Order Limits is mainly un-kerbed, and filter drains are provided to drain the carriageway.

6.5.5 The existing drainage on the local road network including Solihull Road, Catherine-de-Barnes Lane, Bickenhill Lane and also Clock Interchange consists of mainly kerbs and gullies, with some combined kerb drainage.

6.5.6 Catherine-de-Barnes Lane is kerbed and drained by gullies in sections within the Scheme's Order Limits. It has been assumed that the gullies outfall into carrier pipe networks, which in turn discharge to existing named or unnamed watercourses.

6.5.7 Solihull Road is kerbed and drained by gullies in sections within the Scheme's Order Limits. It has been assumed that the gullies outfall either over the edge, or into a carrier pipe network. Runoff flows from Solihull Road and the M42 motorway are then discharged to an existing watercourse on the eastern side of the M42 motorway.

6.5.8 In sections within the Scheme's Order Limits, Clock Interchange and Bickenhill Lane are kerbed and drained by gullies or combined kerb units into a carrier pipe network. Runoff flows from Clock Interchange and Bickenhill Lane are then discharged to existing watercourses to the north and south of Clock Interchange.

6.5.9 The SFRA [REF 4-14] indicates the Scheme crosses the four digit postcode area (B92 0) where four properties have been affected by flooding from drains or sewers, according to the Severn Trent Water DG5 register[2]. However, the data included within the SFRA [REF 4-14] is over 10 years old and as the Scheme would not cross settlement areas (mainly greenfield land), there is expected to be a low risk of flooding to the Scheme.

6.5.10 Based on this information, the risk of flooding from drainage and sewer infrastructure is considered low.

[2] A DG5 register is a register of properties held by the local water utilities company that have flooded (internally and externally) as a result of hydraulic incapacity in the public sewer network. It is not a register of properties at risk of flooding.

7 Climate change

7.1 Context

7.1.1 The NPSNN [REF 1-2] requires site specific FRAs accompanying planning applications to assess the risk of all sources of flooding to and from a development and to demonstrate how these flood risks will be managed, so that the development remains safe throughout its lifetime, taking climate change into account in line with the NPPF [REF 1-3].

7.1.2 The EA published climate change guidance [REF 4-7] for the NPPF [REF 1-3] indicates that climate change is likely to have an impact on river flows, sea levels, rainfall intensity, wave height and wind speed. This guidance has been used to assess the effects of climate change on the Scheme from fluvial and surface water sources, and in the hydraulic modelling of Hollywell Brook (see Appendix D).

7.2 Peak river flow allowances by river basin district

7.2.1 The peak river flow allowances show the anticipated changes to peak flow by river basin district. The range of climate change allowances is based on percentiles. A percentile is a measure used in statistics to describe the proportion of possible scenarios that fall below an allowance level. The 50th percentile is the point at which half of the possible scenarios for peak flows fall below it and half fall above it.

a. central allowance is based on the 50th percentile;

b. higher central is based on the 70th percentile; and

c. upper end is based on the 90th percentile.

7.2.2 The EA guidance [REF 4-7] states “If the central allowance is 30%, scientific evidence suggests that it is just as likely that the increase in peak river flow will be more than 30% as less than 30%”.

7.2.3 At the higher central allowance, 70% of the possible scenarios fall below this value. So, if the higher allowance is 40%, then current scientific evidence suggests that there is a 70% chance that peak flows will increase by less than this value, but there remains a 30% chance that peak flows will increase by more.

7.2.4 The Scheme lies within the Humber River Basin District. **Table 7.1** shows the climate change allowances for the Humber River Basin District.

Table 7.1: Climate change allowances for the Humber River Basin District

Allowance Category	Total potential change anticipated for ‘2020s’ (2015 to 2039)	Total potential change anticipated for ‘2050s’ (2040 to 2069)	Total potential change anticipated for ‘2080s’ (2070 to 2115)
Upper End	20%	30%	50%
Higher Central	15%	20%	30%
Central	10%	15%	20%

Peak river flow allowances for different assessments

7.2.5 For FRAs the EA guidance [REF 4-7] states that the “flood risk vulnerability classification” for the type of development and the “flood zone” should be used to decide which peak river flow allowances (allowance category) to use, based on the lifetime of the Scheme.

7.2.6 **Table 7.2** shows the peak river flow for the different flood risk vulnerability classifications for each flood zone, as stated in the PPG [REF 1-4].

Table 7.2: Peak river flow allowances based on flood risk vulnerability classification and flood zone

Flood Zone 2
• Essential infrastructure – use the higher central and upper end to assess a range of allowances • Highly vulnerable – use the higher central and upper end to assess a range of allowances • More vulnerable – use the central and higher central to assess a range of allowances • Less vulnerable – use the central allowance • Water compatible – use none of the allowances
Flood Zone 3a
• Essential infrastructure – use the upper end allowance • Highly vulnerable – development should not be permitted • More vulnerable – use the higher central and upper end to assess a range of allowances • Less vulnerable – use the central and higher central to assess a range of allowances • Water compatible – use the central allowance
Flood Zone 3b
• Essential infrastructure – use the upper end allowance • Highly vulnerable – development should not be permitted • More vulnerable – development should not be permitted • Less vulnerable – development should not be permitted • Water compatible – use the central allowance
If (exceptionally) development is considered appropriate when not in accordance with flood zone vulnerability categories, then it would be appropriate to use the upper end allowance.

Peak river flow allowances for the Scheme

7.2.7 It is assumed that the lifetime of the Scheme is 100 years (based on long term essential infrastructure use); therefore, the peak river flow climate change allowances for the lifetime of the Scheme has been assessed as shown in **Table 7.3**.

Table 7.3: Peak river flow allowances for the Scheme

M42 Junction 6	
River Basin District	Humber
Flood Zone	Flood Zone 1 with small areas of Flood Zone 3
Flood Risk Vulnerability Classification	Essential Infrastructure
Lifetime of Development	100
Climate Change Allowance to be Assessed	Flood Zone 3 - Upper End Allowance (50%)

7.3 Peak rainfall intensity allowance

7.3.1 Increased rainfall affects river levels and land and urban drainage systems. **Table 7.4** shows the anticipated changes in extreme rainfall intensity in small and urban catchments. In the assessment, both the central and upper end allowances have been assessed to understand the range of impact.

Table 7.4: Peak rainfall intensity allowance in small and urban catchments

Applies across all of England	Total potential change anticipated for 2010 to 2039	Total potential change anticipated for 2040 to 2059	Total potential change anticipated for 2060 to 2115
Upper End	10%	20%	40%
Central	5%	10%	20%

7.4 Impacts of climate change on flood risk

Fluvial flooding

7.4.1 As the Scheme would be located partially in Flood Zone 3 and is classed as essential infrastructure (see **Table 7.2**), a climate change allowance of 50% is considered. Due to the Scheme's distance from the River Blythe, with climate change there is low risk of fluvial flooding expected from this source.

7.4.2 The extents of Flood Zone 3 are associated with Shadow Brook (ordinary watercourse) and Hollywell Brook (Main River downstream of the M42 motorway). The Flood Zone extent from Shadow Brook does not extend into the Scheme's Order Limits and due to the distance, topography and nature of this watercourse (land drain with deep incised banks) the risk of flooding to the Scheme including allowance for climate change is expected to be low.

7.4.3 Hydraulic modelling of Hollywell Brook (see Appendix D) indicated the channel did not overtop in the 1% AEP (1 in 100 year event) with 50% allowance for climate change for peak river flow. Although flood levels are expected to increase over the lifetime of the development, the risk of flooding from the watercourse is expected to remain low.

Groundwater

7.4.4 The predicted increase in the wetness of winters and the intensity of storm events as a result of climate change could impact the groundwater level fluctuations, and possibly increase the level of the water table. As the likelihood of groundwater emergence under the climate change scenario is likely to increase, the potential for groundwater flooding to impact infrastructure also increases.

7.4.5 As a result of earthwork cuttings within the design of the Scheme, groundwater flows may be altered, increasing the risk of groundwater emergence elsewhere. However, the majority of the Scheme would be located in an area as having <25% risk of groundwater emergence on the EA's Areas Susceptible to Groundwater Flooding (AStGWF) map [REF 7-1]. In addition, the identified clayey soils are only anticipated to have minor fluctuations on the groundwater table level as a result of preceding rainfall conditions due to the slow infiltration and low permeability nature of the soils. As a result, the chance of groundwater emergence is not expected to increase significantly as a result of climate change.

Sewers

7.4.6 It is difficult to predict precisely the impact of climate change on sewer flooding; however, the anticipated increase in rainfall intensity may cause greater volumes of rainfall to enter surface water and sewer networks during storm events.

7.4.7 There are no proposed sewer works planned within the Scheme, including discharging surface water to combined sewers. As such, the Scheme is not anticipated to affect the capacity of sewers, including allowance for climate change, over the lifetime of the development.

Surface water runoff generation and overland flow

7.4.8 Climate change has been taken into account when considering surface water runoff generated by the Scheme; this is typically represented by increased peak rainfall intensities.

7.4.9 As any increase in rainfall intensity would increase runoff rates and volumes from the Scheme, the design of drainage infrastructure incorporated into the design of with the Scheme has taken this into account. Accordingly, the peak runoff from the Scheme would be attenuated up to the 1% AEP (1 in 100 year) rainfall event, plus 40% climate change.

7.4.10 Section 8 outlines the key design principles on how surface water runoff would be managed, taking into account the requirements for climate change.

8 Surface water management

8.1 Drainage strategy

8.1.1 As part of the design-development process, a drainage strategy was developed for the Scheme. The measures and design criteria contained within this strategy formed the basis of the drainage design incorporated into the Scheme.

8.1.2 In summary, the key design criteria used in the development of the drainage design were as follows:

a. trapped gully pots and catchpits at 90m spacing maximum;

b. sealed carrier drains designed to accommodate the 100% AEP (1 in 1 year) storm in-bore and without surcharge and 20% AEP (1 in 5 year) storm to ensure that surcharge does not exceed the level of chamber covers;

c. combined drains and ground water drains designed to accommodate a 100% AEP (1 in 1 year) storm in bore without surcharge and 20% AEP (1 in 5 year) storm, to ensure that surcharge does not rise above formation level or sub-formation level where a capping layer is present;

d. the peak discharge rates shall be controlled and appropriate attenuation storage provided. The attenuation for the local networks will be designed to accommodate the 1% AEP (1 in 100 year) event with 40% allowance for climate change;

e. to determine the runoff rates from natural catchments (greenfield) to ditches and watercourses the Institute of Hydrology's "IH 124" method was used for rural catchments larger than $0.4km^2$ and the Agricultural Development and Advisory Service method was used for catchments less than or equal to $0.4km^2$;

f. the design storms to be designed include the 100% AEP (1 in 1 year) and 20% AEP (1 in 5 year) events for piped systems. The 1.33% AEP (1 in 75 year) event for natural catchments without a defined watercourse and 1% AEP (1 in 100 year) event for the design of attenuation. For culverts that convey permanent watercourses beneath roads the flow rate will be assessed for return periods up to 1% AEP (1 in 100 year) event.

g. the drainage design shall incorporate 20% uplift in peak rainfall intensity for climate change. The attenuation for the local networks shall be designed to 40% climate change, as requested by SMBC;

h. attenuation shall be provided through the measures set out in Section 8.5;

i. outfall locations and method of treatment requirements:

   i. pollution/spillage control devices to be provided;

   ii. generally, surface water to be kept away from pavement foundation except in cut;

   iii. sub-surface drainage to be provided via combined carrier / filter drains in cutting; and

iv. gullies to be provided where road is kerbed, e.g. roundabouts, junctions and side roads;

j. combined kerb drainage only considered where spacing of gullies would be <5m consistently over a significant length;

k. filter drains to be provided in cuttings; and

l. pre-earthworks drains to be at toe of embankments slope and top of cut slope when adjacent ground falls towards the road.

8.2 Pre-earthworks drainage

8.2.1 It was determined that pre-earthworks drainage would be required to convey surface water and/or intercept existing drainage, and should take the form of filter drains or ditches.

8.2.2 The rationale for this approach was that ditches are simpler to construct and maintain, generally fit in with the existing drainage network philosophy, and have higher capacities than filter drains.

8.2.3 As filter drains use stone resources (which typically need to be cleaned or replaced every ten to fifteen years depending on pollutant loading and quality of maintenance), on balance it was concluded that ditches shall be used wherever possible, with filter drains used in other locations where drains cannot be used.

8.3 Road drainage

8.3.1 Road drainage solutions incorporated into the Scheme design vary, depending on whether a section of road is kerbed or not. The three main solutions alongside a kerbed road comprise:

a. gullies with adjacent fin drains/narrow filter drains;

b. grassed surface water channels; and

c. combined surface and sub-surface drains (filter drains).

8.3.2 In locations where sections of road are not kerbed, the solutions vary from combined surface and sub-surface drains to surface water channels with adjacent fin drains/narrow filter drains.

8.4 Surface drainage

8.4.1 Surface drainage solutions were influenced by whether a section of road would to be kerbed, and whether it would be positioned on embankment or within an earthwork cutting.

8.4.2 Where sections of road would be in cutting and be unkerbed, combined surface and sub-surface drains have been incorporated into the design to efficiently remove the surface water, effectively drain the lower pavement layers, and also provided a level of treatment of runoff. In locations where these drains may result in stone scatter, 8.4.3 Where sections of road would be kerbed and be on embankment, gullies or kerb drains have been incorporated into the design with adjacent carrier drains and separate sub-surface drainage included. Where kerbed sections of road would be positioned in cutting, gully tails would be connected directly to the combined surface and sub-surface drains.

8.5 SuDS selection

8.5.1 During the consultation process it was identified that Birmingham Airport and the EA had conflicting views on the primary method of attenuation and treatment of surface water treatment. Therefore a meeting was arranged and the following strategy was agreed by both parties, as the most favoured options for SuDS attenuation and treatment:

Shallow reed beds

8.5.2 Reed beds have been incorporated into the Scheme design as part of the treatment train for road runoff. These comprise an area of grass-like marsh plants, artificially constructed to treat small areas or runoff for suspended particles and associated heavy metals whilst providing attenuation.

8.5.3 Reed beds are the preferred SuDS solution on the Scheme, and have been designed in accordance with the requirements of Birmingham Airport, including netting and steepened banks.

Underground storage tanks

8.5.4 Underground storage tank systems have been incorporated into the Scheme design to hold runoff, only where SuDS or other proprietary systems are not feasible or achievable to implement. Runoff captured in the storage tanks would generally be pumped into a downstream SuDS feature.

8.5.5 Storage tanks provide attenuation but do not generally provide a level of treatment, although additional features can be incorporated where required.

Swales

8.5.6 Swales have been incorporated into the Scheme design in locations where a need for a final level of treatment has been identified. These comprise a flat bottomed grass-lined ditch which serves the dual functions of sediment removal/biological filtering and conveyance of runoff. They can also be designed to incorporate attenuation.

8.6 Pumping stations

8.6.1 As the majority of the new mainline link road would be positioned within an earthwork cutting, achieving outfalls to existing watercourses under gravity conditions is not possible in some locations.

8.6.2 Accordingly, pumping stations have been incorporated into the design at specific locations to move runoff to the SuDS treatment locations.

8.7 Culverts

8.7.1 The design of the Scheme does not include the installation of new culvert structures.

8.7.2 A summary of extension works required to existing culverts as a consequence of the road widening included in the Scheme is provided in Section 9.

9 Flood risk management

9.1 Culverts

Culvert extensions

9.1.1 Existing culverts beneath the M42 motorway at the following locations would need to be extended as a consequence of the Scheme:

a. on the A45 at the start of the proposed northbound free flow link at Junction 6;

b. under the M42 at Hollywell Brook; and

c. under Bickenhill Lane to the north of the Clock Interchange.

Culvert sizing

9.1.2 A sizing study was undertaken to determine the required diameter for a circular conduit/pipe in these three locations to continue to convey flows within these watercourses without increasing the risk of fluvial flooding in a 1% AEP event. The methodology for calculating the required culvert diameter is presented within Appendix F.

9.1.3 The results of this study and culvert diameters required are summarised in **Table 9.1**, and were taken into account during the design-development of the Scheme.

Table 9.1: Estimated required pipe diameters based on culvert capacity check using Wallingford tables

Site	Hollywell Brook	Unnamed drain under A45	Unnamed Drain under Bickenhill Lane
Required capacity (m^3/s)	4.38	0.71	0.38
Calculated full bore capacity using Manning's equation (m^3/s)	4.42	0.74	0.4
Manning's suggested pipe diameter (mm)	1260	677	479
Gradient	0.014	0.01	0.022
Selected pipe size from tables (mm)	**1275**	**700**	**500**
mQ from tables	7.049	1.204	0.728
m = Manning's n x 100	1.5	1.5	1.5
Full bore capacity from tables	4.70	0.80	0.49

9.2 Compensatory storage

9.2.1 The Hollywell Brook Capacity Assessment & Modelling Report (see Appendix D) indicates the channel does not over top in the 1% AEP (1 in 100 year event) plus 50% allowance for climate change.

9.2.2 As the Scheme would not encroach on the revised floodplain, no requirement for floodplain compensation has been identified.

9.3 Groundwater flooding

9.3.1 There is a low risk for groundwater emergence based on seasonal fluctuations of the water table and as a result of climate change.

9.3.2 If groundwater is encountered during any below ground construction, including cuttings, then appropriate temporary dewatering/ pumping measures would be employed to prevent localised flooding, in accordance with the approaches presented in the Outline Environmental Management Plan [**TR010027/APP/6.11**].

9.4 Surface water management

9.4.1 As implementation of the Scheme would increase the total area of impermeable hardstanding within the Order Limits, in comparison to the existing situation, the total volume of surface runoff is predicted to increase.

9.4.2 The design of drainage infrastructure within the Scheme has taken account of this predicted increase, and accordingly utilises SuDS measures to provide surface water attenuation storage for a 1% AEP storm event with 40% allowance for climate change.

10 Off-site impacts and residual risk

10.1 Off-site impacts

10.1.1 The drainage strategy incorporated into the Scheme design provides storage for up to and including the 1% AEP storm event with a 40% allowance for climate change.

10.1.2 The assessment has identified that this storage and allowance ensures that the Scheme would not increase flood risk elsewhere, and would provide betterment over the existing situation. Accordingly, drainage within the Scheme design meets the requirements of both the NPSNN [REF 1-2] and the NPPF [REF 1-3].

10.1.3 It is concluded that the Scheme would not result in any off-site impacts.

10.2 Residual risk

10.2.1 Failure, blockage and exceedance of design events for the drainage system are a potential risk to the Scheme and the surrounding area.

10.2.2 Regular maintenance of the drainage system would be undertaken to ensure that the system continues to perform as designed.

10.2.3 The drainage networks have been split into the following adopting authorities:

a. SMBC – who would be responsible for taking ownership and maintenance responsibility for the realigned Catherine-de-Barnes Lane and associated side roads; and

b. Highways England – who would operate and maintain the new mainline link road, Junction 5A and free flow links at Junction 6.

10.2.4 Each authority would be responsible for the network under their jurisdiction, and would be required to ensure that all SuDS features are regularly inspected and maintained over the lifetime of the Scheme.

11 Glossary

Term	Abbreviation	Definition
Agricultural Development and Advisory Service method	-	A methodology developed to calculate runoff for a small catchment area.
Annual Exceedance Probability	AEP	Flood frequency is expressed in terms of an annual exceedance probability, which is the inverse of the annual maximum return period. For example, the 100-year flood (a flood likely to occur once every 100 years) can be expressed as the 1% AEP flood, which has a 1% chance of being exceeded in any year.
Above ordnance datum	AOD	Above Ordinance Datum – a spot height (an exact point on a map) with an elevation recorded beside it that represents its height above a given datum.
Aquifer	-	A source of groundwater comprising water bearing rock, sand or gravel capable of yielding significant quantities of water.
British Geological Survey	BGS	The provider of objective and authoritative geoscientific data, information and knowledge for the UK.
-	CIRIA	A member-based research and information organisation dedicated to improvement in all aspects of the construction industry.
Culvert	-	A channel or pipe that carries water below the level of the ground.
Department for Environment, Food and Rural Affairs	DEFRA	The Government department responsible for policy and regulations on environmental, food and rural issues. The department's priorities are to grow the rural economy, improve the environment and safeguard animal and plant health.
Design Manual for Roads and Bridges	DMRB	A set of documents that provide a comprehensive manual system which accommodates all current standards, advice notes and other published documents relating to the design, assessment and operation of trunk roads (including motorways).
Development Consent Order	DCO	The consent for a Nationally Significant Infrastructure Project required under the Planning Act 2008.
European Community	EC	A community formed in 1967 that consisted of three organisations in the European Union, responsible for dealing with policies and governing member states.
Emergency Refuge Area	ERA	Emergency Refuge Areas are located on smart motorways and designed to offer a 'safe haven' for stranded vehicles on busy vehicles.
Environment Agency	EA	A non-departmental public body sponsored by the United Kingdom government's Department for Environment, Food and Rural Affairs (DEFRA), with responsibilities relating to the protection and enhancement of the environment in England.

Term	Abbreviation	Definition
Environmental Impact Assessment	EIA	A term used for the assessment of environmental consequences (positive or negative) of a plan, policy, program or project prior to the decision to move forward with the proposed action.
Environmental Statement	ES	A document which reports the EIA process, produced in accordance with the EIA Directive as transposed into UK law by the EIA Regulations.
European Union	EU	An economic and political union of 28 countries which operates an internal (or single) market which allows the free movement of goods, capital, services and people between member states.
Exception Test	-	The exception test should be applied following the application of the sequential test. Conditions need to be met before the exception test can be applied.
Flood Risk Assessment	FRA	The formal assessment of flood risk issues relating to a development.
Flood Zones	-	Flood Zones show the probability of flooding, ignoring the presence of existing defences
Fluvial	-	Relating to the actions, processes and behaviour of a watercourse (river or stream).
Gaelic Athletic Association	-	Ireland’s largest sporting association responsible for promoting Gaelic games such as hurling, football, handball and rounders.
Groundwater	-	Water that is in the ground, this is usually referring to water in the saturated zone below the water table.
High Speed 2	HS2	A new high speed railway that will connect the city centres of London, Birmingham, Manchester and Leeds.
IH 124 method	-	A methodology produced by the Institute of Hydrology to address the runoff from small catchments.
Lead local flood authority	LLFA	The authority responsible for maintaining a register of structures and features likely to have a significant effect on flood risk in their area.
Light Detection and Ranging	LiDAR	Airborne ground survey mapping technique, which uses a laser to measure the distance between the aircraft and the ground.
Local flood risk management strategy	LFRMS	A strategy prepared by local authorities which identifies objectives to manage local flood risk.
Main river	-	Watercourse as defined on a ‘Main River Map’ designated by DEFRA. The Environment Agency has permissive powers to carry out flood defence works, maintenance and operational activities for main rivers only.

Term	Abbreviation	Definition
National Planning Policy Framework	NPPF	Part of the Government's reform of the planning system intended to make it less complex, to protect the environment and to promote sustainable growth. It does not contain any specific policies on Nationally Significant Infrastructure Projects but its policies may be taken into account in decisions on DCOs if the Secretary of State considers them to be both important and relevant.
National Policy Statement for National Networks	NPSNN	A statement setting out the need for, and Government's policies to deliver, the development of nationally significant infrastructure projects on the national road and rail networks in England.
National Exhibition Centre	NEC	A venue in Birmingham used for large scale events and exhibitions, located near Junction 6 of the M42.
Order Limits	-	The land within which an authorised Nationally Significant Infrastructure Project would be carried out.
Ordinary watercourse	-	A watercourse that does not form part of a main river. This includes "all rivers and streams and all ditches, drains, cuts, culverts, dikes, sluices (other than public sewers within the meaning of the Water Industry Act 1991) and passages, through which water flows" according to the Land Drainage Act 1991.
Ordnance Survey	OS	The national mapping agency for Great Britain
Outline Environmental Management Plan	-	A plan prepared by a contractor which sets out how a construction project will avoid, minimise or mitigate effects on the environment and surrounding area and the protocols to be followed in implementing these measures, in accordance with environmental commitments.
Preliminary flood risk assessment	PFRA	A high level screening exercise to identify potential flood risk locations.
Planning Act 2008	-	An Act of Parliament in the UK intended to accelerate the process of approving major new infrastructure projects.
Planning Inspectorate	The Inspectorate	Executive agency of the Department for Communities and Local Government of the United Kingdom Government.
Planning Practice Guidance	PPG	Guidance expanding upon and supporting the NPPF.
Residual flood risk	-	The remaining flood risk after risk reduction measures have been taken into account.
Road Investment Strategy	RIS	A document which sets out a long-term vision for England's motorways and major roads, outlining how smooth, smart and sustainable roads will be achieved through investment over a five year period (2015 – 2020).
-	RoFSW	Risk of flooding from surface water
Sequential Test	-	Aims to steer vulnerable development to areas of lowest flood risk.
Scheme	-	The M42 Junction 6 Improvement Scheme

Term	Abbreviation	Definition
Source Protection Zone	SPZ	Defined areas in which certain types of development are restricted to ensure that groundwater sources remain free from contaminants.
Site of Special Scientific Interest	SSSI	An area designated for protection under the Wildlife and Countryside Act 1981 (as amended), due to its value as a wildlife and/or geological site.
-	SMBC	Solihull Metropolitan Borough Council
Strategic flood risk assessment	SFRA	An assessment undertaken by local authorities to assess flood risk in their area, and the risks to and from surrounding areas.
Surface Water	-	Flooding caused when intense rainfall exceeds the capacity of the drainage systems or when, during prolonged periods of wet weather, the soil is so saturated such that it cannot accept any more water.
Sustainable Drainage Systems	SuDS	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.
Topographic survey	-	A survey of ground levels.
UK Central Hub	-	A unique concentration of global businesses and strategic economic assets in the area surrounding M42 Junction 6. The area includes, Birmingham Airport, Birmingham Business Park, the proposed HS2 Interchange Station, the NEC and Jaguar Land Rover

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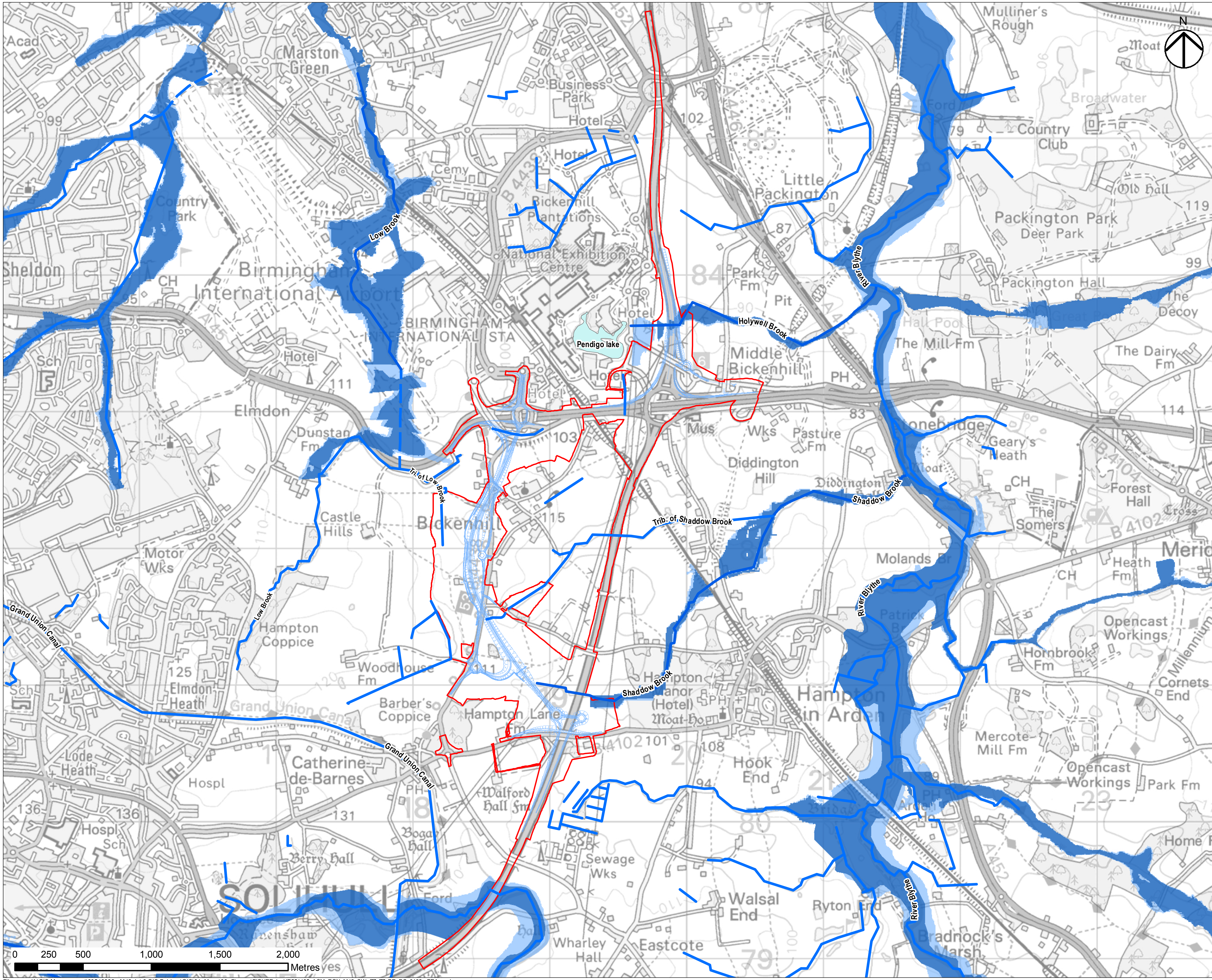
Appendix A: Preliminary design



Filename: K:\GIS Management\60543032 - M42 Jct 6 GIS Folder_\GIS\01_Maps\00_Figures\FIGURE 1 - HE551485_ACM_EGN_M42_SW_ZZ_ZZ_DR_DC_0182 - FRA.mxd

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION BOX

IT IS ASSUMED THAT ALL WORKS ON THIS DRAWING WILL BE CARRIED OUT BY A COMPETENT CONTRACTOR WORKING, WHERE APPROPRIATE, TO AN APPROPRIATE METHOD STATEMENT.

THIS DRAWING IS TO BE USED ONLY FOR THE PURPOSE OF ISSUE THAT IT WAS ISSUED FOR AND IS SUBJECT TO AMENDMENT.

EXCEPTIONAL RISKS RELATING TO THE WORKS ASSOCIATED WITH THIS DRAWING ARE IDENTIFIED BELOW.

CONSTRUCTION

MAINTENANCE / OPERATION / DECOMMISSIONING / DEMOLITION

NOTES

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT DOCUMENTATION.

Preliminary Design

Order Limits

Watercourse

Flood Zone 3 - Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding

Flood Zone 2 - Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding.

Revision Details	By / Check	Date	Suffix
FIRST ISSUE	GB / GC	19/10/18	P01

Purpose of Issue
FOR INFORMATION

Client
Highways England
Floor 5
Two Colmore Square
38 Colmore Circus
B4 6BN

Working on behalf of highways england

Project Title
M42 JUNCTION 6 IMPROVEMENT

Drawing Title
FIGURE 1
WATERCOURSES AND FLOOD ZONES

Designed	Drawn	Checked	Approved	Date
LB	GB	MB	GC	19/10/18

Internal Project No	Suitability
60543032	S2
Scale @ A3: 1:25,000	Zone: M42

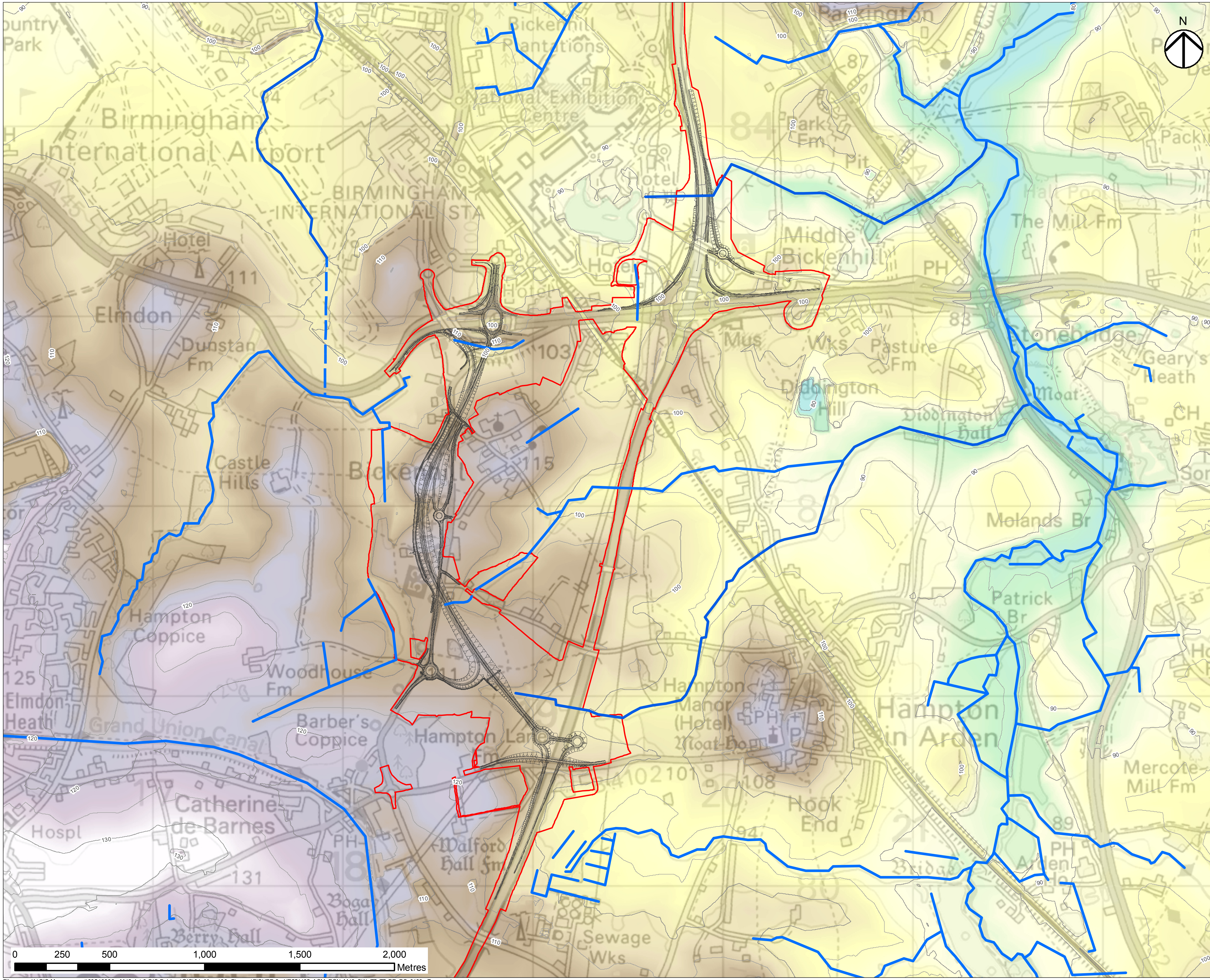
AECOM
Royal Court
Basil Close, Chesterfield
Derbyshire S41 7SL
Tel(01246) 209221
Fax(01246) 209229
www.aecom.com

AECOM Infrastructure & Environment UK Limited
Registered in England Registered number: 880328
Registered office: Midpoint, Alencon Link, Basingstoke, Hampshire RG21 7PP

Drawing Number
Highways England Pin | Originator | Volume
HE551485 -ACM -EGN-
M42_SW_ZZ_ZZ -DR-DC-0182
Location | Type | Role | Number

Rev
P01

Appendix B: Topographical data



SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION BOX

IT IS ASSUMED THAT ALL WORKS ON THIS DRAWING WILL BE CARRIED OUT BY A COMPETENT CONTRACTOR WORKING, WHERE APPROPRIATE, TO AN APPROPRIATE METHOD STATEMENT.

THIS DRAWING IS TO BE USED ONLY FOR THE PURPOSE OF ISSUE THAT IT WAS ISSUED FOR AND IS SUBJECT TO AMENDMENT.

EXCEPTIONAL RISKS RELATING TO THE WORKS ASSOCIATED WITH THIS DRAWING ARE IDENTIFIED BELOW.

CONSTRUCTION

MAINTENANCE / OPERATION / DECOMMISSIONING / DEMOLITION

NOTES

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT DOCUMENTATION.

Revision Details	By / Check	Date	Suffix
FIRST ISSUE	GB / GC	19/10/18	P01

Purpose of Issue

FOR INFORMATION

Client
Highways England
Floor 5
Two Colmore Square
38 Colmore Circus
B4 6BN

Working on behalf of highways england

Project Title

M42 JUNCTION 6 IMPROVEMENT

Drawing Title

FIGURE 2 TOPOGRAPHY

Designed	Drawn	Checked	Approved	Date
LB	GB	MB	GC	19/10/18

Internal Project No	Suitability
60543032	S2

Scale @ A3	Zone
1:18,000	M42

AECOM
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Drawing Number

Highways England Pin | Originator | Volume

HE551485 -ACM -EGN-M42_SW_ZZ_ZZ -DR-DC-0183

Location | Type | Role | Number

Rev

P01

Filename: K:\GIS Management\60543032 - M42 Jct 6 GIS Folder_\GIS\01_Maps\00_Figures\FIGURE 2 - HE551485_ACM_EGN_M42_SW_ZZ_ZZ_DR_DC_0183 - Topography.mxd

Appendix C: Environment Agency Consultation

Tim Jones
AECOM
Timothy.Jones1@eacom.com

Our ref: 59528
Your ref:
Date: 20 October 2017

Dear Tim

Enquiry regarding Assessment for Improvements M42 Junction 6

Thank you for your enquiry which was received on 6 September.

We respond to requests under the Freedom of Information Act 2000 and Environmental Information Regulations 2004.

Groundwater

1. There is 1 active groundwater abstraction, for spray irrigation and located at grid ref SP26010784932.

2. The site is not located on any Groundwater Source Protection Zones, or within 1km of a Groundwater Source Protection Zone.

3. Confirmation of aquifer status;

   The site is located on the bedrock of the Mercia Mudstone Formation, designated as a Secondary B Aquifer. Patches of Arden Sandstone, designated as a Secondary A Aquifer are also indicated to be present for part of the proposed site. Please see attached map ‘Bedrock Aquifer Status’. Superficial deposits are indicated for the proposed site, in the form of Glacio-fluvial deposits, designated as a Secondary A Aquifer. Please see attached map ‘Superficial Deposits’.

   Bedrock and Superficial Aquifer maps attached.

4. Borehole locations – information to follow

5. We do not hold any groundwater level data for the study area.

Surface Water Quality and Ecology

6. See attached Water Quality Data excel sheet.

7. See attached Water Quality Data excel sheet.

8. See attached excel file

WFD

9. See attached zip file for site specific WFD environmental quality standards for these watercourses; In the attached zip file.

10. See attached zip files

11. Mitigation measures information can be downloaded from the Catchment Date Explorer, http://environment.data.gov.uk/catchment-planning.

12. N/A

13. The third river basin plan is not expected until 2021

Flood Risk and Flows

Question 14-22 see attached pdf Flood Risk and Flows.

Flood Map for Planning (Rivers and Sea). *Note - This information relates to the area that the above named property is in and is not specific to the property itself as it is influenced by factors such as the height of door steps, air bricks or the height of surrounding walls. We do not have access to this information and is not currently used in our flood modelling.* Flood Zone definitions can be found at www.gov.uk/guidance/flood-risk-and-coastal-change#Table-1-Flood-Zones

Please find attached a copy of the Flood Map for Planning (Rivers and Sea) for the area relating to your address.

Abstract

Name	Product 4
Description	Flood Map for Planning (Rivers and Sea) for M42 Junction 6 Bickenhill.
Licence	Open Government Licence
Information Warning - OS background mapping	*The mapping of features provided as a background in this product is © Ordnance Survey. It is provided to give context to this product. The Open Government Licence does not apply to this background mapping. You are granted a non-exclusive, royalty free, revocable licence solely to view the Licensed Data for non-commercial purposes for the period during which the Environment Agency makes it available. You are not permitted to copy, sub-license, distribute, sell or otherwise make available the Licensed Data to third parties in any form. Third party rights to enforce the terms of this licence shall be reserved to OS.*
Attribution	Contains Environment Agency information © Environment Agency and/or database rights.

	Contains Ordnance Survey data © Crown copyright 2017 Ordnance Survey 100024198.

Data Available Online

Many of our flood datasets are available online:

- Flood Map For Planning (Flood Zone 2, Flood Zone 3 ,Flood Storage Areas, Flood Defences, Areas Benefiting from Defences)
- Risk of Flooding from Rivers and Sea
- Historic Flood Map
- Current Flood Warnings

Further details about the Environment Agency information supplied can be found on the GOV.UK website:

https://www.gov.uk/browse/environment-countryside/flooding-extreme-weather

If you have requested this information to help inform a development proposal, then you should note the information on GOV.UK on the use of Environment Agency Information for Flood Risk Assessments

https://www.gov.uk/planning-applications-assessing-flood-risk

Water Resources

23. There are no surface water abstractions within the 1km radius
24. There are 7 active discharge consents as follows which can be found on attached excel sheet:

Severn Trent Barston sewage works- Max flow 262 l/s

Home farm private discharge- Max flow 1.4 m3/d

Heath farm private discharge- Max flow 0.7 m3/d

Arden Brickworks- Max flow 0 .9 m3/d

Park Farm private discharge- Max flow 5 l/s

Arden Hotel, Bickenhill- Max flow 22 m3/d

Arden Landfill- Max flow 240 m3/d

25. There are no concerns regarding water resources we are aware of.
26. We can confirm that Pendigo Pool / Lake is the only angling interest within a 1km radius of the NGR provided. NEC

Angling Club currently lease the fishing rights at this site.

All documents are attached in a Sharefile at the link below for 30 days.

https://ea.sharefile.com/d-sa59ef6fe3ce4154a

Please refer to Open Government Licence which explains the permitted use of this information.

Please get in touch if you have any further queries or contact us within two months if you'd like us to review the information we have sent.

Yours sincerely

Carolyn Fowler
Customers & Engagement Officer
West Midlands Area

For further information please contact the Customers & Engagement team on
Tel: 02084 747856
Direct e-mail:- enquiries_WestMids@environment-agency.gov.uk

Flood Zones

According to our published Flood Map for Planning, which provides a general estimate of the **probability** of flooding disregarding the presence and effect of any defences, the area is shown to be **partially within Zone 3, around 419917,283638 and the remainder in Flood Zone 1** -

Zone 3 - High Probability - Land having a 1 in 100 (1%) or greater annual probability of river flooding. (Land shown in dark blue on the Flood Map)

Zone 1 - Low Probability - Land having a less than 1 in 1,000 (0.1%) annual probability of river. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3)

The information provided is largely based on modelled data and is therefore indicative rather than specific. The information indicates the flood risk to areas of land and is not sufficiently detailed to show whether an individual property is at risk of flooding, therefore properties may not always face the same chance of flooding as the areas that surround them. This is because we do not hold details about properties and their floor levels.

The associated Dataset is available here: https://data.gov.uk/dataset/flood-map-for-planning-rivers-and-sea-flood-zone-3

Main River

The nearest 'Main River' is the Hollywell Brook. 'Main rivers' are usually larger streams and rivers, but some of them are small watercourses of significance. All other watercourses are 'ordinary watercourses'. On these watercourses the Lead Local flood Authority or, if within an Internal Drainage District, the Internal Drainage Board are the responsible authority.

The associated Dataset is available here: https://data.gov.uk/dataset/statutory-main-river-map1

Bank Top ePlanning Tool

Local Authorities have the responsibility to consult the Environment Agency on any new development falling within 20 metres of the top of the bank of a Main River. This tool allows the Local Planning Authority to determine if new development falls within these areas and triggers the consultation.

No Modelled Levels

The nearest watercourse is the Holywell Brook. We have not undertaken any detailed flood risk modelling within this area.

Allowance for Climate Change

Should a detailed FRA be carried out for this site, please be aware of the current allowance that should be made for climate change, when considering fluvial modelling. You should refer to 'Flood risk assessments: climate change allowances' to check the allowance appropriate for the type of development you are proposing and its location. You may need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence.

Flood Defences

There are no Environment Agency raised flood defences affecting this site. You may wish to contact the Local Authority to obtain further information regarding localised flooding from drains, culverts and small watercourses, and regarding existing or planned flood defence measures.

Historic Flood Event Outlines

Following examination of our records of historical flooding we have no record of flooding in the area. The absence of coverage for an area does not mean that the area has never flooded, only that we do not currently have records of flooding in this area. It is also possible that the pattern of flooding in this area has changed and that this area would now flood or not flood under different circumstances.

You may also wish to contact your local authority or internal drainage board, to see if they have other relevant local flood information.

Flood Risk from Surface Water

Managing the risk of flooding from surface water is the responsibility of Lead Local Flood Authorities. The Flood Risk from Surface Water map has been produced by the Environment Agency on behalf of government, using information and input from Lead Local Flood Authorities. The map can be found on the Long Term Flood Risk Information website: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?map=SurfaceWater

For further information please contact your Lead Local Flood Authority.

Flood Risk from Reservoirs

Some of the area south of Birmingham Airport is at risk of flooding from reservoirs. The Flood Risk from Reservoirs map can be found on the Long Term Flood Risk Information website: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?map=Reservoirs

Flood Alert Area

Some of the site is within a pink shaded Flood Alert Area and therefore we can provide you with free flood alerts. We issue flood alerts when flooding is possible. In many areas we issue flood alerts for flooding from rivers, the sea and groundwater. If you receive a flood alert you should be prepared for flooding and to take action. Please refer to the enclosed flood alert map.

You can register online with our Floodline Warnings Direct service at https://fwd.environment-agency.gov.uk/app/olr/register. If you would prefer to register by telephone, or if you need help during the registration process, please call Floodline on 0345 988 1188.

The associated Dataset is available here: https://data.gov.uk/dataset/flood-alert-areas2

Cowling, Graeme

From: Enquiries_Westmids <Enquiries_Westmids@environment-agency.gov.uk>
Sent: 23 October 2017 15:55
To: Jones, Timothy
Subject: 59528 - Information Request for M42 Junction 6 - Bickenhill

Dear Tim

We don't have any boreholes in the immediate vicinity of M42J6.

Our closest Boreholes are

Hollyberry Lower 1886GW – Which is at: SP2764483555
Hollyberry Upper 1885GW – Which is at: SP2764483555 (These 2 are next to each other)

& Ram Hall 1219GW – which is at SP 24672 78286.

Kind regards.

Rachel Hamer
Customers & Engagement Officer
Customers & Engagement Team
West Midlands Area
Enquiries Team 02084 747856

☎ 02030251678 (Internal 51678)
Enquiries_Westmids@environment-agency.gov.uk
Environment Agency, 9 Wellington Crescent, Fradley Park, Lichfield, Staffordshire, WS13 8RR.

We do not inherit the earth from our ancestors, we borrow it from our children.

From: Jones, Timothy [mailto:Timothy.Jones1@aecom.com]
Sent: 06 September 2017 15:18
To: Enquiries, Unit <enquiries@environment-agency.gov.uk>
Subject: 170908/TF09 Information Request for M42 Junction 6 - Bickenhill

Dear Sir/Madam,

AECOM are carrying out a water environmental impact assessment for improvements to the M42 Junction 6 on behalf of Highways England. As part of this work, I wish to request the following water resources and flood risk information for our study area (centred on SP 19807 83039), along with information regarding the WFD waterbodies in the vicinity of the scheme. Please see the attached map which shows the site of interest, and we would also like to receive data for an area of 1 km around this site.

I would be grateful for information on the following (where the information is shown on your websites, the request is for any information **not** yet available on your website, or for more detailed information than that available on the web e.g. abstractions information):

Groundwater

1. Active groundwater abstraction licences (location, source and use); -
2. Groundwater Source Protection Zones, and the abstractions which relate to these; -
3. Confirmation of aquifer status; -
4. Borehole locations;
5. Any groundwater level data for the study area for the last 5 years (2013-2017); -

Surface Water Quality and Ecology

6. Any information on the water quality of the surface watercourses in the area (as shown in the attached map) for the period 2012-2017
7. chemical testing (needed for highway work)
   - Total/filtered/bioavailable (if available)
   - heavy metals (including copper and zinc)
   - major ions and key compounds including sodium, chloride and TBT
   - physico-chemical parameters (including temperature, pH, conductivity, DO, BOD)
   - total suspended sediments / turbidity
   - hydrocarbons (especially Total Polycyclic Aromatic Hydrocarbons and separate pyrene, fluoranthene, anthracene, phenanthrene concentrations).

7\. Please provide the latest survey data for biological quality elements (fish, macroinvertebrates, phytoplankton, macrophytes) for any Environment Agency monitoring points within the area of interest (including 1km buffer area around the site) for the period 2012-2017.

8\. Details of category 3 or worse water pollution incidents as recorded on NIRS during the last 5 years within the study area (location, pollution source, category and receiving waters). If possible, could you provide this information as a GIS layer or Excel file.

WFD

I understand that the following WFD Waterbodies are located in the vicinity of the scheme:

- Blythe from source to Cuttle Brook (GB104028042400);
- Blythe from Temple Balsall Brook to Patrick Brook (GB104028042571);
- Bythe from Patrick Bridge to River Tame (GB104028042572);
- Grand Union Canal, Solihull to Birmingham (GB70410204).

For each of these watercourses could we please request the following:

9. Please provide the site specific WFD environmental quality standards for these watercourses;
10. Please provide copies of any WFD investigation reports that have been compiled for these water bodies (e.g. catchment walkovers, water quality/biological/NNIS risk assessments);
11. Please provide details of the mitigation measures that are currently in place and those that are not in place;
12. Please provide details of other current or proposed schemes on the waterbodies, which could be linked for cumulative benefits;
13. Please provide any available information on the proposed future baseline conditions for the waterbodies;

Flood Risk and Flows

14. Any hydrological flow monitoring data (gauged flow/stage data, POT/AMAX, Q95) for the study area since 2012;
15. **Detailed FRA Map** for this site including modelled flood extents, and all modelled flood levels for the watercourses within the study area (including detailed 2D model output grids within these extents and/or 1D nodes with max modelled water levels)

Please can you confirm that the model and associated hydrology used to produce this data are the most up to date held by the EA for this area and, as the information is to be used to inform a FRA, confirm that this information is fit for that purpose; -

16. Details of flood defences, including crest heights, the associated standard of protection and where applicable details of proposed improvements to these defences. If applicable please provide any available information on breach outputs or information relating to the impacts of a possible breach of these defences;

17. Please provide any additional information that you have on the flood storage areas including details of their operation, storage volumes, areas protected etc;

18. Information relating to surface water, including surface water flood maps if available;

19. Information/mapping of historical flooding events on site, from all sources (i.e. fluvial, surface water, groundwater, sewer, reservoir, canal, etc.). Where you are aware of historical flooding at the site, where available could you please include flood levels, estimated return periods, photographs, and other such data as may be relevant to our assessment;

20. Information on drainage within the site and also the local area, including if there are any known drainage problems;

21. Guidance on any surface water discharge requirements including, runoff rates, waterbody(s) to be discharged to, and any SuDS/WSUD requirements that you may have;

22. Any other information that you think may be of use to help us produce a FRA /EIA for this site.

W Water Resources

23. Current surface water abstraction licenses in the study area;

24. Active discharge consents (including consented rates of discharge l/s) in the study area;

25. Any issues of concern regarding water resources, both surface and groundwater, in the area; and

26. Details of any other water attribute or recreational / amenity activity (e.g. angling etc.) that we should be aware of.

For any data supplied please confirm the national grid reference for the monitoring / sampling location.

Please feel free to contact me on DD 0121 214 8275 if you have any queries,

Many thanks for your help.

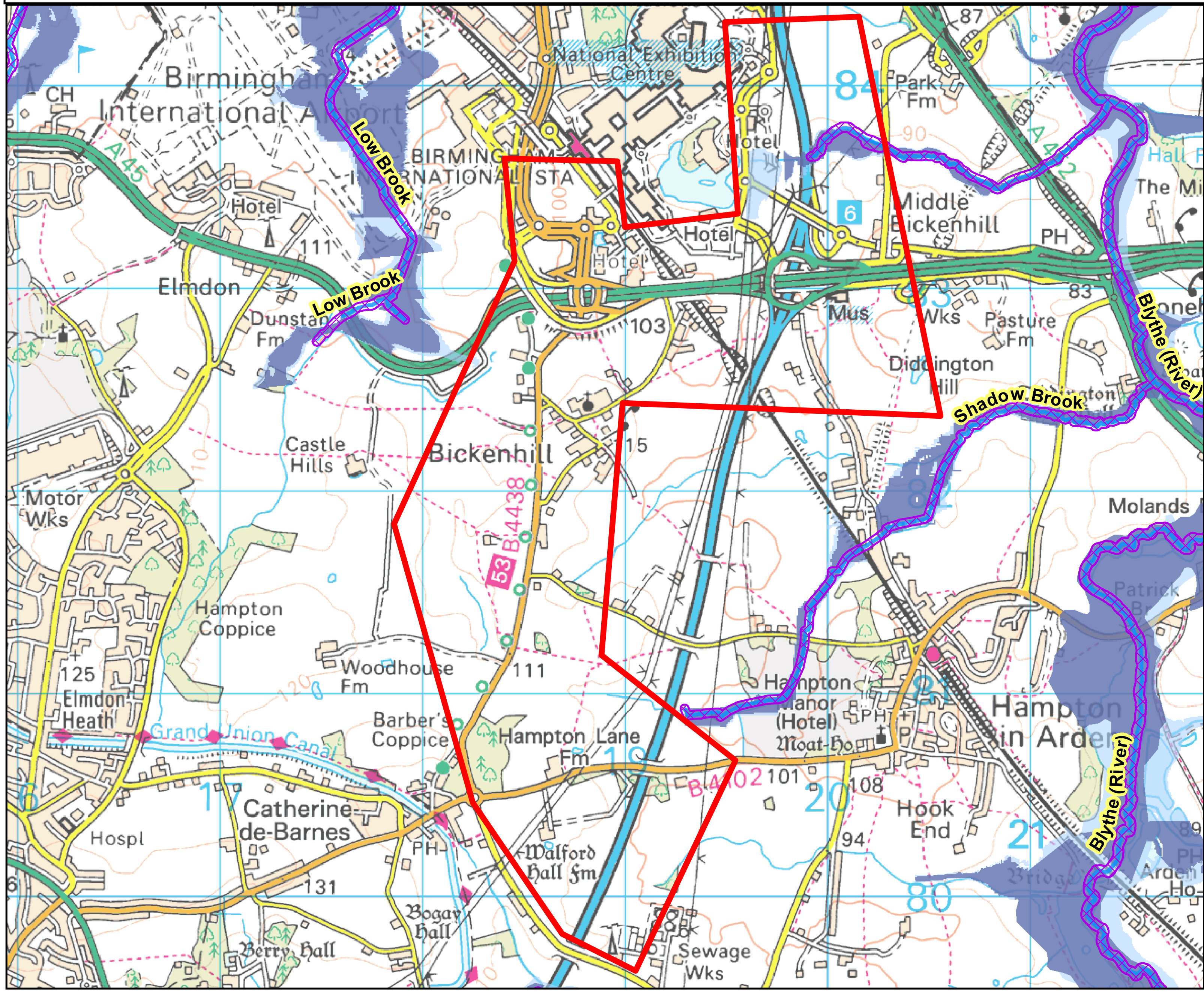
Kind regards,

Tim

Tim Jones BSc (Hon) PhD
Water Scientist
Environment and Planning, Environment and Ground Engineering
D +44(0) 121 214 8275
M +44(0) 7730 532 082
timothy.jones1@aecom.com

AECOM
1st Floor
Victoria Square House
Victoria Square
Birmingham, B2 4AJ
T +44 (0)121 212 3035
www.aecom.com

Flood Map for Planning. M42 Junction 6 Bickenhill. Created 26 September 2017 Ref 59528



Environment Agency

Legend

- Bank Top ePlanning Tool
- Main Rivers
- Flood Zone 3
- Flood Zone 2
- Approximate location of site

Flood Map Areas (assuming no defences)
Flood Zone 3 shows the area that could be affected by flooding from a river with a 1 in 100 (1%) or greater chance of happening each year.
Flood Zone 2 shows the extent of an extreme flood from rivers with up to a 1 in 1000 (0.1% - 1%) chance of occurring each year

Scale : 28,000

N W E S

M42 J6

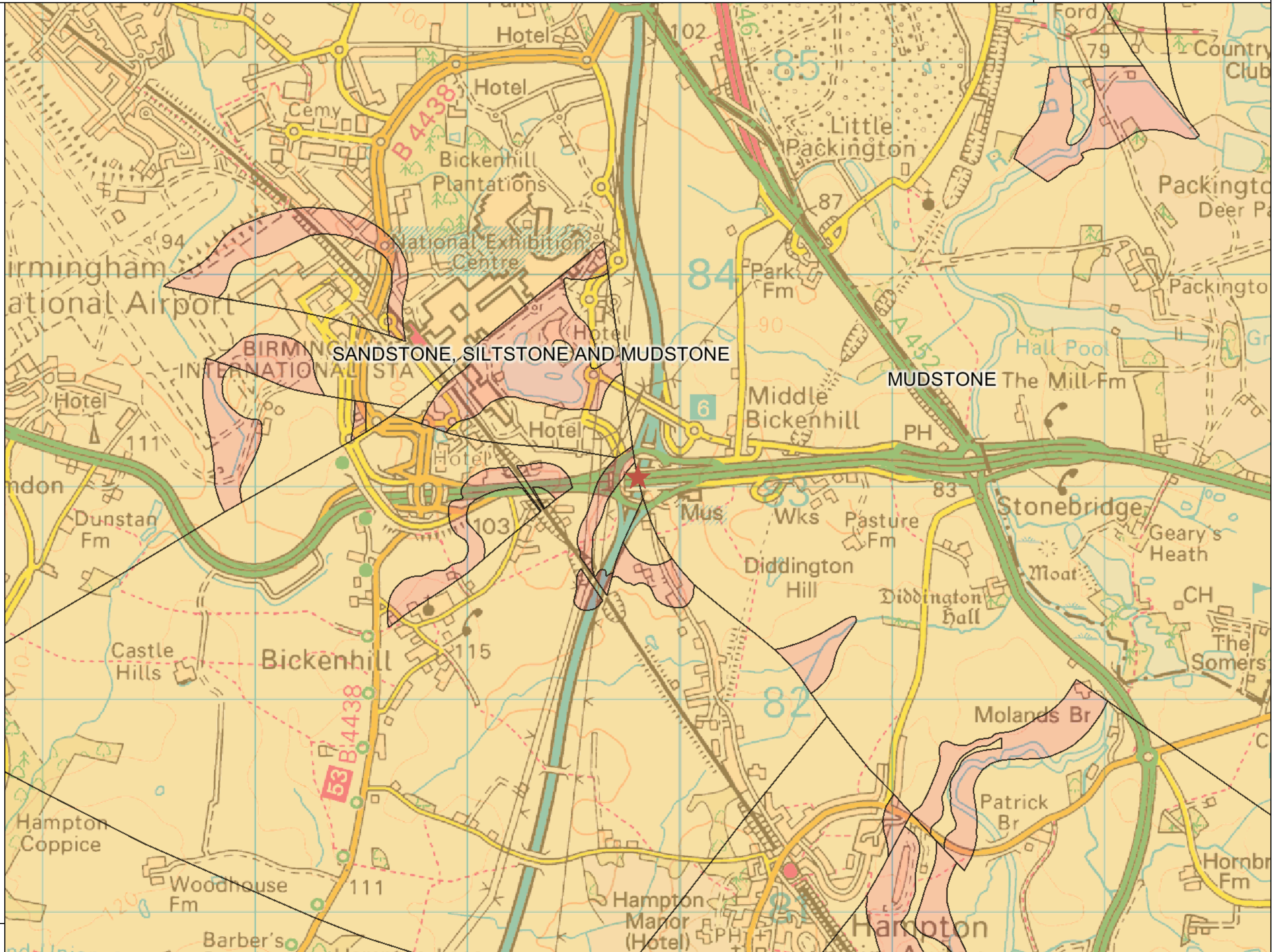
Legend

Source Protection Zones

- Zone I - Inner Protection Zone
- Zone II - Outer Protection Zone
- Zone III - Total Catchment
- Zone of Special Interest

Aquifer Designation (Bedrock)

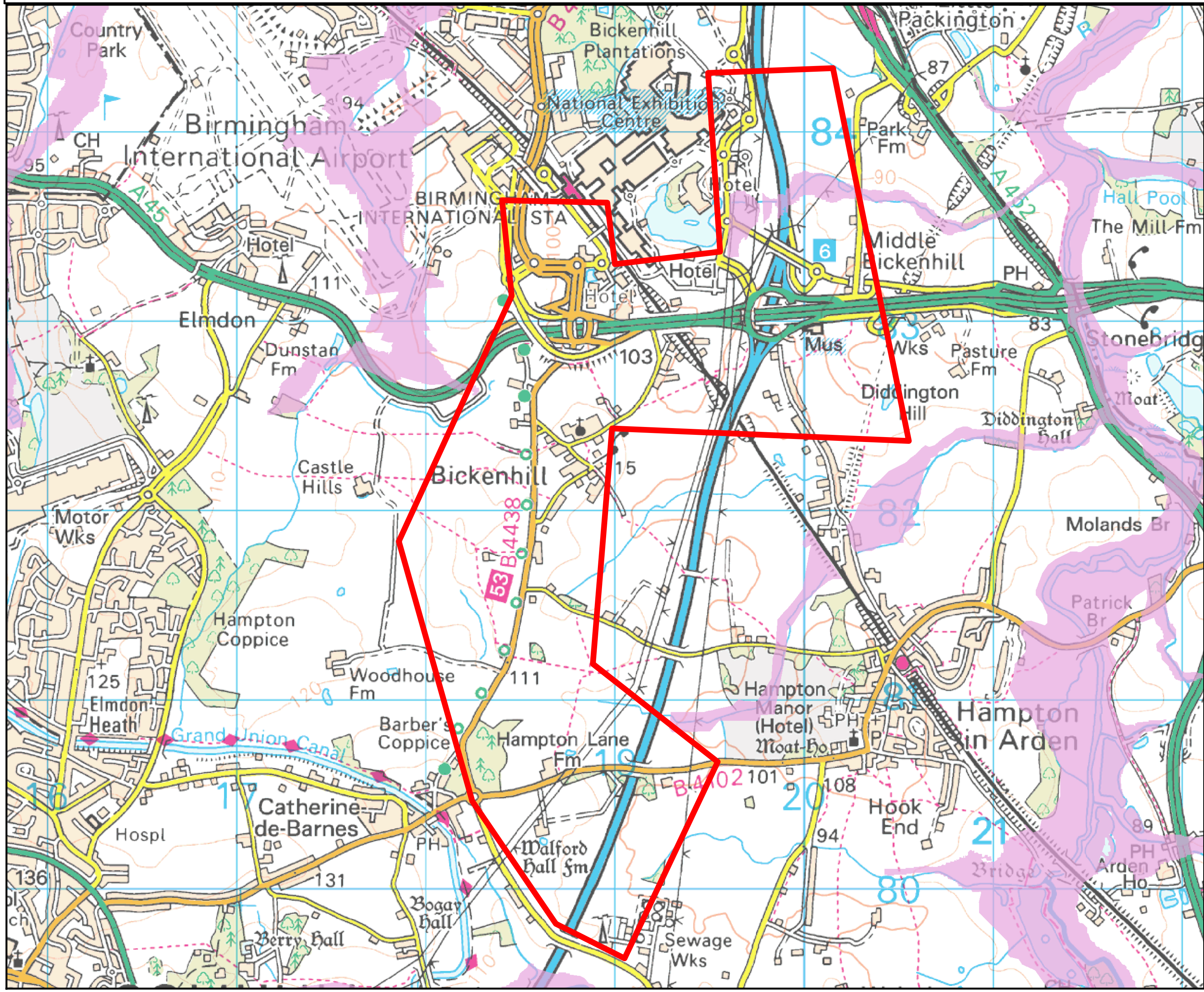
- Principal
- Secondary A
- Secondary B
- Secondary (undifferentiated)
- Unproductive



0 260 520 780 m.

N W E S

Flood Alert Map. SP 19807 83039. Created 28 September 2017 Ref 59528



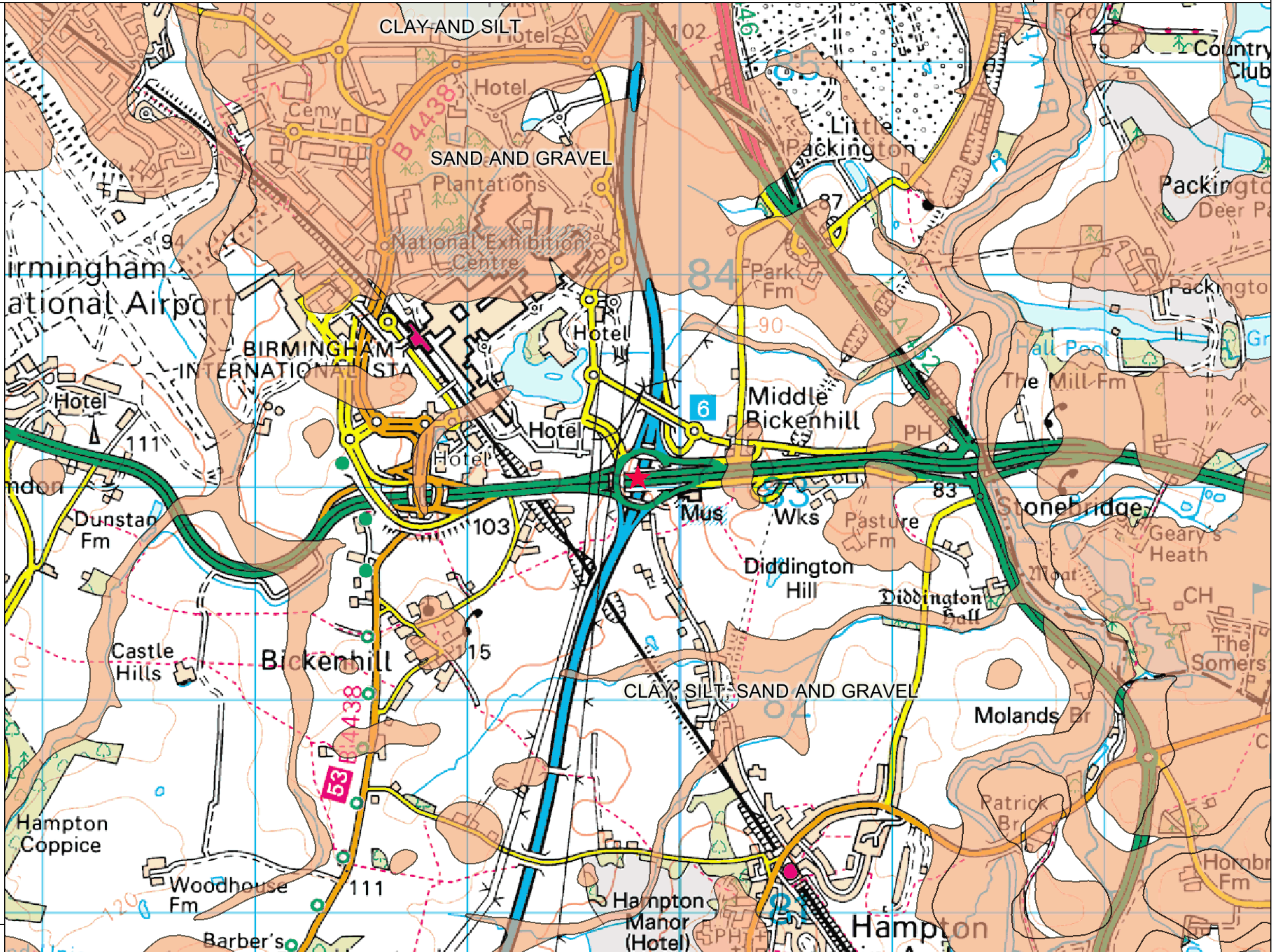
Legend

Flood Alert Area

Approximate location of site

Scale : 30,000

M42 J6 Superficial Deposits



Legend

Source Protection Zones

- Zone I - Inner Protection Zone
- Zone II - Outer Protection Zone
- Zone III - Total Catchment
- Zone of Special Interest

Aquifer Designation (Superficial)

- Principal
- Secondary A
- Secondary B
- Secondary (undifferentiated)
- Unknown (Lakes and Landslip)
- Unproductive

0 260 520 780 m.

N W E S

Appendix D: Hydraulic modelling and capacity assessment

Holywell Brook

Capacity Assessment & Modelling Report

9 August 2018

Prepared for:

Prepared by:

Daniel Hotten
Graduate Engineer
T: 01133916865

AECOM Limited
5th Floor, 2 City Walk
Leeds LS11 9AR
United Kingdom

T: +44 (0)113 391 6800
aecom.com

Table of Contents

Figures

Tables

1. Introduction

AECOM has developed this report in conjunction with the M42 Junction 6 improvement Flood Risk Assessment. The report assesses the capacity of Hollywell Brook and discusses its impact on the motorway's permanent road drainage design. Ultimately, this is to inform whether flood compensation storage is required as part of the works, and if so how much.

2. Background

Site Details & Proposal

The proposed scheme comprises:

- a new dumbbell roundabout junction (junction 5A) on the M42, north of Solihull Road bridge;
- new 120 kph (70 mph) dual carriageway link towards Birmingham Airport and Clock Interchange on the A45 aligned to the west of Bickenhil;
- the realignment of the existing B4438 Catherine de Barnes Lane; and;
- junction improvements to the M42 Junction 6.

As part of the proposed scheme, a number of improvements to Junction 6 of the M42 would be undertaken to compliment the proposed bypass – these would include dedicated on and off-slip lanes in a northbound and southbound direction on to and off the existing M42 from the A45 Coventry Road.

The proposed works impact the existing crossing of Hollywell Brook, to the north of the M42 Junction 6, where an extension of an existing culvert will be required. This will require construction over areas designated as Flood Zones associated with the watercourse.

Previous AECOM Assessments

Flood Compensation

The slip roads for the proposed improvements to the M42 J6 disrupt the flood plain of Hollywell Brook, which the Environment Agency identifies as being in Flood Zone 3 and Flood Zone 2 (Figure 1). Definitions of the Environment Agency flood zones are summarised in Table 1 below.

Table 1. EA Flood Zone Definitions

Flood Zone	Definition	Probability of Flooding
Flood Zone 2	Land that has a medium probability of flooding (between 1 in 100 and 1 in 1,000 annual probability of river flooding (0.1-1%), or between 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.1-0.5%))	Medium
Flood Zone 3	Land that has a high probability of flooding (1 in 100 year or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%))	High

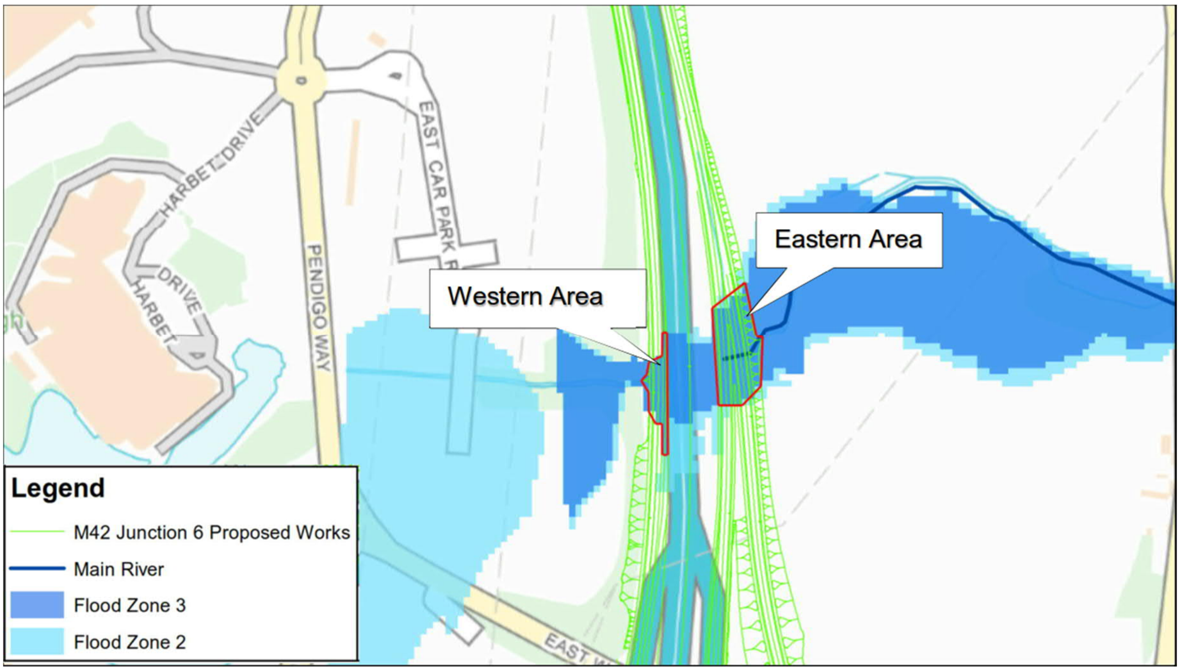


Figure 1. Flood Zone extents for Hollywell Brook and the Proposed Scheme Crossings

Based on the EA Flood Mapping, flood flows overtop the channel banks and are stored in the surrounding plains. The proposed design would reduce the land available for this storage and could increase flood risk downstream. If this is the case then compensatory flood storage could be required. AECOM calculated potential storage volumes, based on available topographical data and an assumption of top water level (TWL) based off of the topographical data. The volumes that were calculated as part of this assessment are listed in Table 2.

Table 2. Lost Flood Volumes Summary

Storage Area	Volume (m^3)	Area (m^2)	Assumed TWL (m AOD)
Western Area	120	860	89
Eastern Area	1230	2560	88.7
Combined – Flood Zone 3	1350	320	N/A

During this assessment, the accuracy of the EA Flood Mapping for this area was questioned, as the supposed flooding extents did not follow the topography of the site according to the available data.

Channel Capacity Assessment

Due to the conflicting and limited information of the initial calculations, and the EA flood mapping, it was decided to undertake a brief calculation to assess the capacity of the Hollywell Brook channel. This was additionally intended to verify the TWL's used in the previous assessment. A 90 m stretch of the Brook immediately downstream of the M42 Culvert was chosen for this assessment. Calculations are detailed in Appendix A.

Topographical data from the available survey data was used, in conjunction with Manning's open flow calculation to estimate both the capacity of the channel before overtopping, and the freeboard available during the 1% Annual Exceedance Probability (AEP) + 50% Climate Change (CC) event.

The results from this assessment indicate that the channel has a capacity of 16.2 m^3/s, which is significantly higher than expected during the worst case design condition of a 1% AEP + 50% CC event (6.6 m^3/s). Additionally, the design flow for this event provides 1.16 m of freeboard (i.e. the channel will not overtop). This suggests that the EA Flood Zone 3 could be inaccurate for this area. This could mean that there is no flood storage in this area and therefore the proposed works would have no impact on downstream flood risk.

Therefore, it was decided that hydraulic modelling was necessary to better assess the accuracy of the EA Flood Zone 3 and furthermore, the requirement for flood compensatory storage.

3. Hydraulic Modelling

To better assess the accuracy of the EA Flood Zone 3, a 1D model was created using Flood Modeller. As it was assumed that the channel would not overtop during the 1% AEP + 50% CC event, a 1D only model was deemed to be adequate for this scenario.

Cross Sections were extracted from the Civils 3D topographical drawing. These cross sections were chosen to reflect the nature of the channel. As highlighted in Figure 2, three cross sections are located within the boundary of the proposed slip roads and therefore would be good indicators of whether the proposals impact the existing flood zone. The data source of the topographical data is unknown, but the level of detail provided is thought to suggest LIDAR and therefore a sufficiently accurate base for this assessment.

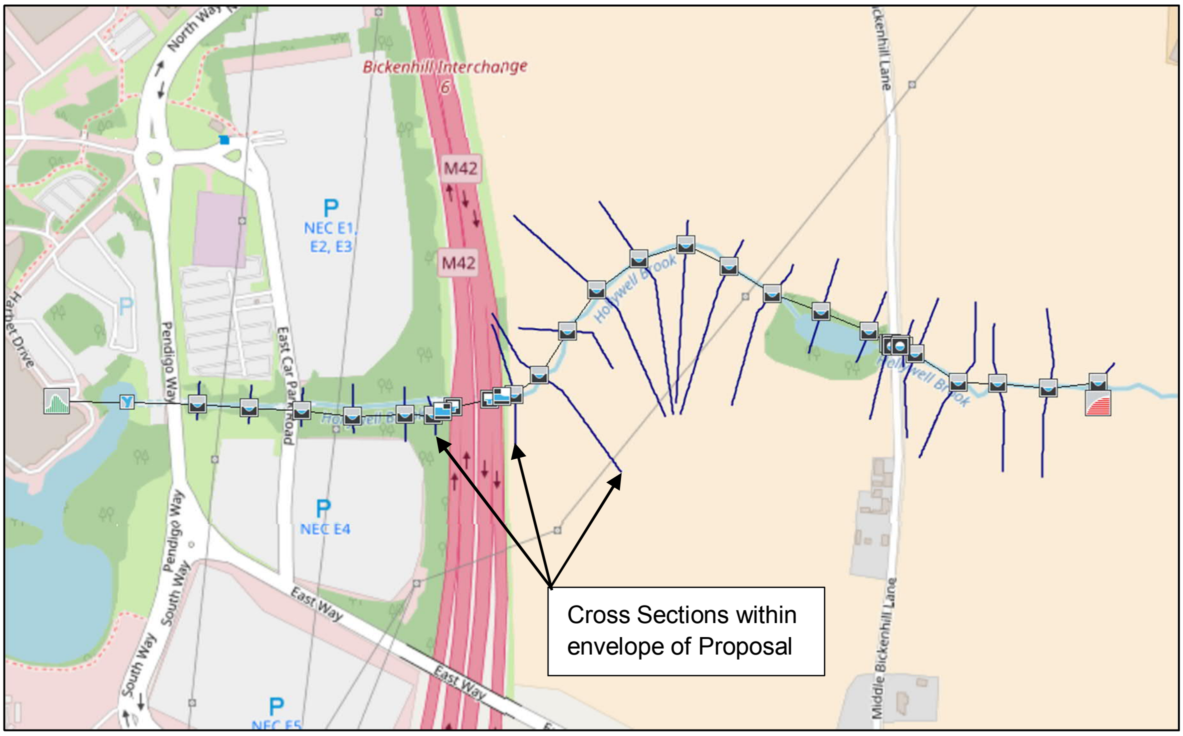


Figure 2. 1D Model of Hollywell Brook

An inflow of 6.6 m^3/s was used as the model input which represents the peak flow during the 1% AEP event. This was calculated using ReFH2 by AECOM (Appendix B), assuming an allowance of 50% for Climate Change.

A global Manning's roughness coefficient of 0.04 was chosen for the watercourse and the floodplains which is suitable to represent both; a clean, winding channel with some pools and shoals, and a pasture flood plain with high grass. A Manning's coefficient of 0.011 was chosen for the concrete culverts within the bridge at Middle Bickenhall Lane and is suitable to represent concrete culverts that are straight and full of debris. A Colebrook White roughness of 0.02 chosen for the culvert under the M42 which is representative of a corrugated steel culvert. This is discussed within Highways England's survey of the existing M42's culvert as seen in Appendix C.

A sensitivity analysis was performed on the Manning's coefficient. Two separate model runs were performed, with the roughness globally modified by ± 20%. Colebrook White roughness values were also modified by ± 10%. It was found that this had an insignificant effect on the output of the model. A sensitivity analysis was also performed on the downstream boundary condition, with the slope modified by ± 50%. Similarly, it was not found that this had a significant impact on the results of the model.

4. Results

The results from the modelling show that, during the 1% AEP + 50% CC event, the Holywell Brook is not expected to overtop at the cross sections within the envelope of the proposals. This is shown in Figure 3.

If all flow remains in channel, then there is no storage at any point and therefore no storage area lost as a result of the planned works. This means that there will be no impact to flood risk downstream.

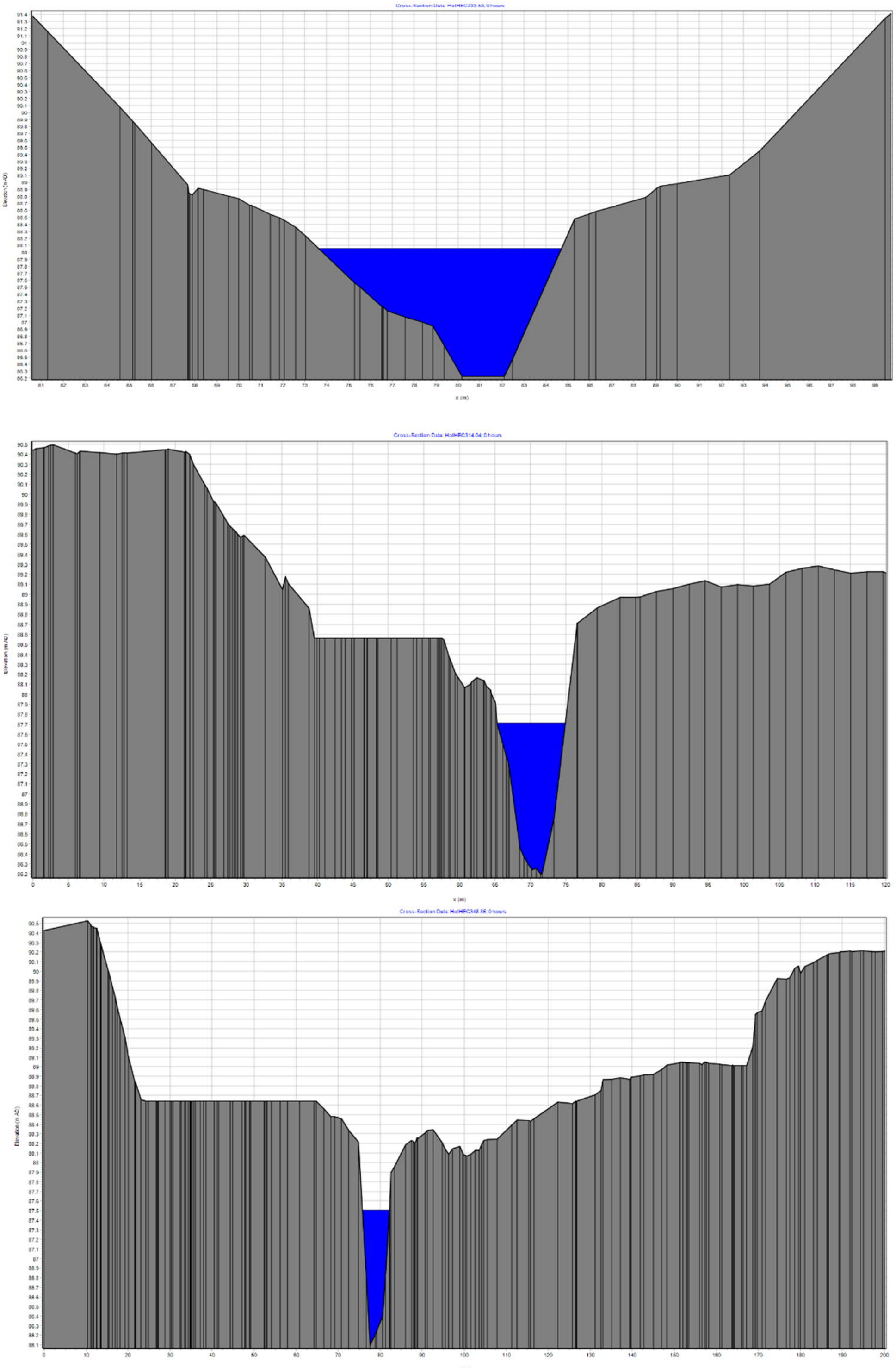


Figure 3. Modelling Results for Cross Sections of Interest

Therefore, it is expected that the proposals do not encroach on a flood plain. Due to this, there is no requirement to provide flood compensatory storage in conjunction with the scheme.

Appendix A – Hollywell Brook Capacity Assessment

Technical Note

AECOM

Project:	**M42 Junction 6 Improvement Scheme**	Job No: **60543032**
Subject:	**Hollywell Brook Capacity Assessment**	
Prepared by:	**Daniel Hotten**	Date: **24th July 2018**
Checked by:	**Christopher Irwin**	Date: **25th July 2018**
Approved by:	**Cathryn Spence**	Date: **25th July 2018**

1 Introduction

Further discussions have taken place between the M42 design team and the Leeds Water team. As seen in drawing HE551485-ACM-HDG-M42_GEN_ZZ_ZZ-SK-CD-0008-P02 (Annex A), the proposed slip road toward Junction 6 encroaches into an EA Flood Zone 3. In addition, reed beds have been proposed to provide surface water runoff treatment, however these have been place within the EA Flood Zone 3 also.

2 Scope

Due to the available flood storage being reduced, as part of the M42 upgrades (as discussed above) the M42 design team are required to provide compensatory storage. However, a number of uncertainties with the accuracy of the EA flood mapping have been highlighted. Leeds Water team have been tasked with undertaking a high level calculation to assess the capacity of the Hollywell Brook, and to determine if it overtops during the below specified events.

3 Methodology and data

The Hollywell brook is under the influence of the Humber river basin district. Therefore, will be assessed by the following Annual Exceedance Probability (AEP) plus climate change (CC) as recommended by the Environment Agency[1].

Table 1. AEP + Climate change assessments

Flood zone	Infrastructure classification	AEP% + CC
3a	Essential infrastructure	1% AEP + 50% CC
3a	Less vulnerable	1% AEP + 30% CC

[1]Environment Agency. Flood risk assessments: climate change allowances. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#what-climate-change-allowances-are

Manning's open channel flow equation has been used to evaluate the capacity of the Hollywell brook. The topographical data was provided by the M42 design team. The channel's cross sectional shape is similar to a trapezoid shape, therefore a trapezoidal channel has been assumed in the calculations.

A manning's 'n' value of 0.04 has been chosen, which reflects a sluggish natural channel. A 90 m length, downstream of the culvert under the M42 was sampled to calculate the slope of the brook. This slope is consistent with the downstream cross section modelled in the HS2 London – West Midlands Environmental Statement[2].

Table 2. Key Data (90m length downstream sample)

Channel Dimension	Value
Upstream Bed Level	86.40 m AOD
Downstream Bed Level	85.97 m AOD
Length of Channel	90.00 m
Channel Gradient	1 : 205 m
Base width of Channel	2.40 m
Depth of Channel	2.20 m (with 0.3m freeboard)
Gradient of side slope of Channel	1 : 0.70 m

4 Outputs

As seen in Appendix B the capacity of the Hollywell brook has been calculated to be **16.20 m^3/s**. This capacity was compared against the assessed flow rates for the Hollywell Brook sourced from the HS2 London – West Midlands Environmental Statement. These flow rates are shown in Table 3.

Table 3. Peak Flow calculations

AEP% + CC	Flow (m^3/s)
1% AEP + 30% Climate Change	5.70
1% AEP + 50% Climate Change	**6.60**

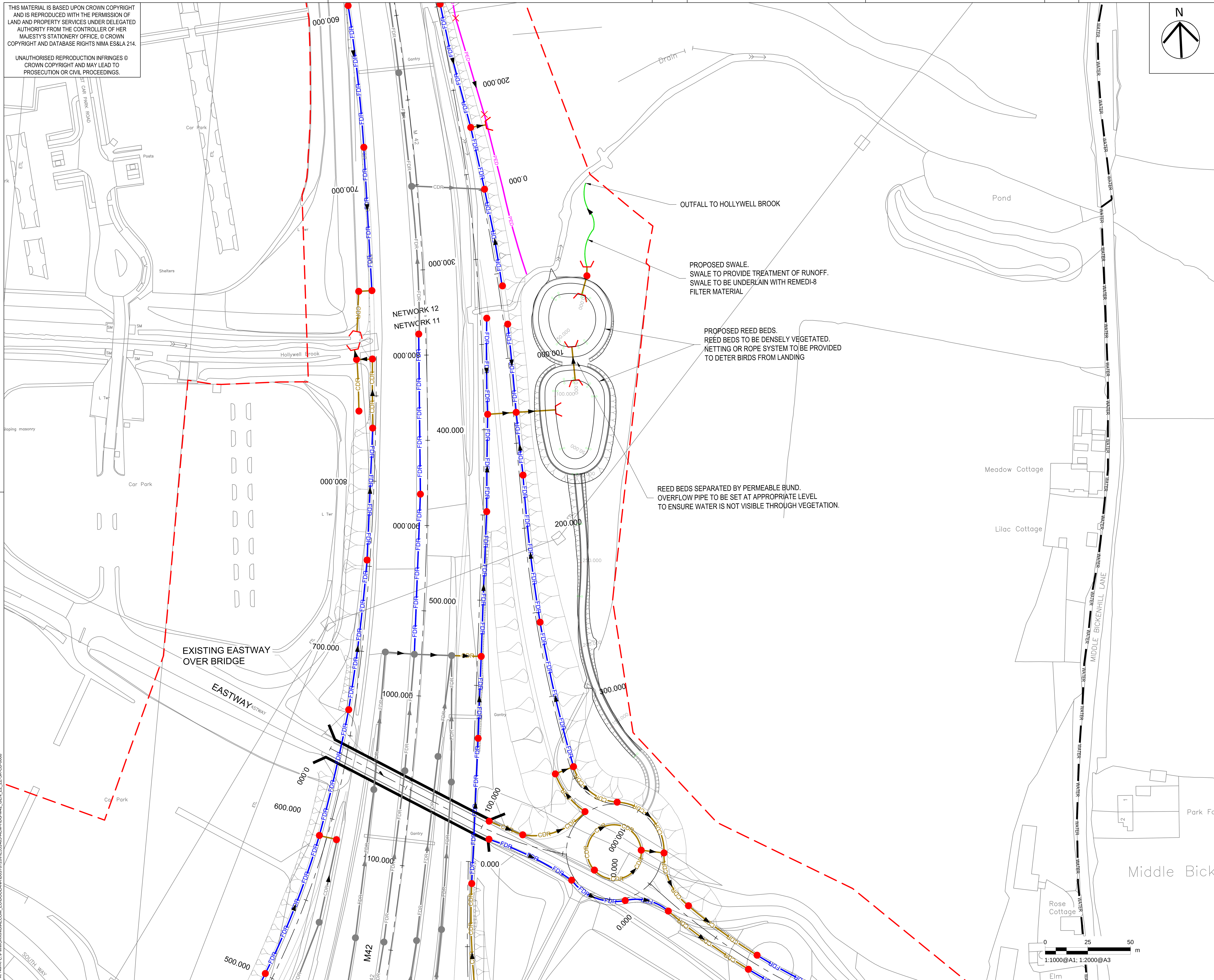
As seen in Annex C when the flow rate of 6.60 m^3/s was achieved, the depth of flow within the brook was approximately 1.34 m. As a result, this provided a freeboard 1.16 m. It is therefore not expected that the brook will overtop during the 1% AEP + 50% Climate Change event.

5 Further Actions

To confirm the true accuracy of the EA Flood Zone 3's extents, a more detailed hydraulic model is required. The hydraulic model will assess the Hollywell Brook during the 1% AEP + 50% CC scenario. The above calculations do not consider downstream constrictions that may result in overtopping and out of bank flooding. There is a road culvert downstream that constricts flow and could result in flooding. It is recommended that AECOM open discussion with HS2 about the using their current hydraulic model, which already include both the downstream storage pond and the under road culvert.

[2] HS2. (2013). London - West Midlands Environmental Statement. Volume 5 | Technical Appendices, p.27. Available at: http://webarchive.nationalarchives.gov.uk/20140613023457/http:/assets.dft.gov.uk/hs2-environmental-statement/volume-5/water/Vol5_CFA2324_Water_resources_River_modelling_technical_report_WR-004-018.pdf

Annex A



SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION BOX

IT IS ASSUMED THAT ALL WORKS ON THIS DRAWING WILL BE CARRIED OUT BY A COMPETENT CONTRACTOR WORKING, WHERE APPROPRIATE, TO AN APPROPRIATE METHOD STATEMENT.

THIS DRAWING IS TO BE USED ONLY FOR THE PURPOSE OF ISSUE THAT IT WAS ISSUED FOR AND IS SUBJECT TO AMENDMENT.

EXCEPTIONAL RISKS RELATING TO THE WORKS ASSOCIATED WITH THIS DRAWING ARE IDENTIFIED BELOW.

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NOTES

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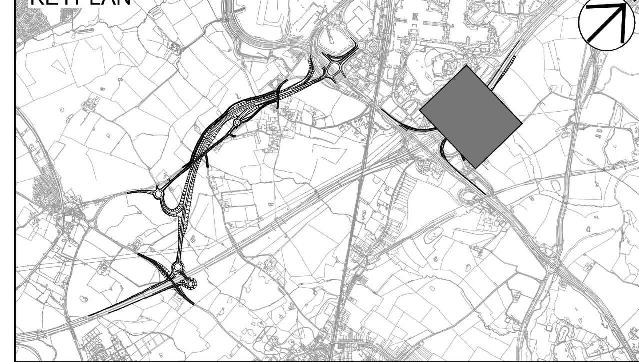
3. ALL DIMENSIONS IN METRES, ALL CHAINAGES, LEVELS AND COORDINATES ARE IN METRES UNLESS DEFINED OTHERWISE.
4. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE PROJECT HEALTH & SAFETY FILE FOR ANY IDENTIFIED POTENTIAL RISKS.

LEGEND

- EXTENT OF SCHEME
- CDR — PROPOSED CARRIER DRAIN
- FDR — PROPOSED FILTER DRAIN
- PROPOSED SWALE
- PED — PROPOSED PRE-EARTHWORKS DITCH
- BKD — PROPOSED BRIDGE KERB DRAIN
- CDR — EXISTING CARRIER DRAIN
- FDR — EXISTING FILTER DRAIN
- PROPOSED CHAMBER
- EXISTING CHAMBER
- OPEN CHANNEL POINT
- FLOW ARROW
- HEADWALL
- PROPOSED STRUCTURE
- DB — DETENTION BASIN

N8/3.000/225 — NETWORK, PIPE NUMBER, PIPE DIAMETER

KEYPLAN



Revision Details	By	Check	Date	Suffix
First Issue	RD	JF	07/06/18	P01

Purpose of issue

FOR REVIEW AND COMMENT

Client
Highways England
The Cube
199 Wharfside Street
Birmingham
B1 1RN

Working on behalf of highways england

Project Title

M42 JUNCTION 6 IMPROVEMENTS

Drawing Title

M42 JUNCTION 6 STORAGE ALTERNATIVES NETWORK 11 REED BEDS & SWALE

Designed	Drawn	Checked	Approved	Date
RD	---	---	---	05/07/18

Internal Project No. 60543032	Suitability S3
Scale @ A1 1:1000	Zone M42

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AECOM
Royal Court
Basil Close
Chesterfield
Tel01246 209221
Fax01246 209229
www.aecom.com

AECOM Infrastructure & Environment UK Limited
Registered in England Registered number: 880328
Registered office: Scott House, Alencon Link, Basingstoke, Hampshire RG21 7PP

Scale: 0 25 50 m — 1:1000@A1; 1:2000@A3

Drawing Number: HE551485 -ACM -HDG - M42_GEN_ZZ_ZZ -SK -CD -0008 Rev P02

Annex B

Mannings calculation - Open channel flow

Project:	**M42**	Spreadsheet Originator / creator:	Adrian Hill	Date:	19/03/2014
Project no:	**60543032**	Calculation undertaken by:	DH	Date:	20/07/2018
		Checked by:	CI	Date:	23/07/2018
Description:	**High level channel capacity analysis**	Approved (for use) by:		Date:	
Option:	**Full capacity check**				

Mannings equation

$$V = \frac{k}{n}\left(\frac{A}{P}\right)^{2/3} S^{1/2}$$

Key:

(yellow)	Cells which require user input
(orange)	Cells with inbuilt formulas or cells which do not require user input

Superelevation at bends

rc =	1000	Radius of curvature to the centerline of the channel, m
ro =	1002.95	Radius of curvature to the outside flow line around the bend, m
ri =	997.05	Radius of curvature to the inside flow line around the bend, m (ft)
ΔZ/2 =	0.001	**m (unlined channel)**
ΔZ/2 =	0.001	**m (lined channel)**

$$\Delta Z = Z_o - Z_i = \frac{V^2}{g r_c}(r_o - r_i)$$

$$\Delta Z = \frac{V_{max}^2}{2g}\left\{2 - \left(\frac{r_i}{r_o}\right)^2 - \left(\frac{r_c}{r_o}\right)^2\right\}$$

Change in velocity at bends

% change	0%	1.87	**m/s (outer bend)**
		1.86	**m/s (inner bend)**

V = **1.87** **m/s (centre line of channel)**

Vc = (g*dm)^0.5 =	3.94	**m/s**
Froude number =	**0.47**	(Non-dimensional)

Q = VA

Q = **16.20** **m3/s**

(select from drop down list)

Manning's variations (Click on +/- button to expand / contract)

Flow variations (Click on +/- button to expand / contract)

Where		Values used		
Type of structure	single channel/culvert	(select from drop down list for type of channel)		**or User defined**
n =	0.0400 Natural channels - sluggish, deep pools	0.0400	(select from drop down list). Mannings n (see table)	**0.0350**
R =	Trapezoidal channel	(select from drop down list for type of channel) Hydraulic radius = A/P		
So =	0.0048	Use So calculator		

So calculation

86.40	m AOD - Bed level at point A
85.97	m AOD - Bed level at point B
90.00	m - Distance between point A and point B
205.00	Channel gradient (1 in)

Values of R

Data for rectangular and trapizoidal channels only channel

2.40	Base width of channel (b)	5.90	m Top width of channel (inner face to inner face)
2.20	Depth of flow (y)	0.30	m Freeboard
2.50	Depth of channel / culvert	0.30	m Freeboard (with super elevation at bends - worst case)
0.70	gradient of side slope of channel (x)		

Channel type	**A**	**P**	**R**	**B**	**dm**	**Channel width**
Rectangular channel	5.28	6.80	0.78	2.40	2.20	2.40
Trapezoidal channel	8.67	7.77	1.12	5.48	1.58	5.90
User defined	345.00	94.00	3.67	100.00	3.45	100.00

Table of typical Maning values (taken from Hydraulics in Civil and Environmental Engineering, 2nd edition) - (Click on +/- button to expand / contract)

Annex C

Mannings calculation - Open channel flow

Spreadsheet Originator / creator:	Adrian Hill	Date:	19/03/2014
Calculation undertaken by:	DH	Date:	20/07/2018
Checked by:	CI	Date:	23/07/2018
Approved (for use) by:		Date:	

Project: M42

Project no: 60543032

Description: High level channel capacity analysis

Option: 1% AEP + 50% CC check

Mannings equation

$$V = \frac{k}{n}\left(\frac{A}{P}\right)^{2/3} S^{1/2}$$

Key:

(yellow)	Cells which require user input
(orange)	Cells with inbuilt formulas or cells which do not require user input

Superelevation at bends

rc =	1000	Radius of curvature to the centerline of the channel, m
ro =	1002.95	Radius of curvature to the outside flow line around the bend, m
ri =	997.05	Radius of curvature to the inside flow line around the bend, m (ft)
ΔZ/2 =	0.001	**m (unlined channel)**
ΔZ/2 =	0.001	**m (lined channel)**

$$\Delta Z = Z_o - Z_i = \frac{V^2}{g r_c}(r_o - r_i)$$

$$\Delta Z = \frac{V_{max}^2}{2g}\left\{2 - \left(\frac{r_i}{r_o}\right)^2 - \left(\frac{r_c}{r_o}\right)^2\right\}$$

Change in velocity at bends

% change	0%	1.49	**m/s (outer bend)**
		1.48	**m/s (inner bend)**

V = **1.48** **m/s (centre line of channel)**

Vc = (g*dm)^0.5 =	3.20	**m/s**
Froude number =	**0.46**	(Non-dimensional)

Q = VA

Q = **6.60** **m3/s**

(select from drop down list)

Manning's variations (Click on +/- button to expand / contract)

Flow variations (Click on +/- button to expand / contract)

Where		Values used		
Type of structure	single channel/culvert	(select from drop down list for type of channel)		**or User defined**
n =	0.0400 Natural channels - sluggish, deep pools	0.0400	(select from drop down list). Mannings n (see table)	**0.0350**
R =	Trapezoidal channel	(select from drop down list for type of channel) Hydraulic radius = A/P		
So =	0.0048	Use So calculator		

So calculation

86.40	m AOD - Bed level at point A
85.97	m AOD - Bed level at point B
90.00	m - Distance between point A and point B
205.00	Channel gradient (1 in)

Values of R

Data for rectangular and trapizoidal channels only channel

2.40	Base width of channel (b)
1.34	Depth of flow (y)
2.50	Depth of channel / culvert
0.70	gradient of side slope of channel (x)

5.90	m Top width of channel (inner face to inner face)
1.16	m Freeboard
1.16	m Freeboard (with super elevation at bends - worst case)

Channel type	**A**	**P**	**R**	**B**	**dm**	**Channel width**
Rectangular channel	3.21	5.07	0.63	2.40	1.34	2.40
Trapezoidal channel	4.46	5.66	0.79	4.27	1.04	5.90
User defined	345.00	94.00	3.67	100.00	3.45	100.00

Table of typical Maning values (taken from Hydraulics in Civil and Environmental Engineering, 2nd edition) - (Click on +/- button to expand / contract)

Appendix B – ReFH2 Rate for Hollywell Brook

AECOM

Revitalised Flood Hydrograph (ReFH2) Method

Flood Estimates from the ReFH2 Method

Return Period	Site Code						
	Hollywell	A45 Drain	Bickenhill				
2	1.51	0.24	0.12				
5	2.01	0.33	0.17				
10	2.41	0.40	0.21				
20	2.86	0.47	0.25				
25	3.03	0.50	0.26				
30	3.18	0.52	0.28				
50	3.63	0.60	0.32				
75	4.05	0.66	0.35				
100	4.38	0.71	0.38				
200	5.29	0.86	0.46				
1000	7.76	1.25	0.67				

The ReFH2 FEH 2013 model peak flows are based on the 'urbanised' design rainfall, rather than the 'as rural' design rainfall/flow.
All flow rates are in m3/s

Appendix C – Highway England's Survey of Existing M42 Culvert

HIGHWAYS AGENCY

Culvert 11 Holywell Brook

ROADS 277 (smis)

HA Structure No.	/M42//32.90/Q/	HA ST Key	24377
O/S Grid Ref. (E/N)	419890 /283640	MA Structure Ref	
County/Borough	Solihull		
Maintaining Region	West Midlands	Date of Production	17/04/2018
Structure Agent	Kier Highways - Area 9	Date of Last Principal Inspection	27/05/2016
Structure Owner (if not HA)	Highways Agency		
Assigned road	M42		

Year Structure Commissioned	1976
Design Office	Not Known
Design Load	HA + 45 HB
Special loading/restriction	N/A

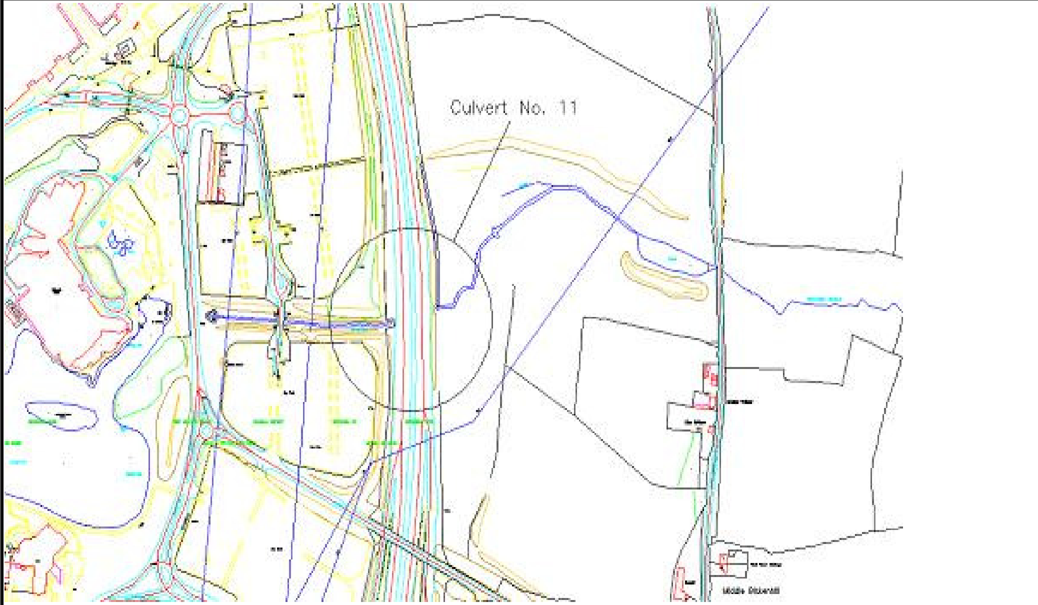
The **Road M42** goes **over Small Culvert**,authority **Highways Agency**
The **Natural Watercourse** goes **under Culvert 11 Holywell Brook**,**is not** tidal,**is not** navigable,authority **Environment Agency**

Structure Susceptible to Scour?	N
Structure on High Load Route?	N
Structure on Heavy Load Route?	N
Structure Ancient Monument?	N

SuperStructure Construction Details

Deck/Wall/Mast etc. Materials	**Corrugated Rolled Steel**
Type of Construction	**Corrugated Steel Buried Structure (CSBS) - Arch Profile With Footings**

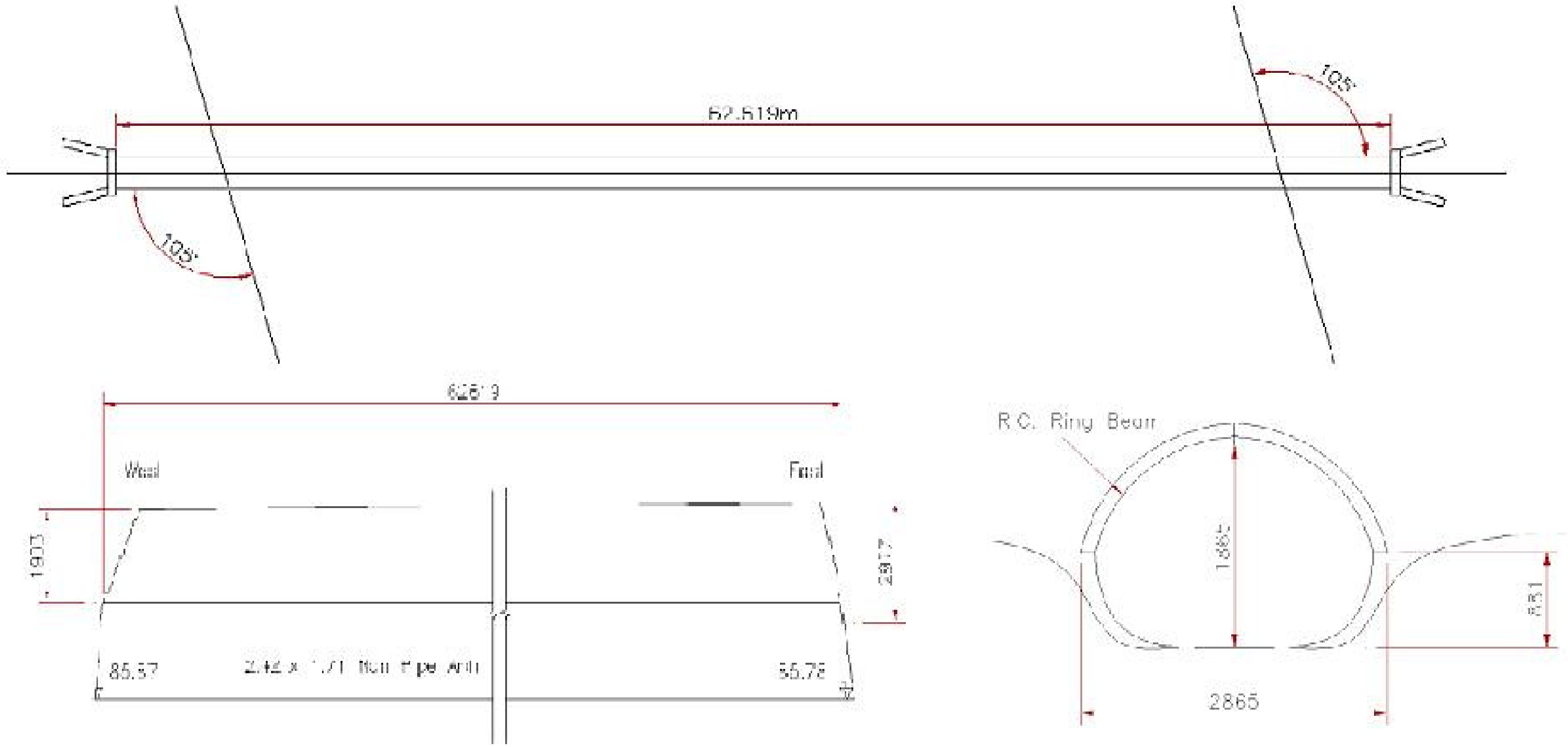
SubStructure Construction Details



HA ST Key 24377 This is produced from SMIS data current at Date of Production 17/04/2018

Culvert 11 Holywell Brook

ROADS 277 (smis)



	Manufacturer	Type	Component	Manufacturer/Fabricator	Type

HA ST Key 24377 This is produced from SMIS data current at Date of Production 17/04/2018 aecom.com

Appendix E: Solihull Metropolitan Borough Council Consultation

ASSET BLOCKAGE SENSITIVITY TESTING
SOLIHULL METROPOLITAN BOROUGH COUNCIL

Asset Reference	SOL_0083
SMBC Structure Code	-
Description	-
Carries	Footpath
Over	Stream
Ward Location	Bickenhill Ward
National Grid Reference	418514 279639

Solihull Metropolitan Borough Council
Highway Services
The Council House
Manor Square
Solihull
B91 3QB

JBA Office

JBA Consulting
The Library
St Philips Courtyard
Church Hill
COLESHILL
Warwickshire
B46 3AD

Revision History

Revision Ref / Date Issued	Amendments	Issued to
Final / October 2016		Edward Bradford

Contract

This report describes work commissioned by Solihull Metropolitan Borough Council, by Commission Order No 485867 dated 30th March 2016. Solihull Council's representative for the contract was Edward Bradford. David Kearney, Nelly Marcy, Anneka Lowis and Jack Dudman carried out this work.

Prepared by .... Jack Dudman BSc MSc

Reviewed by .... Anneka Lowis BSc MSc FRGS

Purpose

This document has been prepared as a Summary Report for the investigation of flood risk (calculation of a 100% blockage and a 'without blockage' scenario) for 504 culvert locations as agreed with Solihull Metropolitan Borough Council. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

JBA Consulting has no liability regarding the use of this report except to Solihull Metropolitan Borough Council.

Acknowledgements

JBA would like to acknowledge the support of Edward Bradford of Solihull Metropolitan Borough Council.

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Contents

List of Tables

Abbreviations

DTM .... Digital Terrain Model

JFlow+ .... JBA Consulting's in house two dimensional flood software

LIDAR .... Light Detection and Ranging

NGR .... National Grid Reference

NRD .... National Receptor Database

1 Introduction

This report investigates the possible flood risk associated with an asset on Stream in Bickenhill Ward, with asset reference SOL_0083.

1.1 General Asset Information

1.1.1 Asset

Asset Reference	SOL_0083
Inlet National Grid Reference (NGR)	418514 279639

1.1.2 Dimensions

Asset Length (m)	3.82
Assumed Capacity (m^3)	0.90
Height (m)	1.00
Width (m)	1.00
Shape	Circular
Material	Concrete
Manning's Roughness Coefficient	0.011
Slope	0.0010
Note: The asset data contained within this report is indicative and should be verified by reviewing detailed asset survey reports.	

2 Methodology

2.1 Hydrology

The peak flows for the 6 Return Periods modelled are summarised in Table 2-2.

Table 2-2 Peak Flows

30 year	100 year	1000 year	100 year + 20% CC	100 year + 30% CC	100 year + 50% CC
0.50	0.68	1.19	0.81	0.88	1.01

2.2 Hydraulic Modelling

2.2.1 General Model Assumptions

- Model constructed using JFlow+
- Digital Terrain Model derived from 2 metre composite LIDAR and IHM (used under licence from the Environment Agency).

2.2.2 100% Blockage Modelling Assumptions

For the purpose of blockage, we have assumed a culvert capacity of zero, thus assuming that no water can be conveyed and that all of the flow will be forced out of bank at the culvert inlet.

2.2.3 Without Blockage Modelling Assumptions

The 'without blockage' modelling scenario required the calculation of the culvert capacity, in order to estimate the volume of water conveyed through the structure. Any flows greater than the capacity of the culvert were represented as out of bank flow at the culvert inlet. The culvert capacity was calculated using the Manning's equation.

2.3 Model Scenarios

The model has been run for 6 return periods: 30, 100, 1000-year with three climate change modifications to the 100-year return period of +20%, +30% and +50%. For each return period a 100% blockage ('with blockage') and 0% blockage ('without blockage') scenario were modelled. Depth, hazard and velocity flow grids were produced for each scenario. See below for modelling results.

2.4 Standard of Protection

Design flood flows at each asset inlet were calculated for a range of return periods. The culvert capacity was then compared with these to provide an estimate of each asset's Standard of Protection (SoP). Standard of protection is equal to the highest return period with a peak flow less than the asset capacity.

The SoP for asset ID SOL_0083 is 100 years + 30%.

3 Consequence

The modelled depth grids were converted to outlines and these were queried against the National Receptor Dataset (NRD) to obtain counts of flooded properties and lengths of flooded infrastructure.

3.1 Properties at risk

NRD property points were split into three categories; Residential, Non Residential, and Key Infrastructure. The total number of flooded properties and ground floor properties for all events and scenarios are reported in Table 3-1.

Table 3-1 All events – Number of properties flooded

		Model Event											
		100% Blocked						Without Blockage					
Consequence		Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%
Area Flooded (m^2)		32168	39380	54120	42652	44624	49904	0	0	13560	0	0	4248
Properties Affected													
All	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0
Res	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0
Non - Res	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0
Key	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0

3.2 Infrastructure at risk

The lengths of flooded roads and railway[1] are shown in Table 3-2. This is a simple assessment and does not take into account the fact that some structures may be elevated out of the flooding.

Table 3-2 All events - Infrastructure at risk (m)

	Model Event											
	100% Blocked						Without Blockage					
Infrastructure (m)	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%
Motorway	9	9	9	9	9	9	0	0	9	0	0	5
A Road	0	0	0	0	0	0	0	0	0	0	0	0
B Road	0	0	0	0	0	0	0	0	0	0	0	0
Unclassified Road	12	12	14	12	12	12	0	0	12	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0

[1] Contains public sector information licensed under the Open Government Licence v3.0.

Appendices

Where the channel capacity of the asset for the relevant blockage scenario is greater than the modelled return period flow all of the flow is conveyed through the structure and no map has been produced.

A 100% Blocked Maps

A.1 Extent – 30 Year Return Period

A.2 Depth – 30 Year Return Period

A.3 Extent – 100 Year Return Period

A.4 Depth – 100 Year Return Period

A.5 Extent – 1000 Year Return Period

A.6 Depth – 1000 Year Return Period

B 0% Blocked Maps

B.1 Extent – 30 Year Return Period

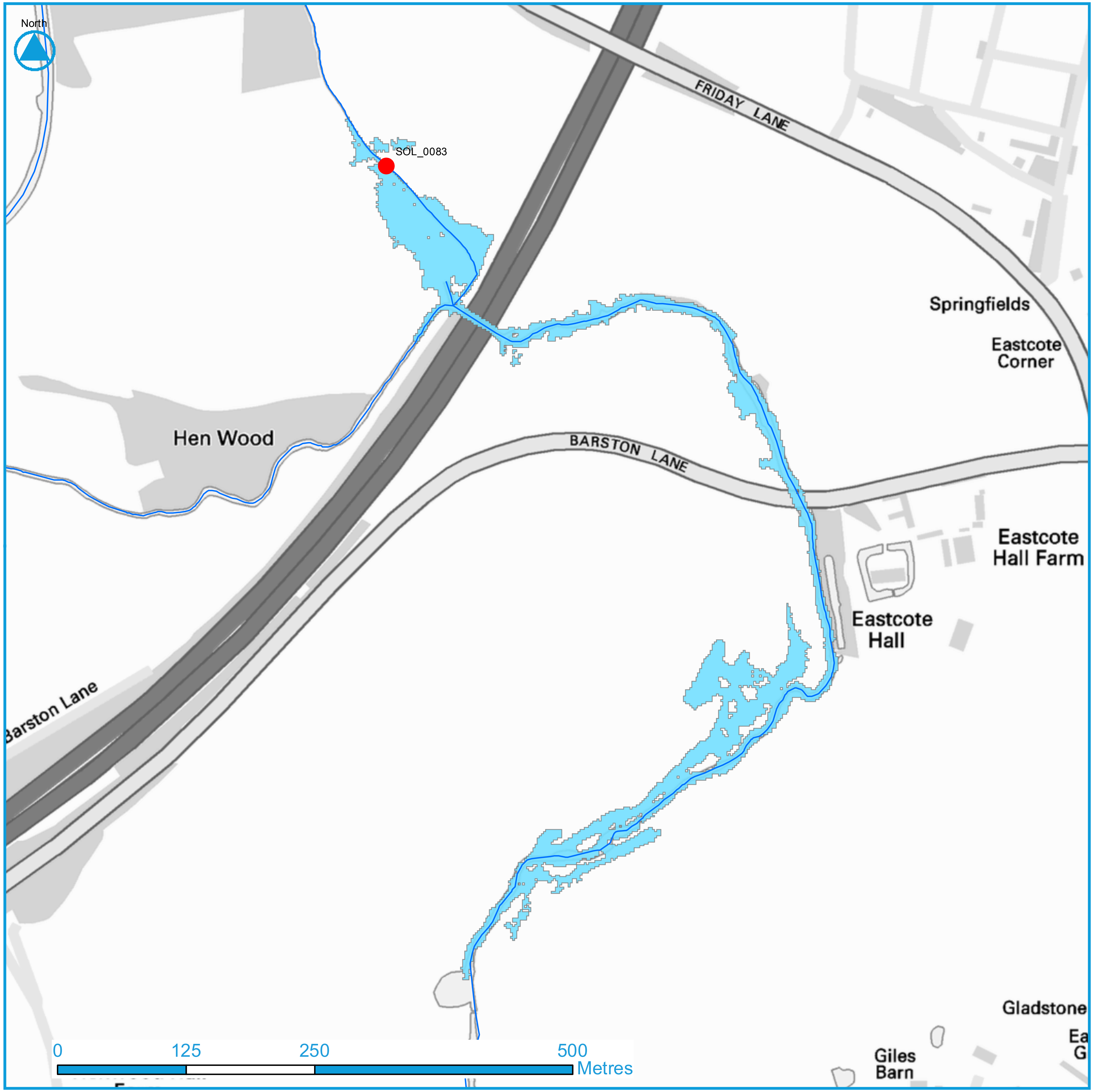
B.2 Depth – 30 Year Return Period

B.3 Extent – 100 Year Return Period

B.4 Depth – 100 Year Return Period

B.5 Extent – 1000 Year Return Period

B.6 Depth – 1000 Year Return Period

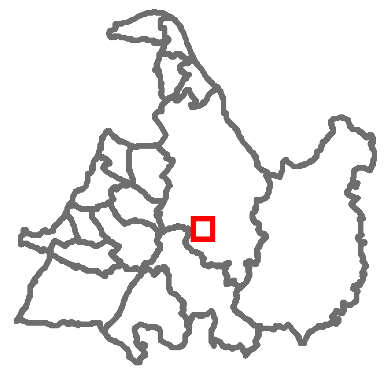


Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0083
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

NRD Property Points
- Key Infrastructure
- Residential
- Non Residential
- Flood Extent
- Asset Location



X: 418514 **Y:** 279639

Shape: Circular
Capacity (m^3/s): 0.90 **Length (m):** 3.82
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

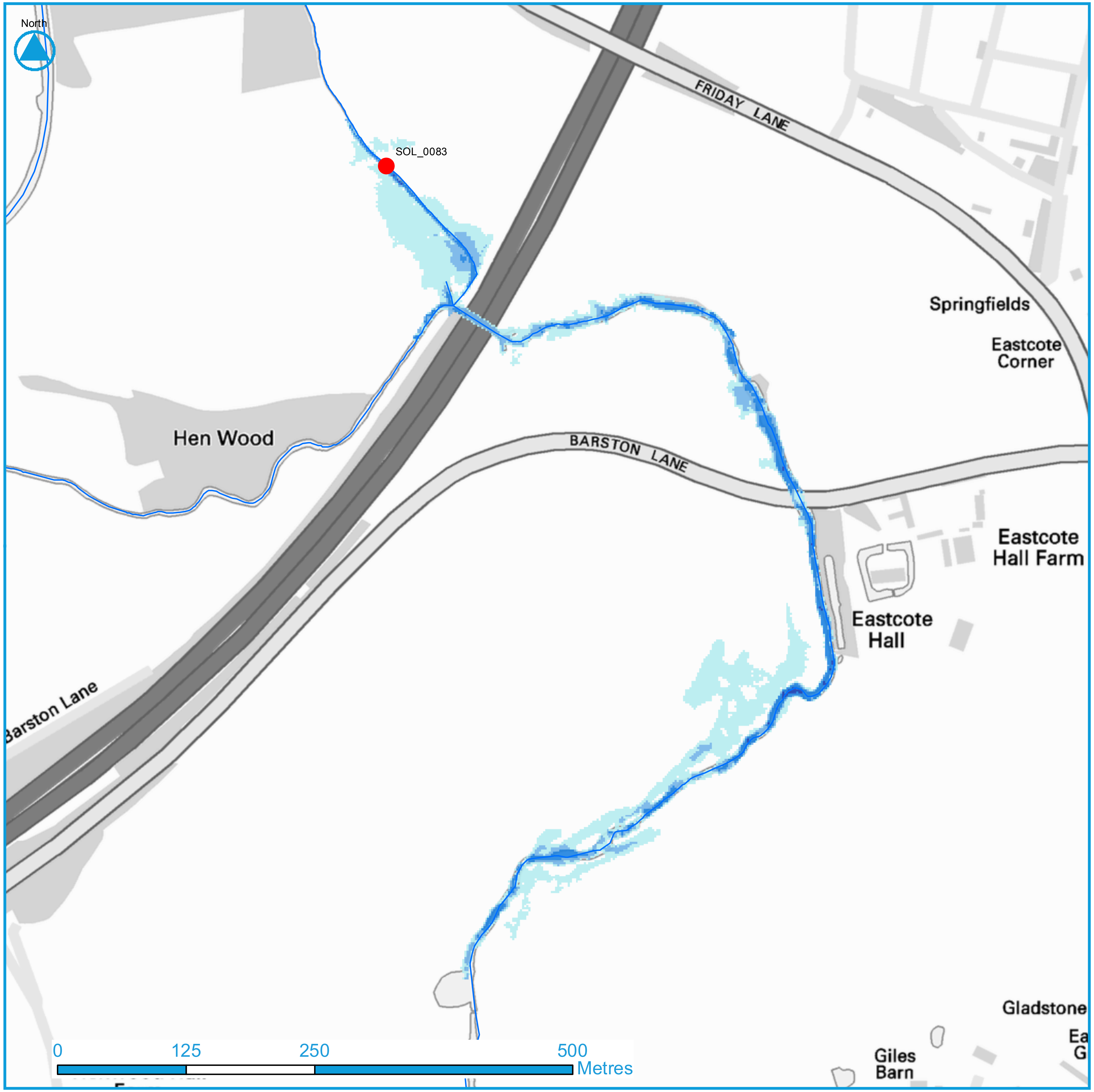
Consequence

Scenario: 30 Year Return Period - 100% Blocked

Area Flooded (m^2): 32,168

Road Length Flooded (m): 22

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0



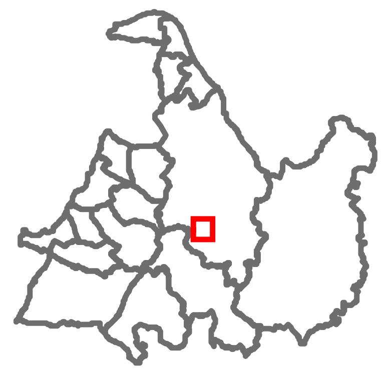
Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0083
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

Depth
- 0 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1 m
- 1 - 2 m
- > 2 m
- Asset Location



X: 418514 **Y:** 279639

Shape: Circular
Capacity (m^3/s): 0.90 **Length (m):** 3.82
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence

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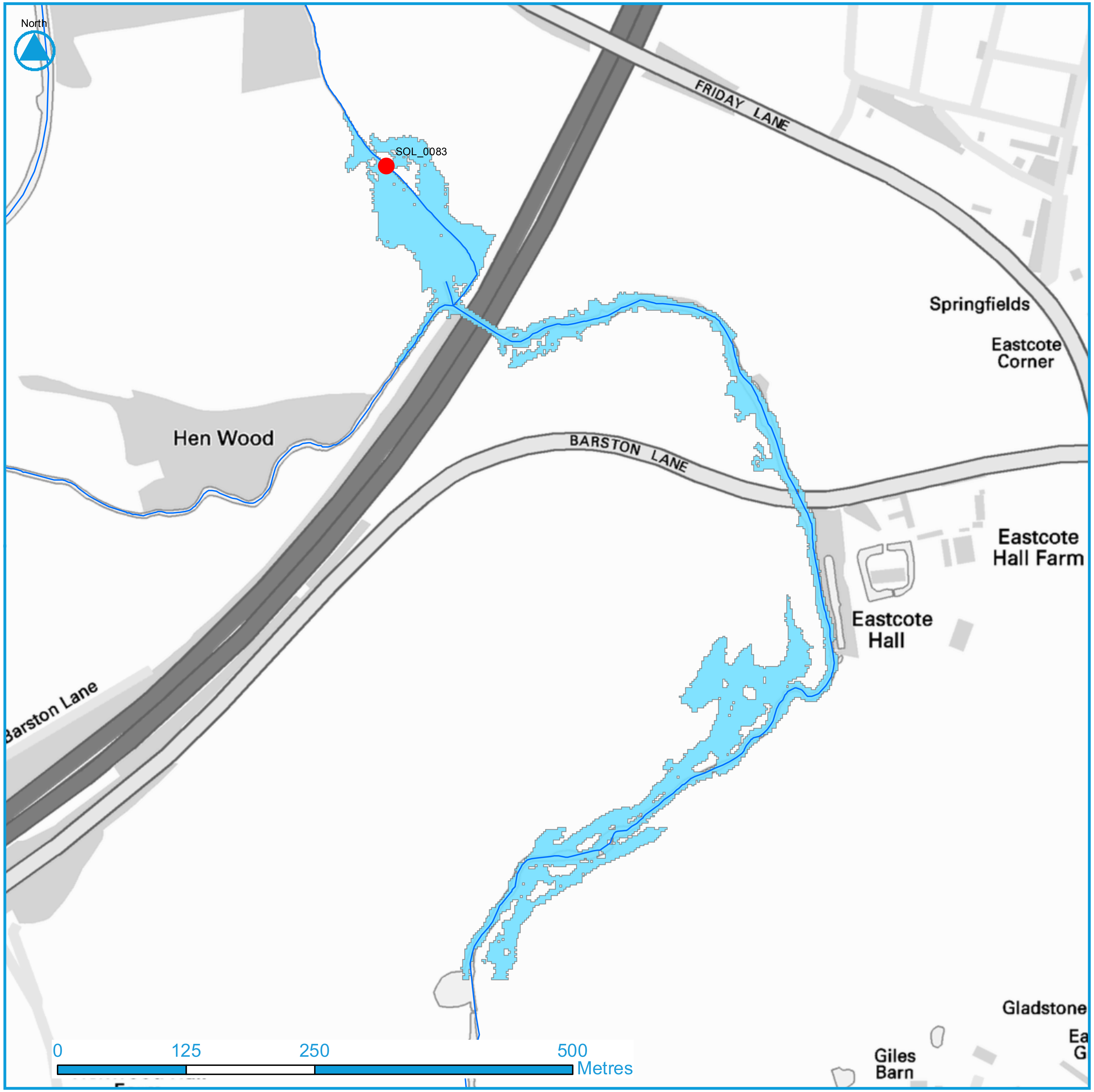
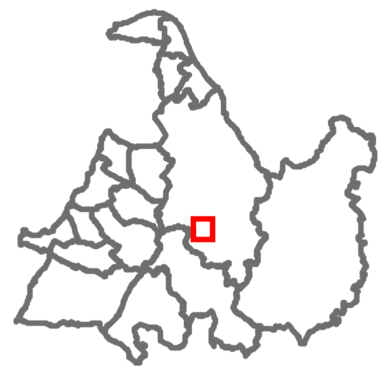


Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0083
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

NRD Property Points
Key Infrastructure
Residential
Non Residential
Flood Extent
Asset Location

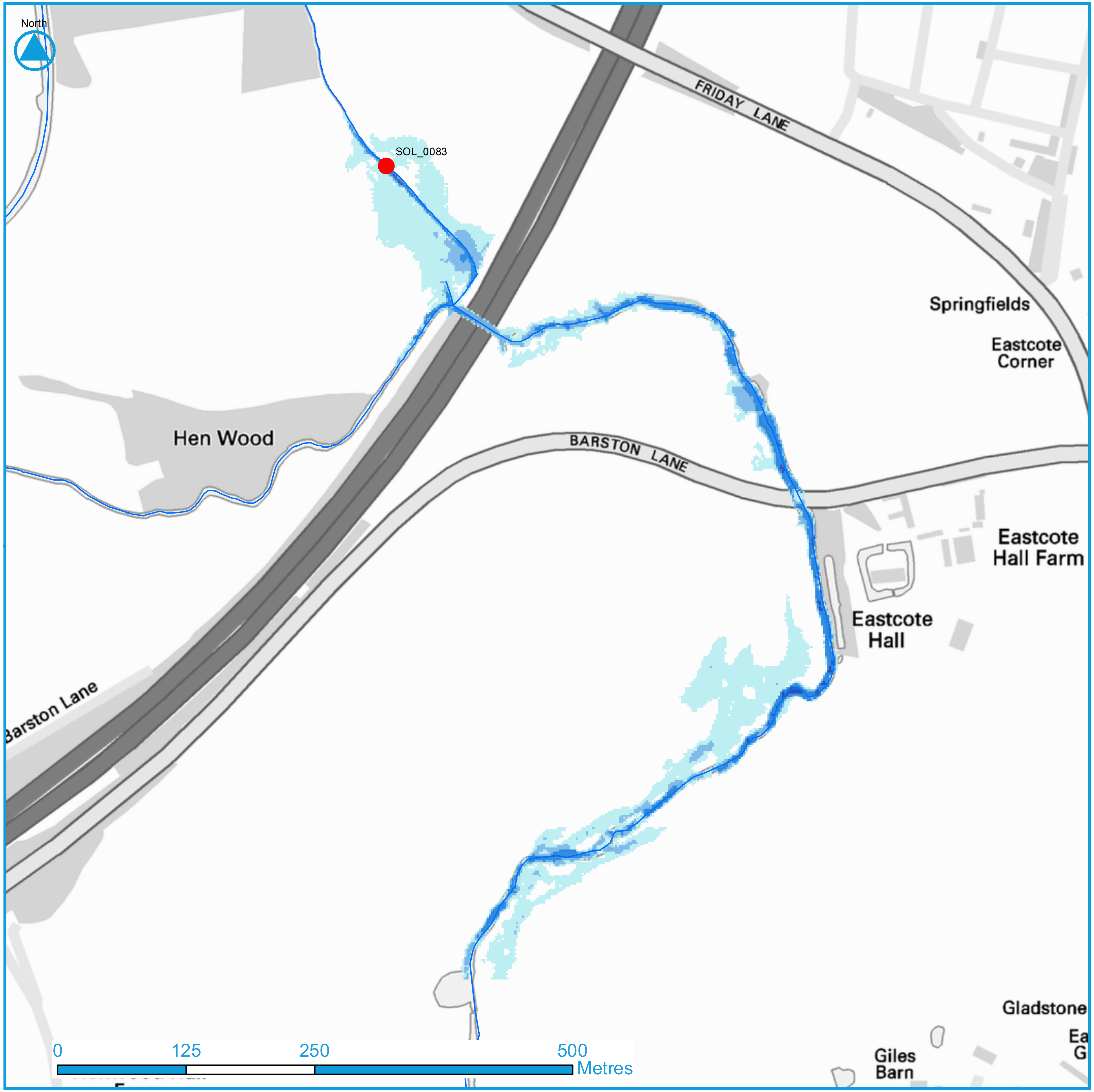


X: 418514 **Y:** 279639

Shape: Circular
Capacity (m^3/s): 0.90 **Length (m):** 3.82
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 100 Year Return Period - 100% Blocked
Area Flooded (m^2): 39,380
Road Length Flooded (m): 22

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

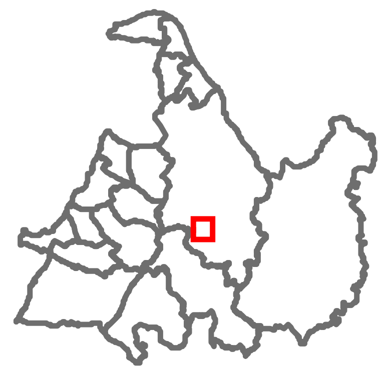


Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0083
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

Depth
- 0 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1 m
- 1 - 2 m
- > 2 m
- Asset Location



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Capacity (m^3/s): 0.90 **Length (m):** 3.82
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Material: Concrete **Manning's *n*:** 0.011

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Road Length Flooded (m): 22

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Key Infrastructure	0	0
All	0	0

Solihull Metropolitan Borough Council
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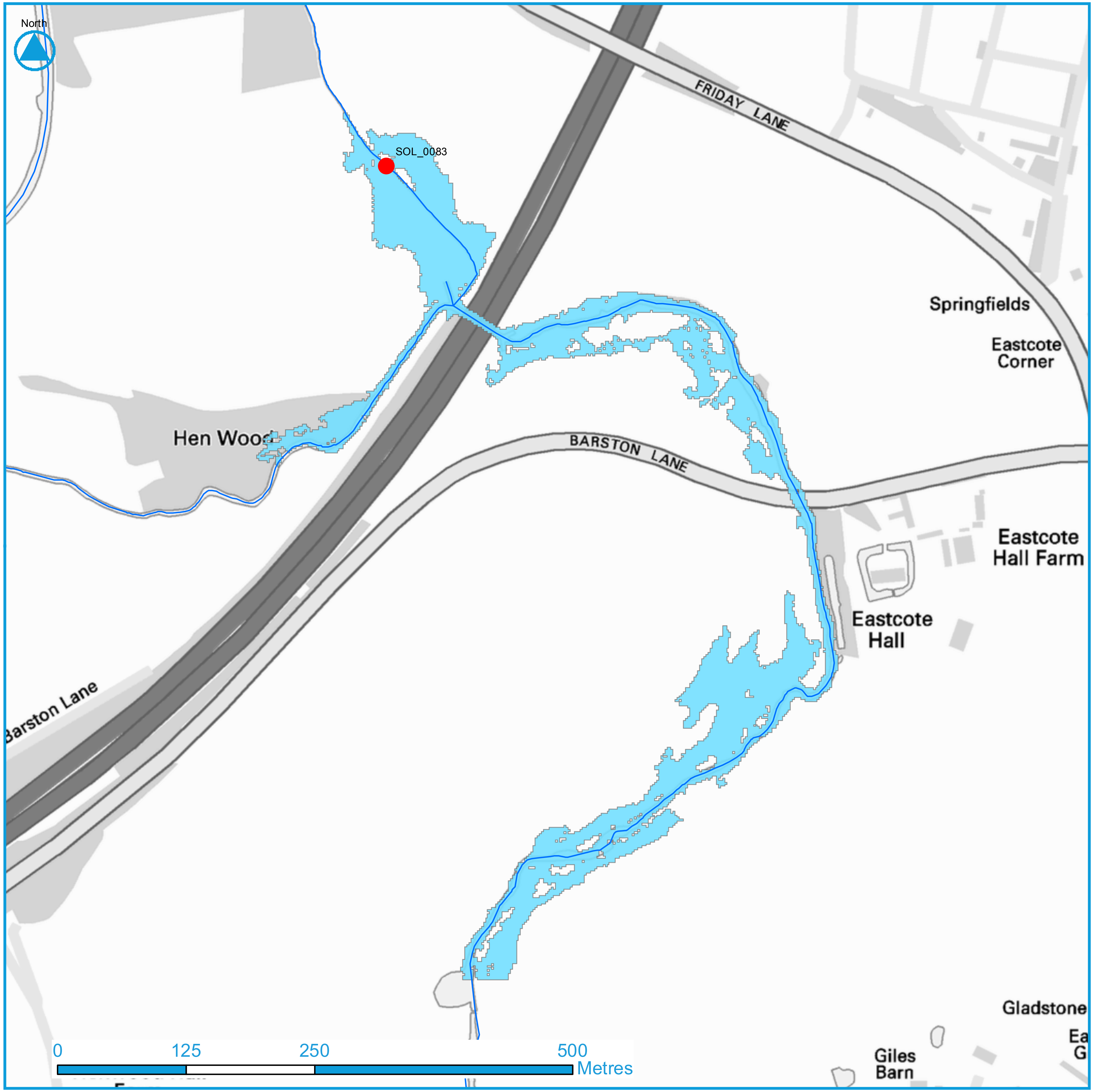
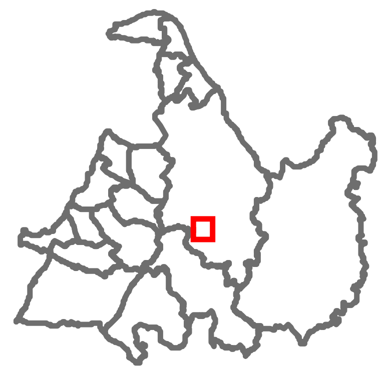


Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0083
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

NRD Property Points
Key Infrastructure
Residential
Non Residential
Flood Extent
Asset Location



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Shape: Circular
Capacity (m^3/s): 0.90 **Length (m):** 3.82
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 1000 Year Return Period - 100% Blocked
Area Flooded (m^2): 54,120
Road Length Flooded (m): 24

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

Solihull METROPOLITAN BOROUGH COUNCIL
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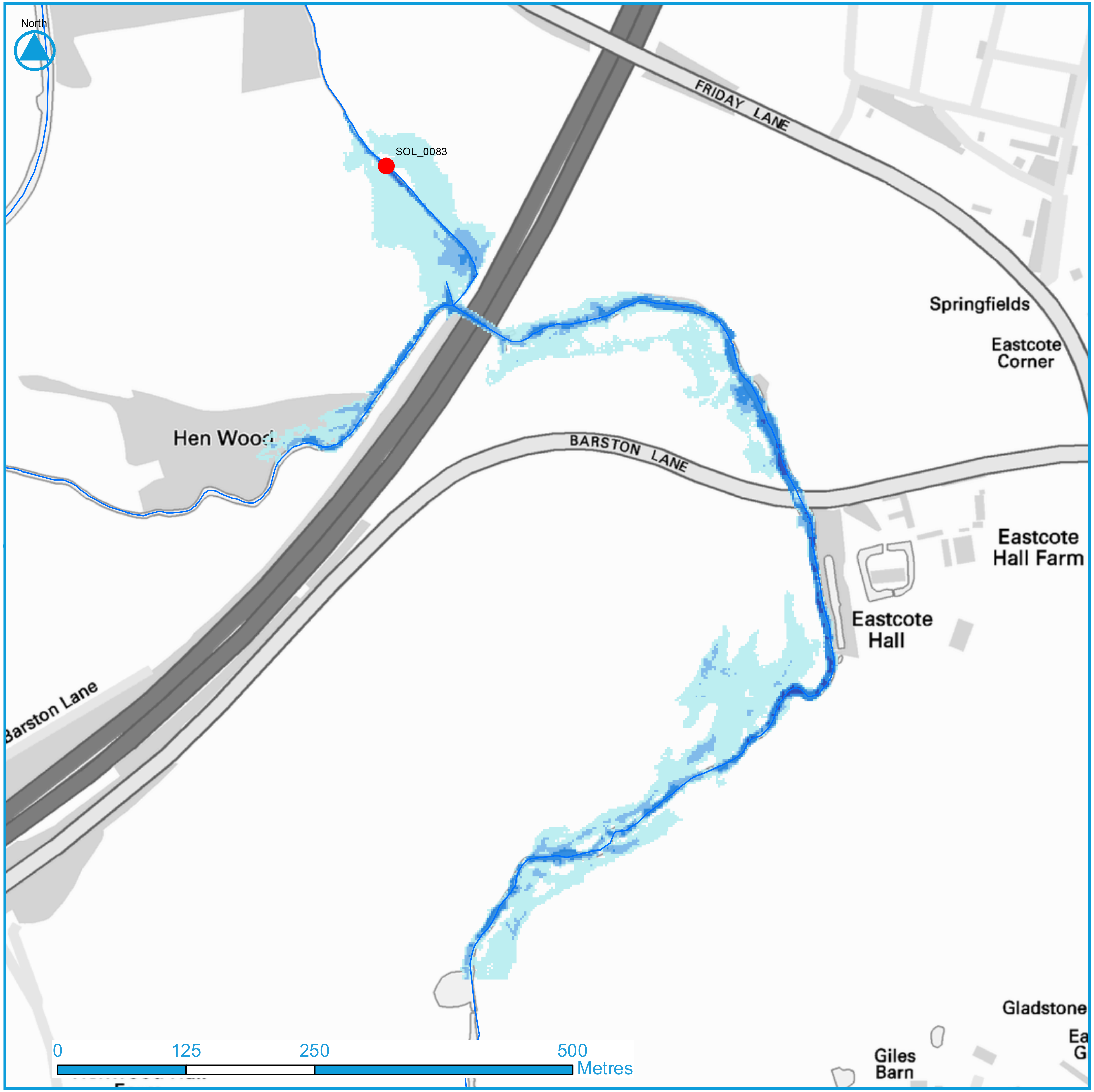

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0083
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

Depth
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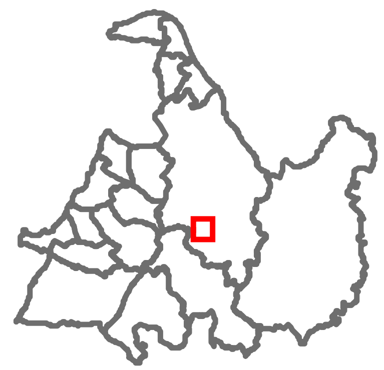
- 0.25 - 0.5 m
- 0.5 - 1 m
- 1 - 2 m
- > 2 m
- Asset Location



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Shape: Circular
Capacity (m^3/s): 0.90 **Length (m):** 3.82
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence

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Area Flooded (m^2): 54,120

Road Length Flooded (m): 24

Property Count	Total	Ground
Residential	0	0
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Key Infrastructure	0	0
All	0	0

Solihull Metropolitan Borough Council — Urbs in Rure
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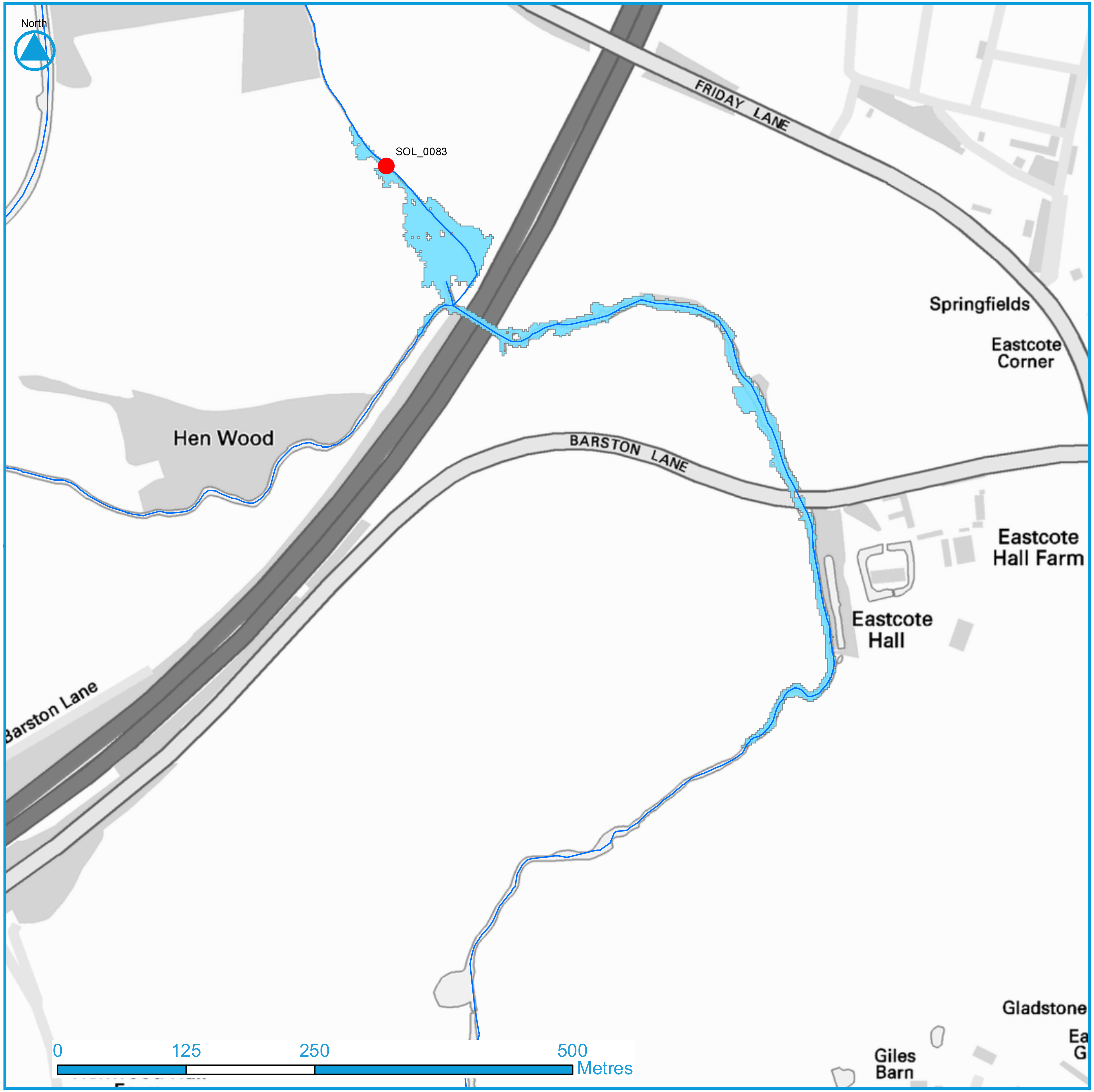


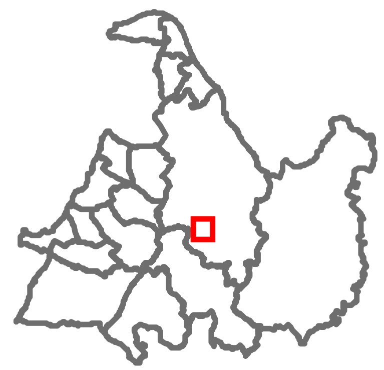
Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0083
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

NRD Property Points
- Key Infrastructure
- Residential
- Non Residential
- Flood Extent
- Asset Location



X: 418514 **Y:** 279639

Shape: Circular
Capacity (m^3/s): 0.90 **Length (m):** 3.82
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 1000 Year Return Period - 0% Blocked
Area Flooded (m^2): 13,560
Road Length Flooded (m): 22

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

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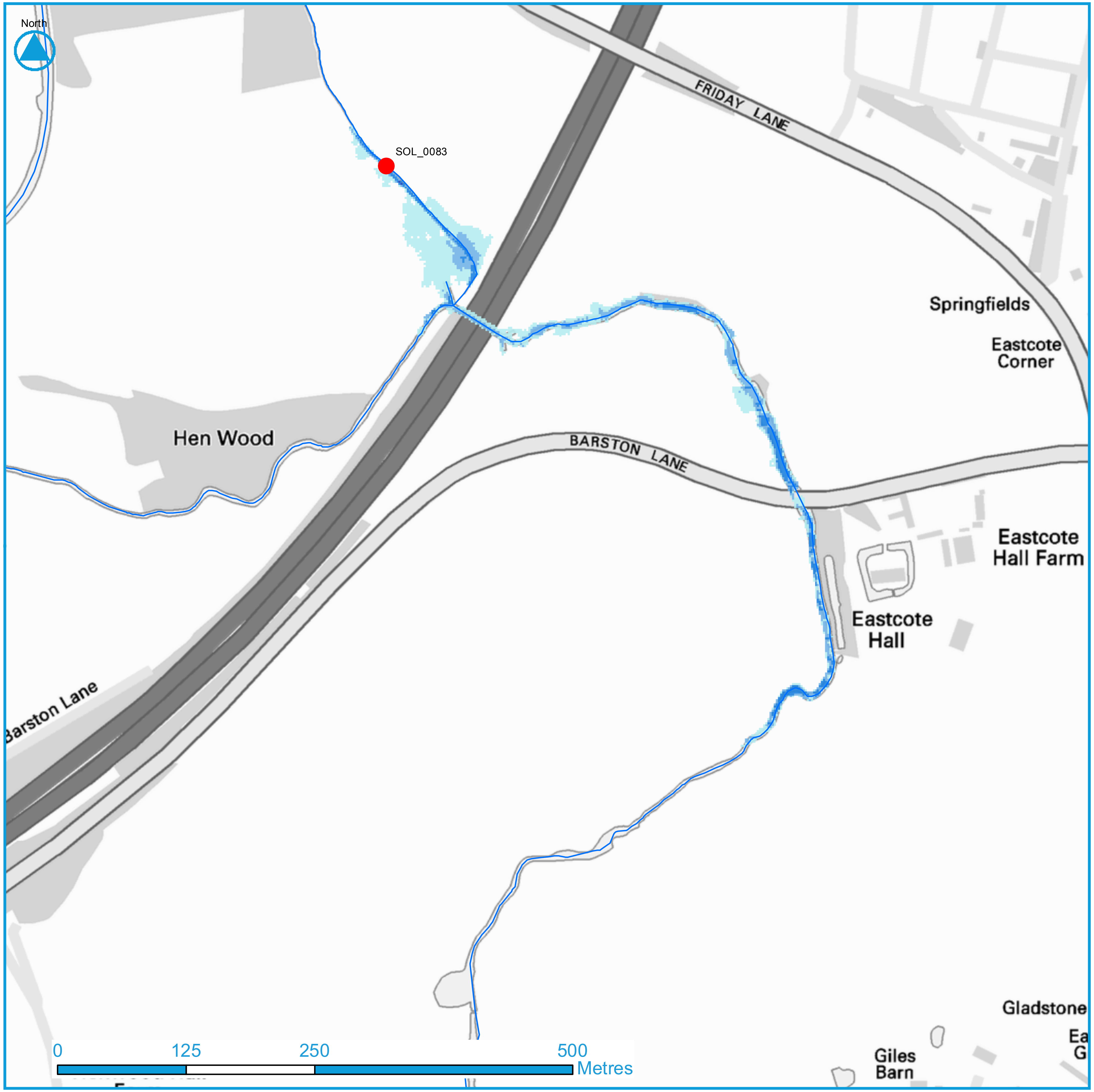

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0083
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

Depth
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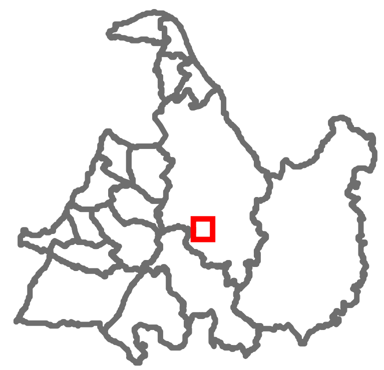

X: 418514 **Y:** 279639

Shape: Circular
Capacity (m^3/s): 0.90 **Length (m):** 3.82
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 1000 Year Return Period - 0% Blocked
Area Flooded (m^2): 13,560
Road Length Flooded (m): 22

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

Solihull Metropolitan Borough Council — Urbs in Rure
JBA consulting

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South Barn
Broughton Hall
SKIPTON
North Yorkshire
BD23 3AE
United Kingdom

t:+44(0)1756 799919
e:info@jbaconsulting.com

Jeremy Benn Associates Ltd
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ASSET BLOCKAGE SENSITIVITY TESTING
SOLIHULL METROPOLITAN BOROUGH COUNCIL

Asset Reference	SOL_0155
SMBC Structure Code	-
Description	-
Carries	M42
Over	River Blythe
Ward Location	Bickenhill Ward
National Grid Reference	418590 279495

Solihull Metropolitan Borough Council
Highway Services
The Council House
Manor Square
Solihull
B91 3QB

JBA Office

JBA Consulting
The Library
St Philips Courtyard
Church Hill
COLESHILL
Warwickshire
B46 3AD

Revision History

Revision Ref / Date Issued	Amendments	Issued to
Final / October 2016		Edward Bradford

Contract

This report describes work commissioned by Solihull Metropolitan Borough Council, by Commission Order No 485867 dated 30th March 2016. Solihull Council's representative for the contract was Edward Bradford. David Kearney, Nelly Marcy, Anneka Lowis and Jack Dudman carried out this work.

Prepared by .... Jack Dudman BSc MSc

Reviewed by .... Anneka Lowis BSc MSc FRGS

Purpose

This document has been prepared as a Summary Report for the investigation of flood risk (calculation of a 100% blockage and a 'without blockage' scenario) for 504 culvert locations as agreed with Solihull Metropolitan Borough Council. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

JBA Consulting has no liability regarding the use of this report except to Solihull Metropolitan Borough Council.

Acknowledgements

JBA would like to acknowledge the support of Edward Bradford of Solihull Metropolitan Borough Council.

Copyright

Contents

List of Tables

Abbreviations

DTM ....Digital Terrain Model
JFlow+ ....JBA Consulting's in house two dimensional flood software
LIDAR..........Light Detection and Ranging
NGR..........National Grid Reference
NRD ....National Receptor Database

1 Introduction

This report investigates the possible flood risk associated with an asset on River Blythe in Bickenhill Ward, with asset reference SOL_0155.

1.1 General Asset Information

1.1.1 Asset

Asset Reference	SOL_0155
Inlet National Grid Reference (NGR)	418590 279495

1.1.2 Dimensions

Asset Length (m)	33.80
Assumed Capacity (m^3)	2.28
Height (m)	1.00
Width (m)	1.00
Shape	Circular
Material	Concrete
Manning's Roughness Coefficient	0.011
Slope	0.0065
Note: The asset data contained within this report is indicative and should be verified by reviewing detailed asset survey reports.	

2 Methodology

2.1 Hydrology

The peak flows for the 6 Return Periods modelled are summarised in Table 2-2.

Table 2-2 Peak Flows

30 year	100 year	1000 year	100 year + 20% CC	100 year + 30% CC	100 year + 50% CC
23.16	29.35	44.69	35.22	38.16	44.03

2.2 Hydraulic Modelling

2.2.1 General Model Assumptions

- Model constructed using JFlow+
- Digital Terrain Model derived from 2 metre composite LIDAR and IHM (used under licence from the Environment Agency).

2.2.2 100% Blockage Modelling Assumptions

For the purpose of blockage, we have assumed a culvert capacity of zero, thus assuming that no water can be conveyed and that all of the flow will be forced out of bank at the culvert inlet.

2.2.3 Without Blockage Modelling Assumptions

The 'without blockage' modelling scenario required the calculation of the culvert capacity, in order to estimate the volume of water conveyed through the structure. Any flows greater than the capacity of the culvert were represented as out of bank flow at the culvert inlet. The culvert capacity was calculated using the Manning's equation.

2.3 Model Scenarios

The model has been run for 6 return periods: 30, 100, 1000-year with three climate change modifications to the 100-year return period of +20%, +30% and +50%. For each return period a 100% blockage ('with blockage') and 0% blockage ('without blockage') scenario were modelled. Depth, hazard and velocity flow grids were produced for each scenario. See below for modelling results.

2.4 Standard of Protection

Design flood flows at each asset inlet were calculated for a range of return periods. The culvert capacity was then compared with these to provide an estimate of each asset's Standard of Protection (SoP). Standard of protection is equal to the highest return period with a peak flow less than the asset capacity.

The SoP for asset ID SOL_0155 is less than 30 years.

3 Consequence

The modelled depth grids were converted to outlines and these were queried against the National Receptor Dataset (NRD) to obtain counts of flooded properties and lengths of flooded infrastructure.

3.1 Properties at risk

NRD property points were split into three categories; Residential, Non Residential, and Key Infrastructure. The total number of flooded properties and ground floor properties for all events and scenarios are reported in Table 3-1.

Table 3-1 All events – Number of properties flooded

		Model Event											
		100% Blocked						Without Blockage					
Consequence		Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%
Area Flooded (m^2)		265320	289408	340780	309712	319920	339492	255248	280760	332684	301580	311660	331112
Properties Affected													
All	Total	4	4	5	4	4	5	4	4	4	4	4	4
	Ground	4	4	5	4	4	5	4	4	4	4	4	4
Res	Total	2	2	3	2	2	3	2	2	2	2	2	2
	Ground	2	2	3	2	2	3	2	2	2	2	2	2
Non - Res	Total	2	2	2	2	2	2	2	2	2	2	2	2
	Ground	2	2	2	2	2	2	2	2	2	2	2	2
Key	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0

3.2 Infrastructure at risk

The lengths of flooded roads and railway[1] are shown in Table 3-2. This is a simple assessment and does not take into account the fact that some structures may be elevated out of the flooding.

Table 3-2 All events - Infrastructure at risk (m)

	Model Event											
	100% Blocked						Without Blockage					
Infrastructure (m)	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%
Motorway	16	16	16	16	16	16	16	16	16	16	16	16
A Road	0	0	0	0	0	0	0	0	0	0	0	0
B Road	0	0	0	0	0	0	0	0	0	0	0	0
Unclassified Road	411	452	512	482	486	510	395	439	508	474	482	504
Rail	0	0	0	0	0	0	0	0	0	0	0	0

[1] Contains public sector information licensed under the Open Government Licence v3.0.

Appendices

Where the channel capacity of the asset for the relevant blockage scenario is greater than the modelled return period flow all of the flow is conveyed through the structure and no map has been produced.

A 100% Blocked Maps

A.1 Extent – 30 Year Return Period

A.2 Depth – 30 Year Return Period

A.3 Extent – 100 Year Return Period

A.4 Depth – 100 Year Return Period

A.5 Extent – 1000 Year Return Period

A.6 Depth – 1000 Year Return Period

B 0% Blocked Maps

B.1 Extent – 30 Year Return Period

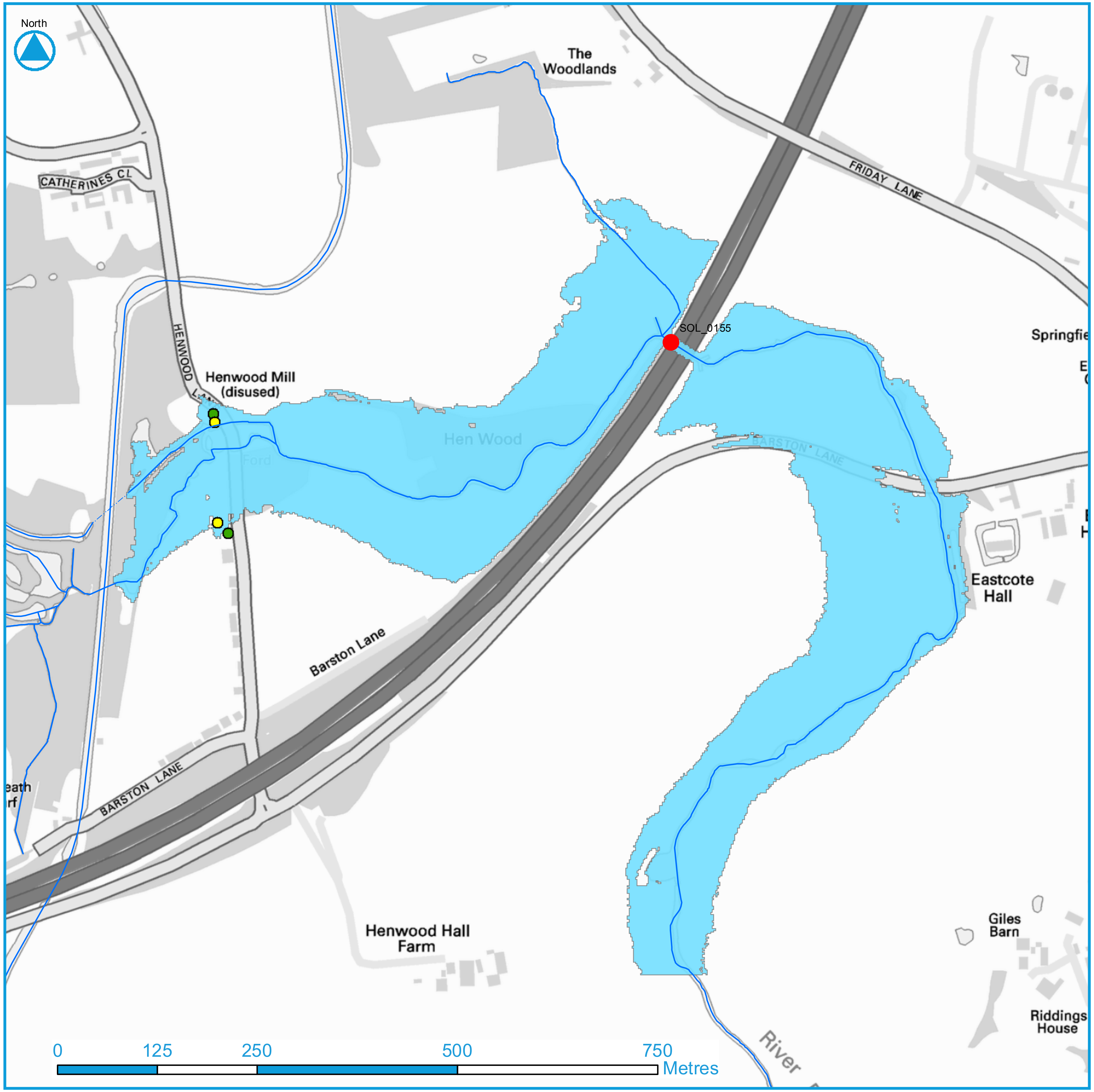
B.2 Depth – 30 Year Return Period

B.3 Extent – 100 Year Return Period

B.4 Depth – 100 Year Return Period

B.5 Extent – 1000 Year Return Period

B.6 Depth – 1000 Year Return Period

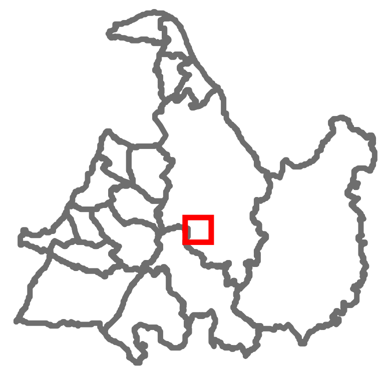


Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0155
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

NRD Property Points
Key Infrastructure
Residential
Non Residential
Flood Extent
Asset Location



X: 418590 **Y:** 279495

Shape: Circular
Capacity (m^3/s): 2.28 **Length (m):** 33.80
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 30 Year Return Period - 100% Blocked
Area Flooded (m^2): 265,320
Road Length Flooded (m): 427

Property Count	Total	Ground
Residential	2	2
Non Residential	2	2
Key Infrastructure	0	0
All	4	4

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0155
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

Depth
0 - 0.25 m
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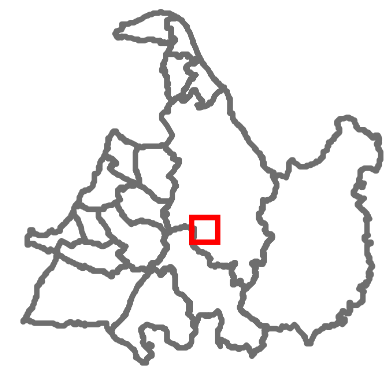

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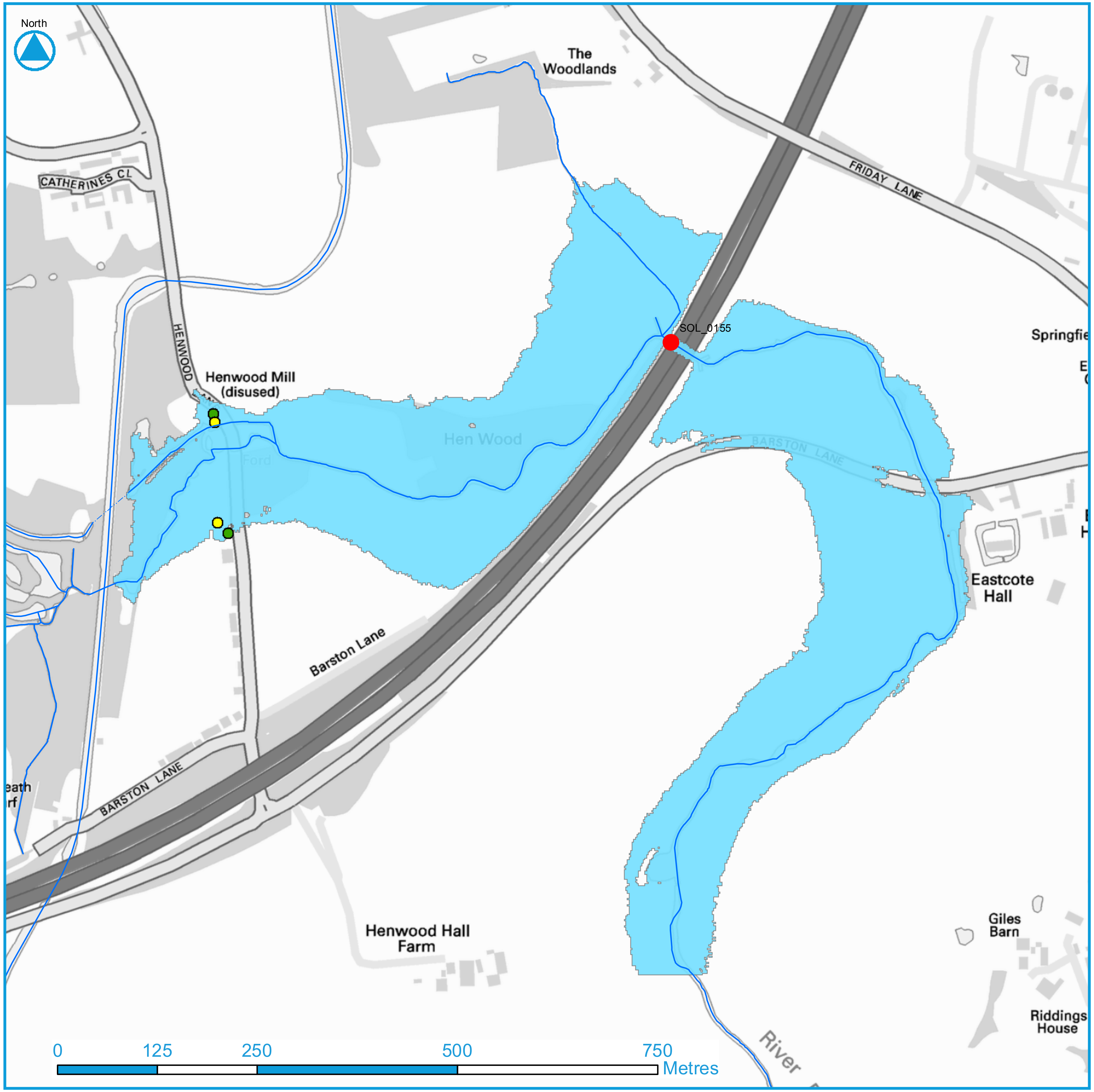

Solihull Metropolitan Borough Council

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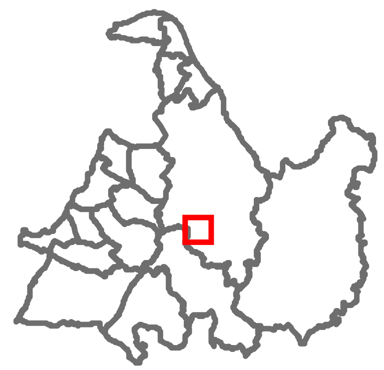

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Shape: Circular

Capacity (m^3/s): 2.28 **Length (m):** 33.80

Height (m): 1.00 **Width (m):** 1.00

Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 100 Year Return Period - 100% Blocked

Area Flooded (m^2): 289,408

Road Length Flooded (m): 469

Property Count	Total	Ground
Residential	2	2
Non Residential	2	2
Key Infrastructure	0	0
All	4	4

Solihull Metropolitan Borough Council
JBA consulting

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0155
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

Depth
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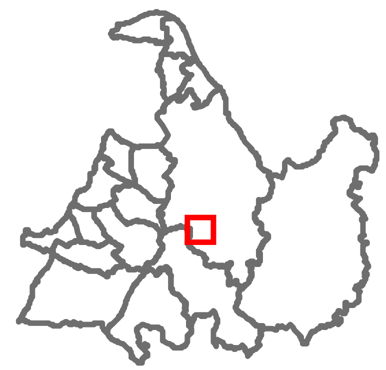
0.25 - 0.5 m
0.5 - 1 m
1 - 2 m
> 2 m
Asset Location



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Shape: Circular
Capacity (m^3/s): 2.28 **Length (m):** 33.80
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 100 Year Return Period - 100% Blocked
Area Flooded (m^2): 289,408
Road Length Flooded (m): 469

Property Count	Total	Ground
Residential	2	2
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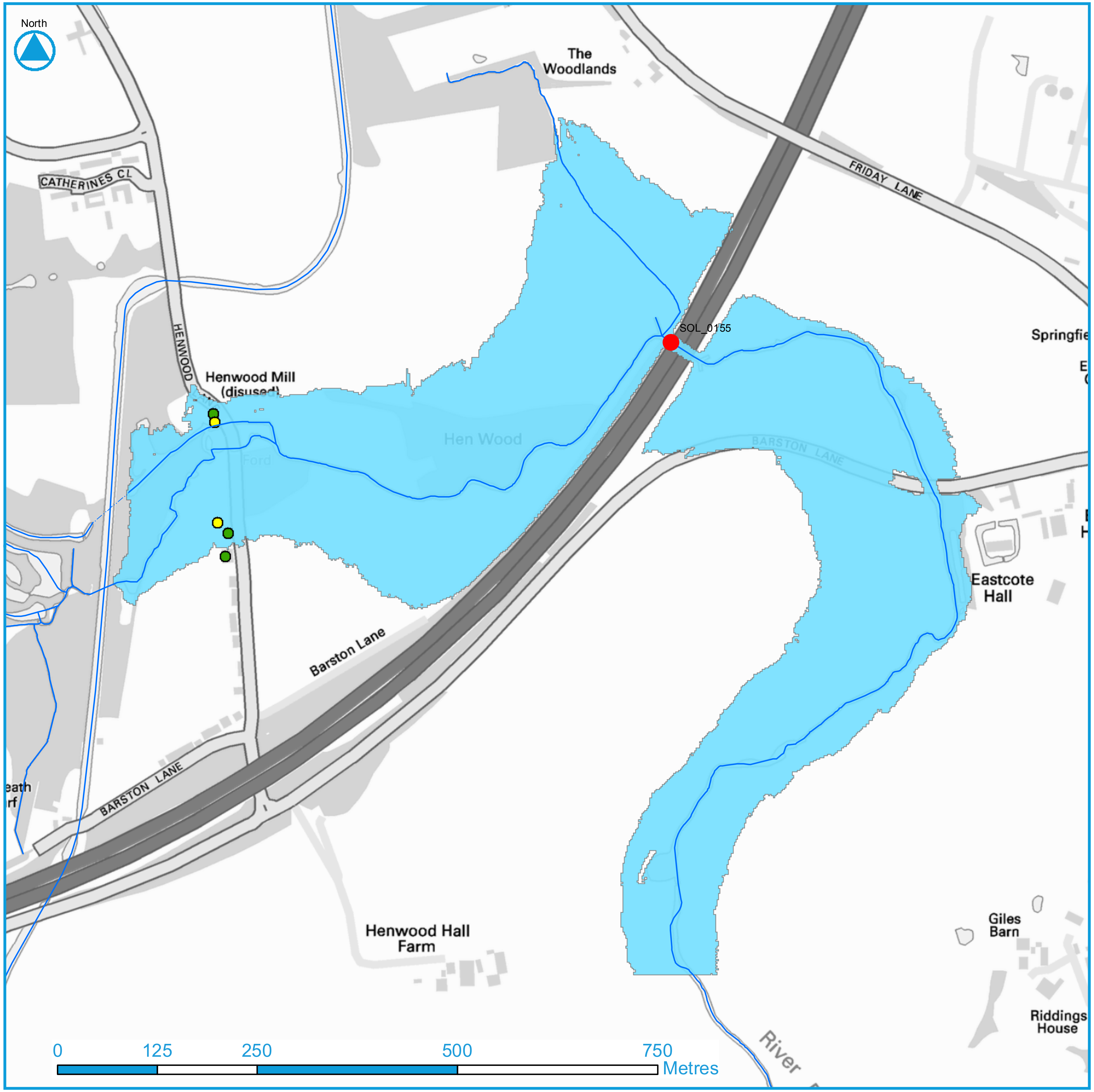
Key Infrastructure	0	0
All	4	4

Solihull Metropolitan Borough Council
JBA consulting



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Asset Blockage Sensitivity Testing

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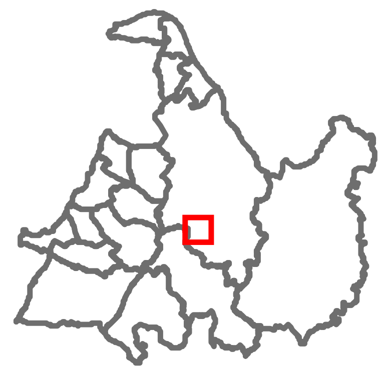

X: 418590 **Y:** 279495

Shape: Circular
Capacity (m^3/s): 2.28 **Length (m):** 33.80
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 1000 Year Return Period - 100% Blocked
Area Flooded (m^2): 340,780
Road Length Flooded (m): 529

Property Count	Total	Ground
Residential	3	3
Non Residential	2	2
Key Infrastructure	0	0
All	5	5

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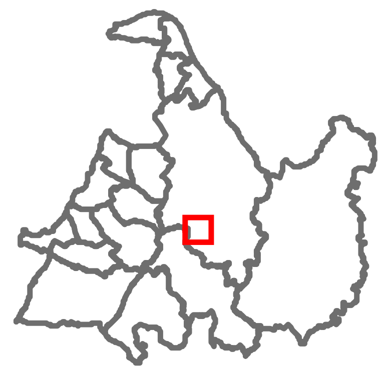
Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0155
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

Depth
0 - 0.25 m
0.25 - 0.5 m
0.5 - 1 m
1 - 2 m
> 2 m
Asset Location



X: 418590 **Y:** 279495

Shape: Circular
Capacity (m^3/s): 2.28 **Length (m):** 33.80
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

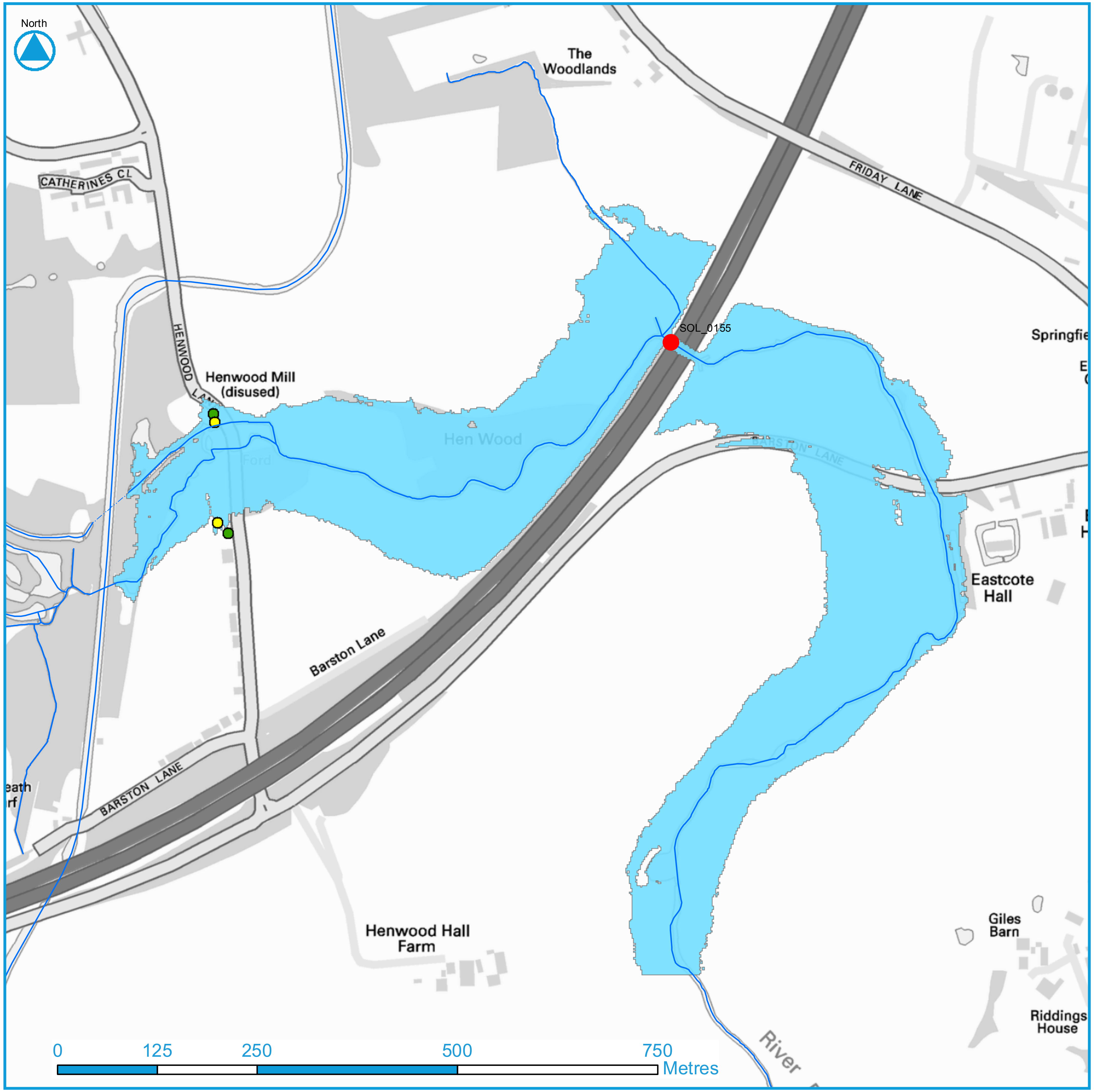
Consequence

Scenario: 1000 Year Return Period - 100% Blocked

Area Flooded (m^2): 340,780

Road Length Flooded (m): 529

Property Count	Total	Ground
Residential	3	3
Non Residential	2	2
Key Infrastructure	0	0
All	5	5

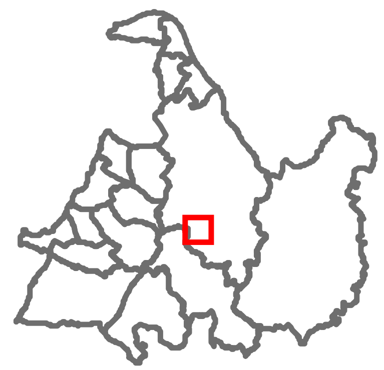


Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0155
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

NRD Property Points
- Key Infrastructure
- Residential
- Non Residential
- Flood Extent
- Asset Location



X: 418590 **Y:** 279495

Shape: Circular
Capacity (m^3/s): 2.28 **Length (m):** 33.80
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 30 Year Return Period - 0% Blocked
Area Flooded (m^2): 255,248
Road Length Flooded (m): 411

Property Count	Total	Ground
Residential	2	2
Non Residential	2	2
Key Infrastructure	0	0
All	4	4

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Solihull Metropolitan Borough Council

Asset Blockage Sensitivity Testing

Asset Reference: SOL_0155

SMBC Structure Code: -

Description: -

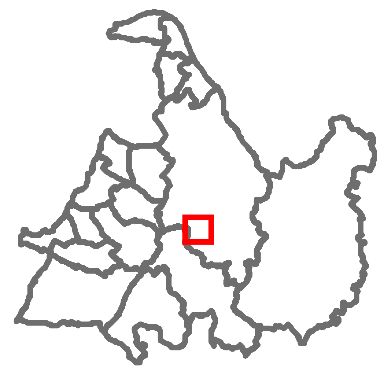
Ward: Bickenhill Ward

Watercourse

- Culvert
- Open Channel

Depth

- 0 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1 m
- 1 - 2 m
- > 2 m
- Asset Location



X: 418590 **Y:** 279495

Shape: Circular

Capacity (m^3/s): 2.28 **Length (m):** 33.80

Height (m): 1.00 **Width (m):** 1.00

Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 30 Year Return Period - 0% Blocked

Area Flooded (m^2): 255,248

Road Length Flooded (m): 411

Property Count	Total	Ground
Residential	2	2
Non Residential	2	2
Key Infrastructure	0	0
All	4	4

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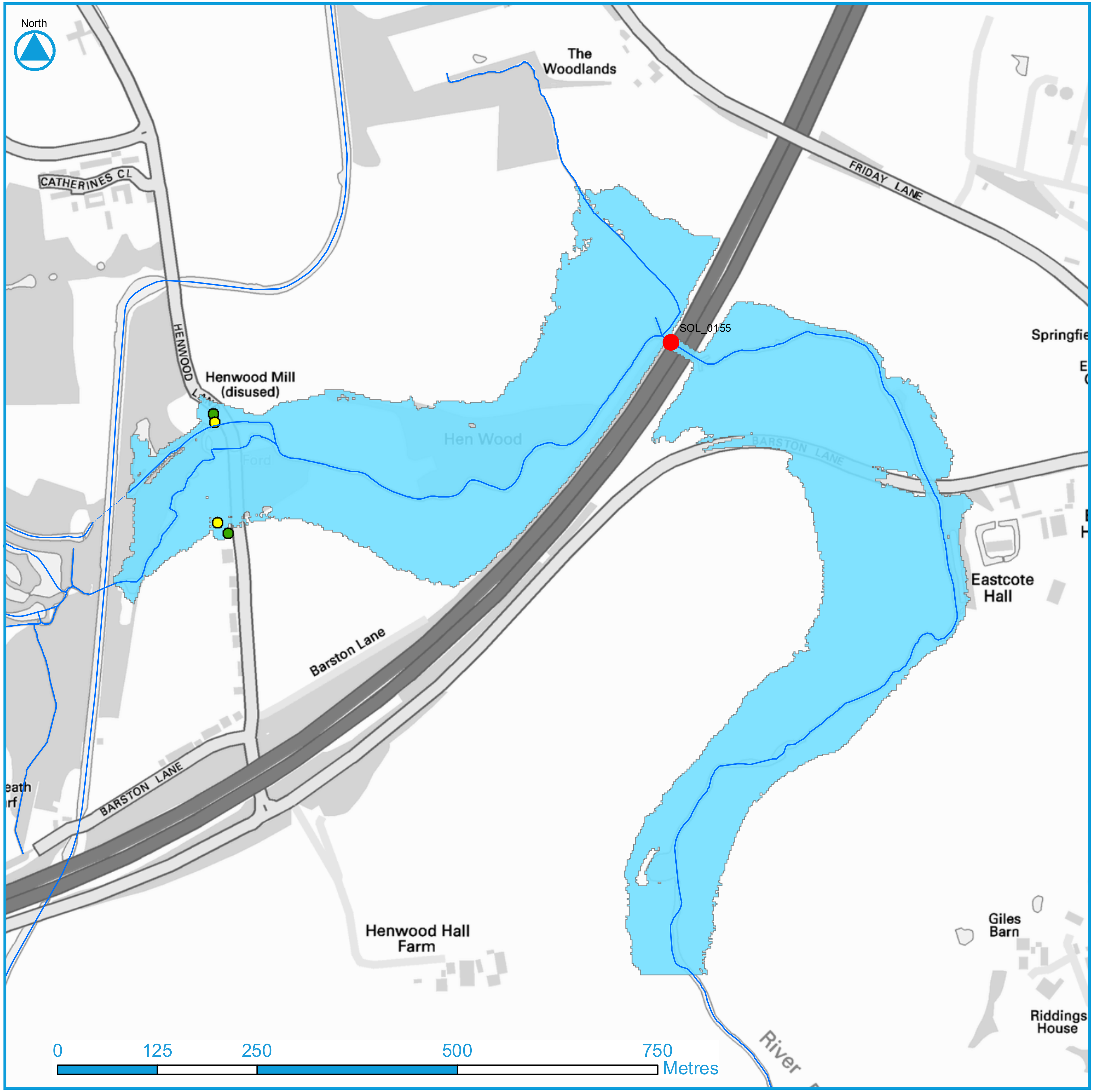


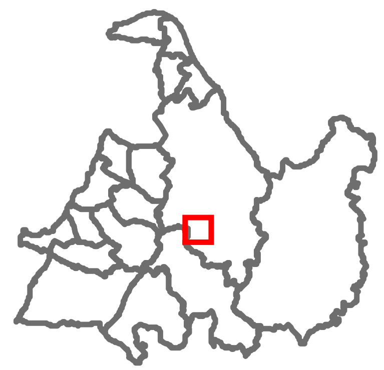
Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0155
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

NRD Property Points
Key Infrastructure
Residential
Non Residential
Flood Extent
Asset Location



X: 418590 **Y:** 279495

Shape: Circular
Capacity (m^3/s): 2.28
Length (m): 33.80
Height (m): 1.00
Width (m): 1.00
Material: Concrete
Manning's *n*: 0.011

Consequence

Scenario: 100 Year Return Period - 0% Blocked

Area Flooded (m^2): 280,760

Road Length Flooded (m): 455

Property Count	Total	Ground
Residential	2	2
Non Residential	2	2
Key Infrastructure	0	0
All	4	4

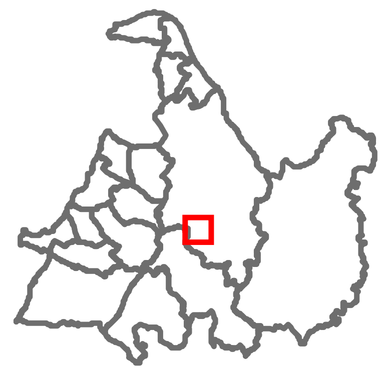
Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0155
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

Depth
- 0 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1 m
- 1 - 2 m
- > 2 m
- Asset Location

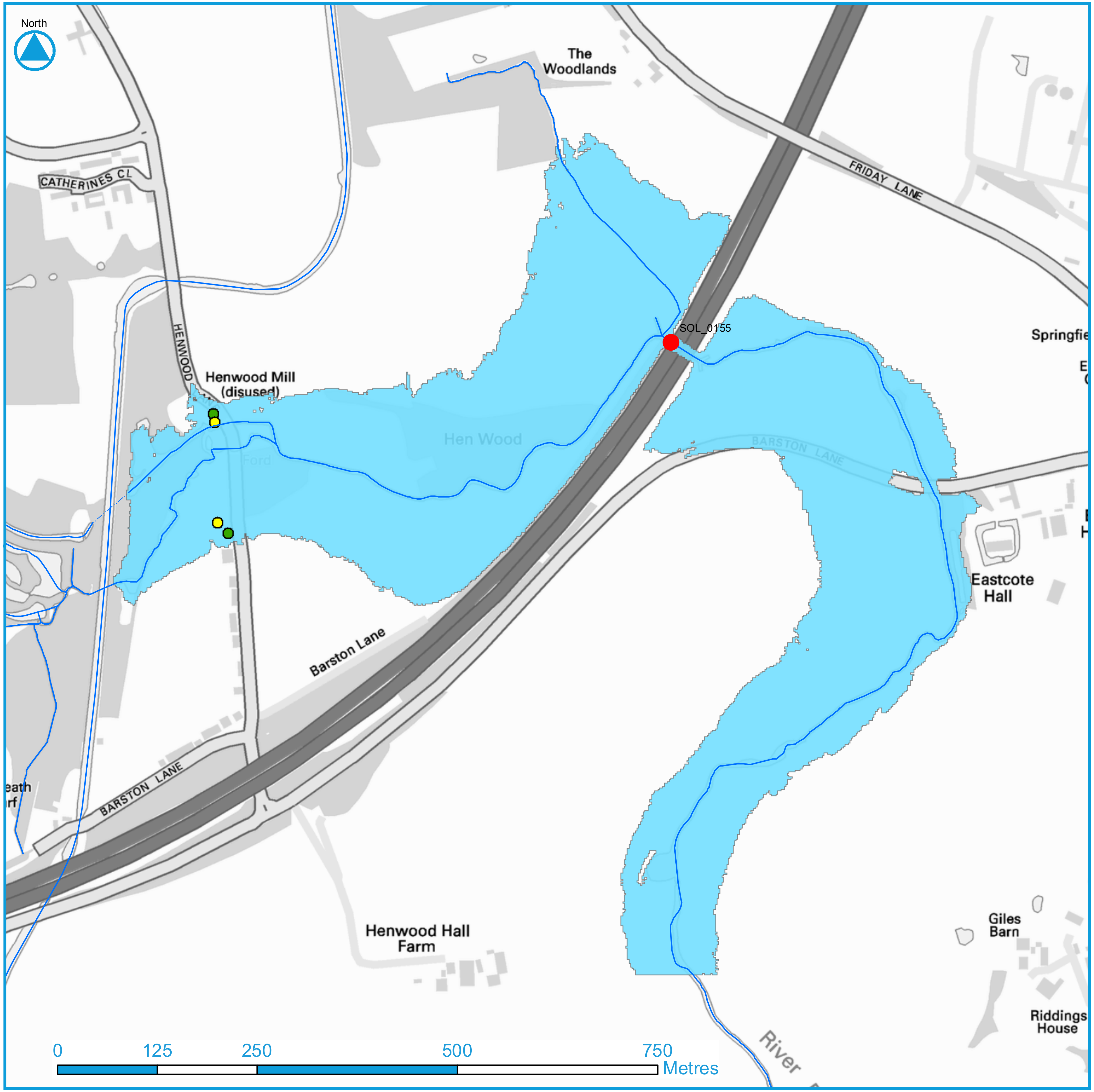


X: 418590 **Y:** 279495

Shape: Circular
Capacity (m^3/s): 2.28 **Length (m):** 33.80
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 100 Year Return Period - 0% Blocked
Area Flooded (m^2): 280,760
Road Length Flooded (m): 455

Property Count	Total	Ground
Residential	2	2
Non Residential	2	2
Key Infrastructure	0	0
All	4	4



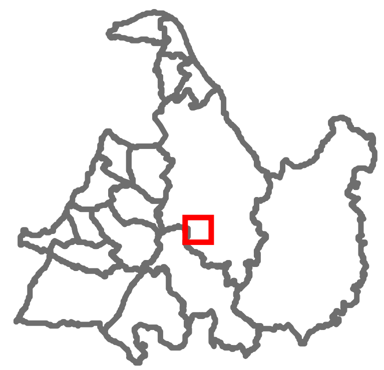
Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0155
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

NRD Property Points
- Key Infrastructure
- Residential
- Non Residential
- Flood Extent
- Asset Location



X: 418590 **Y:** 279495

Shape: Circular	
Capacity (m^3/s): 2.28	**Length (m):** 33.80
Height (m): 1.00	**Width (m):** 1.00
Material: Concrete	**Manning's *n*:** 0.011

Consequence

Scenario: 1000 Year Return Period - 0% Blocked

Area Flooded (m^2): 332,684

Road Length Flooded (m): 525

Property Count	Total	Ground
Residential	2	2
Non Residential	2	2
Key Infrastructure	0	0
All	4	4

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0155
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

Depth
- 0 - 0.25 m
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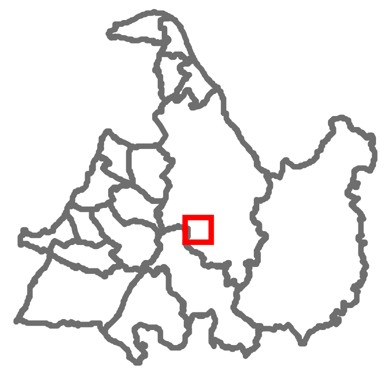
- Asset Location



X: 418590 **Y:** 279495

Shape: Circular
Capacity (m^3/s): 2.28 **Length (m):** 33.80
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 1000 Year Return Period - 0% Blocked
Area Flooded (m^2): 332,684
Road Length Flooded (m): 525

Property Count	Total	Ground
Residential	2	2
Non Residential	2	2
Key Infrastructure	0	0
All	4	4

Solihull Metropolitan Borough Council
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Broughton Hall
SKIPTON
North Yorkshire
BD23 3AE
United Kingdom

t:+44(0)1756 799919
e:info@jbaconsulting.com

Jeremy Benn Associates Ltd
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3246693

Visit our website
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ASSET BLOCKAGE SENSITIVITY TESTING
SOLIHULL METROPOLITAN BOROUGH COUNCIL

Asset Reference	SOL_0156
SMBC Structure Code	-
Description	-
Carries	Footpath
Over	Stream
Ward Location	Bickenhill Ward
National Grid Reference	418587 279513

Solihull Metropolitan Borough Council
Highway Services
The Council House
Manor Square
Solihull
B91 3QB

JBA Office

JBA Consulting
The Library
St Philips Courtyard
Church Hill
COLESHILL
Warwickshire
B46 3AD

Revision History

Revision Ref / Date Issued	Amendments	Issued to
Final / October 2016		Edward Bradford

Contract

This report describes work commissioned by Solihull Metropolitan Borough Council, by Commission Order No 485867 dated 30th March 2016. Solihull Council's representative for the contract was Edward Bradford. David Kearney, Nelly Marcy, Anneka Lowis and Jack Dudman carried out this work.

Prepared by .... Jack Dudman BSc MSc

Reviewed by .... Anneka Lowis BSc MSc FRGS

Purpose

This document has been prepared as a Summary Report for the investigation of flood risk (calculation of a 100% blockage and a 'without blockage' scenario) for 504 culvert locations as agreed with Solihull Metropolitan Borough Council. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

JBA Consulting has no liability regarding the use of this report except to Solihull Metropolitan Borough Council.

Acknowledgements

JBA would like to acknowledge the support of Edward Bradford of Solihull Metropolitan Borough Council.

Copyright

Contents

List of Tables

Abbreviations

DTM .... Digital Terrain Model
JFlow+ .... JBA Consulting's in house two dimensional flood software
LIDAR .... Light Detection and Ranging
NGR .... National Grid Reference
NRD .... National Receptor Database

1 Introduction

This report investigates the possible flood risk associated with an asset on Stream in Bickenhill Ward, with asset reference SOL_0156.

1.1 General Asset Information

1.1.1 Asset

Asset Reference	SOL_0156
Inlet National Grid Reference (NGR)	418587 279513

1.1.2 Dimensions

Asset Length (m)	10.12
Assumed Capacity (m^3)	5.03
Height (m)	1.00
Width (m)	1.00
Shape	Circular
Material	Concrete
Manning’s Roughness Coefficient	0.011
Slope	0.0316
Note: The asset data contained within this report is indicative and should be verified by reviewing detailed asset survey reports.	

2 Methodology

2.1 Hydrology

The peak flows for the 6 Return Periods modelled are summarised in Table 2-2.

Table 2-2 Peak Flows

30 year	100 year	1000 year	100 year + 20% CC	100 year + 30% CC	100 year + 50% CC
0.50	0.68	1.19	0.81	0.88	1.01

2.2 Hydraulic Modelling

2.2.1 General Model Assumptions

- Model constructed using JFlow+
- Digital Terrain Model derived from 2 metre composite LIDAR and IHM (used under licence from the Environment Agency).

2.2.2 100% Blockage Modelling Assumptions

For the purpose of blockage, we have assumed a culvert capacity of zero, thus assuming that no water can be conveyed and that all of the flow will be forced out of bank at the culvert inlet.

2.2.3 Without Blockage Modelling Assumptions

The 'without blockage' modelling scenario required the calculation of the culvert capacity, in order to estimate the volume of water conveyed through the structure. Any flows greater than the capacity of the culvert were represented as out of bank flow at the culvert inlet. The culvert capacity was calculated using the Manning's equation.

2.3 Model Scenarios

The model has been run for 6 return periods: 30, 100, 1000-year with three climate change modifications to the 100-year return period of +20%, +30% and +50%. For each return period a 100% blockage ('with blockage') and 0% blockage ('without blockage') scenario were modelled. Depth, hazard and velocity flow grids were produced for each scenario. See below for modelling results.

2.4 Standard of Protection

Design flood flows at each asset inlet were calculated for a range of return periods. The culvert capacity was then compared with these to provide an estimate of each asset's Standard of Protection (SoP). Standard of protection is equal to the highest return period with a peak flow less than the asset capacity.

The SoP for asset ID SOL_0156 is more than 1000 years.

3 Consequence

The modelled depth grids were converted to outlines and these were queried against the National Receptor Dataset (NRD) to obtain counts of flooded properties and lengths of flooded infrastructure.

3.1 Properties at risk

NRD property points were split into three categories; Residential, Non Residential, and Key Infrastructure. The total number of flooded properties and ground floor properties for all events and scenarios are reported in Table 3-1.

Table 3-1 All events – Number of properties flooded

		Model Event											
		100% Blocked						Without Blockage					
Consequence		Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%
Area Flooded (m^2)		28796	33684	47676	36992	38740	41808	0	0	0	0	0	0
Properties Affected													
All	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0
Res	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0
Non - Res	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0
Key	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0

3.2 Infrastructure at risk

The lengths of flooded roads and railway[1] are shown in Table 3-2. This is a simple assessment and does not take into account the fact that some structures may be elevated out of the flooding.

Table 3-2 All events - Infrastructure at risk (m)

	Model Event											
	100% Blocked						Without Blockage					
Infrastructure (m)	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%
Motorway	9	9	9	9	9	9	0	0	0	0	0	0
A Road	0	0	0	0	0	0	0	0	0	0	0	0
B Road	0	0	0	0	0	0	0	0	0	0	0	0
Unclassified Road	12	12	12	12	12	12	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0

[1] Contains public sector information licensed under the Open Government Licence v3.0.

Appendices

Where the channel capacity of the asset for the relevant blockage scenario is greater than the modelled return period flow all of the flow is conveyed through the structure and no map has been produced.

A 100% Blocked Maps

A.1 Extent – 30 Year Return Period

A.2 Depth – 30 Year Return Period

A.3 Extent – 100 Year Return Period

A.4 Depth – 100 Year Return Period

A.5 Extent – 1000 Year Return Period

A.6 Depth – 1000 Year Return Period

B 0% Blocked Maps

B.1 Extent – 30 Year Return Period

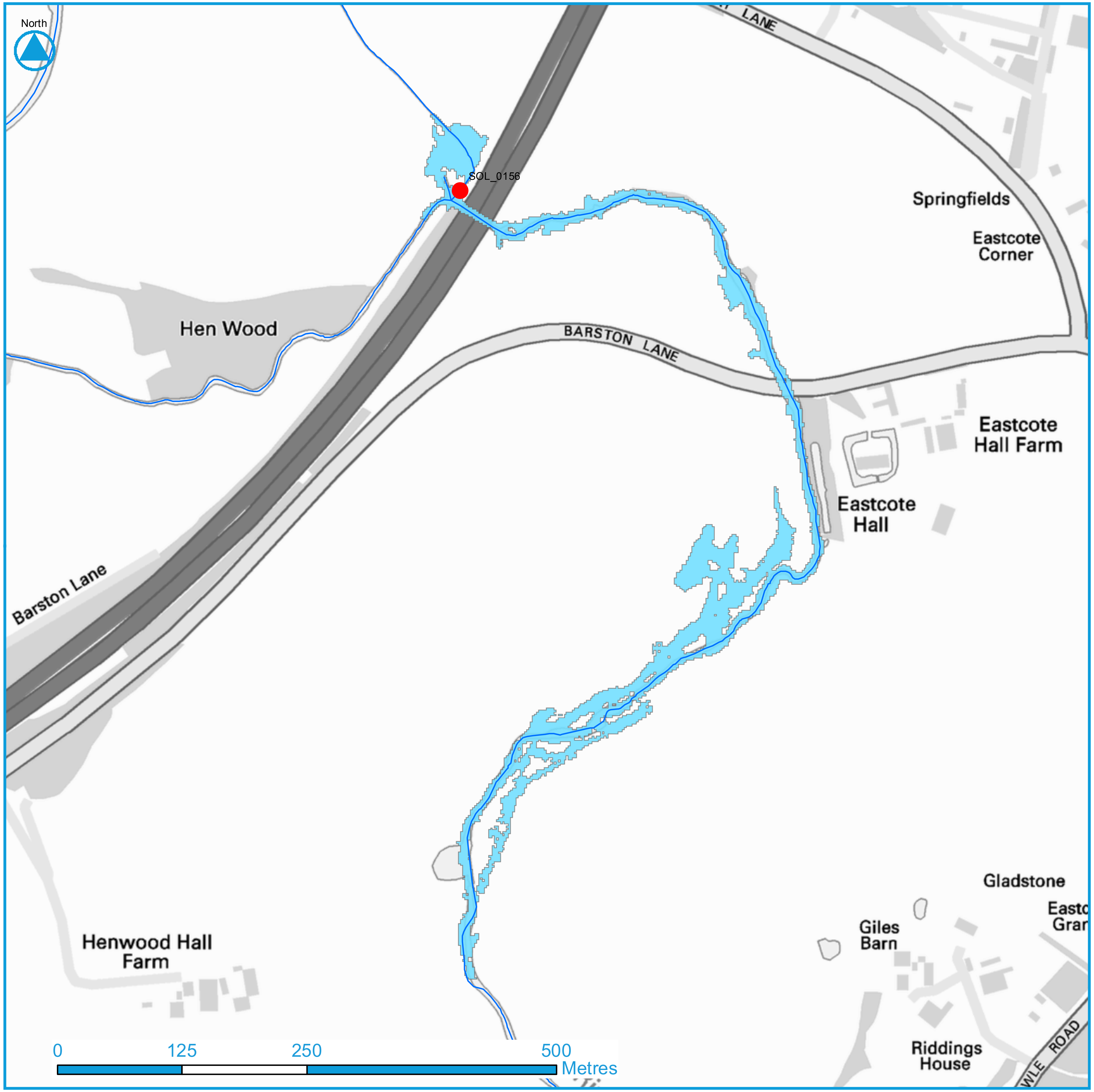
B.2 Depth – 30 Year Return Period

B.3 Extent – 100 Year Return Period

B.4 Depth – 100 Year Return Period

B.5 Extent – 1000 Year Return Period

B.6 Depth – 1000 Year Return Period



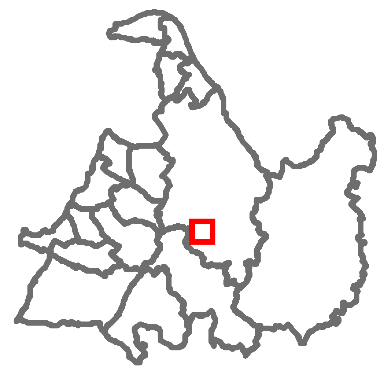
Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0156
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

NRD Property Points
Key Infrastructure
Residential
Non Residential
Flood Extent
Asset Location



X: 418587 **Y:** 279513

Shape: Circular
Capacity (m^3/s): 5.03 **Length (m):** 10.12
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 30 Year Return Period - 100% Blocked
Area Flooded (m^2): 28,796
Road Length Flooded (m): 22

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

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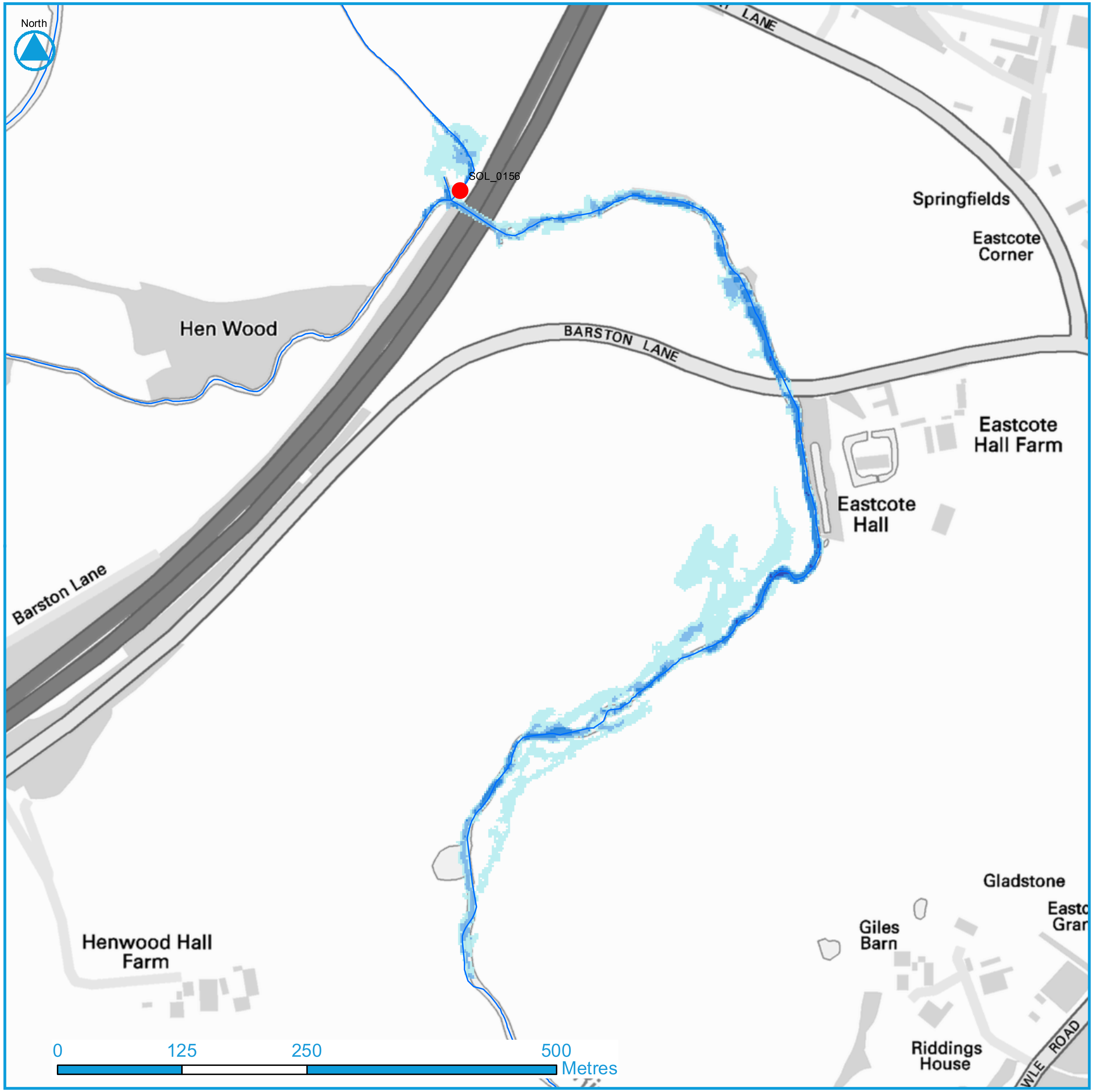


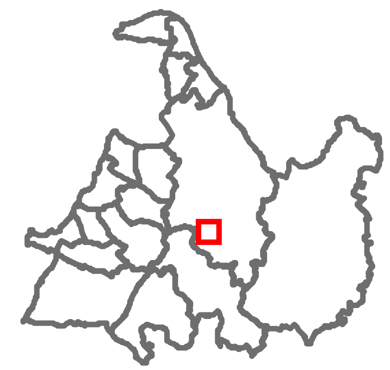
Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0156
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

Depth
- 0 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1 m
- 1 - 2 m
- > 2 m
- Asset Location



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Road Length Flooded (m): 22

Property Count	Total	Ground
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Key Infrastructure	0	0
All	0	0

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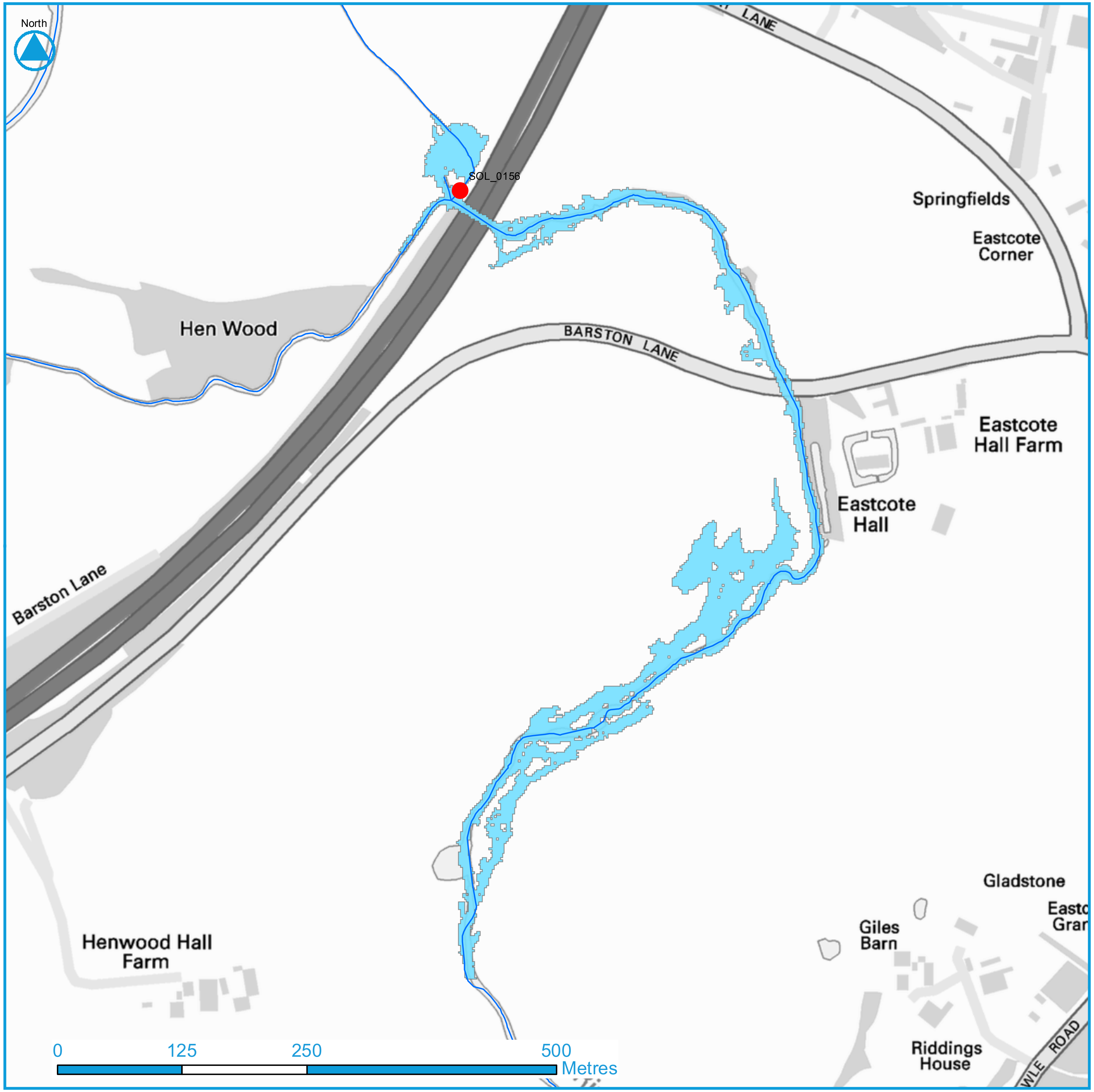


Solihull Metropolitan Borough Council

Asset Blockage Sensitivity Testing

Asset Reference: SOL_0156

SMBC Structure Code: -

Description: -

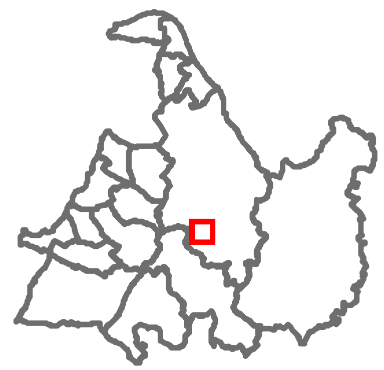
Ward: Bickenhill Ward

Watercourse

- Culvert
- Open Channel

NRD Property Points

- Key Infrastructure
- Residential
- Non Residential
- Flood Extent
- Asset Location



X: 418587 **Y:** 279513

Shape: Circular

Capacity (m^3/s): 5.03 **Length (m):** 10.12

Height (m): 1.00 **Width (m):** 1.00

Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 100 Year Return Period - 100% Blocked

Area Flooded (m^2): 33,684

Road Length Flooded (m): 22

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

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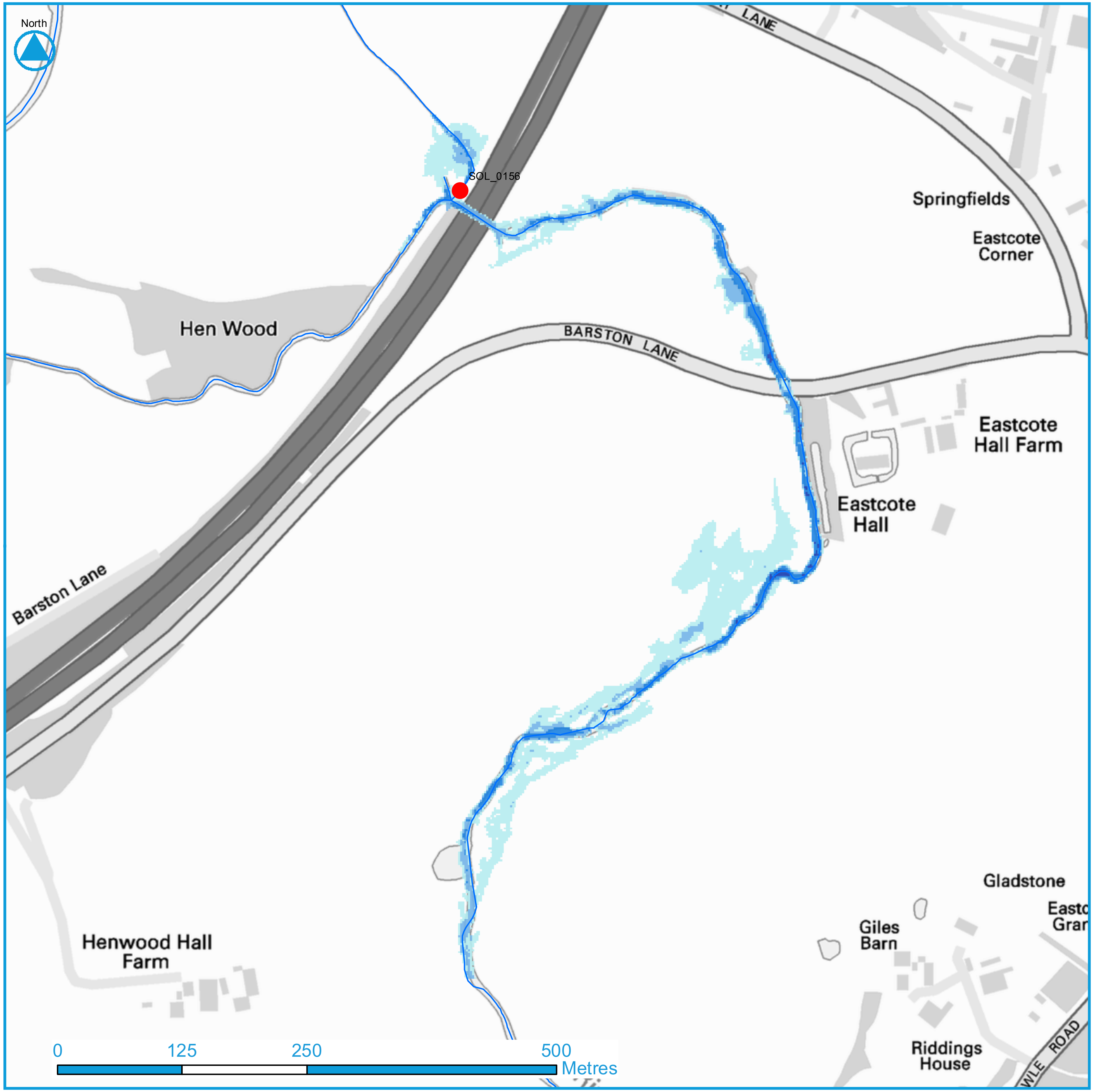

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0156
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

Depth
- 0 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1 m
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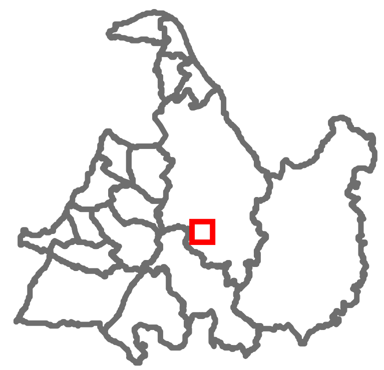
- > 2 m
- Asset Location



X: 418587 **Y:** 279513

Shape: Circular
Capacity (m^3/s): 5.03 **Length (m):** 10.12
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 100 Year Return Period - 100% Blocked

Area Flooded (m^2): 33,684

Road Length Flooded (m): 22

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

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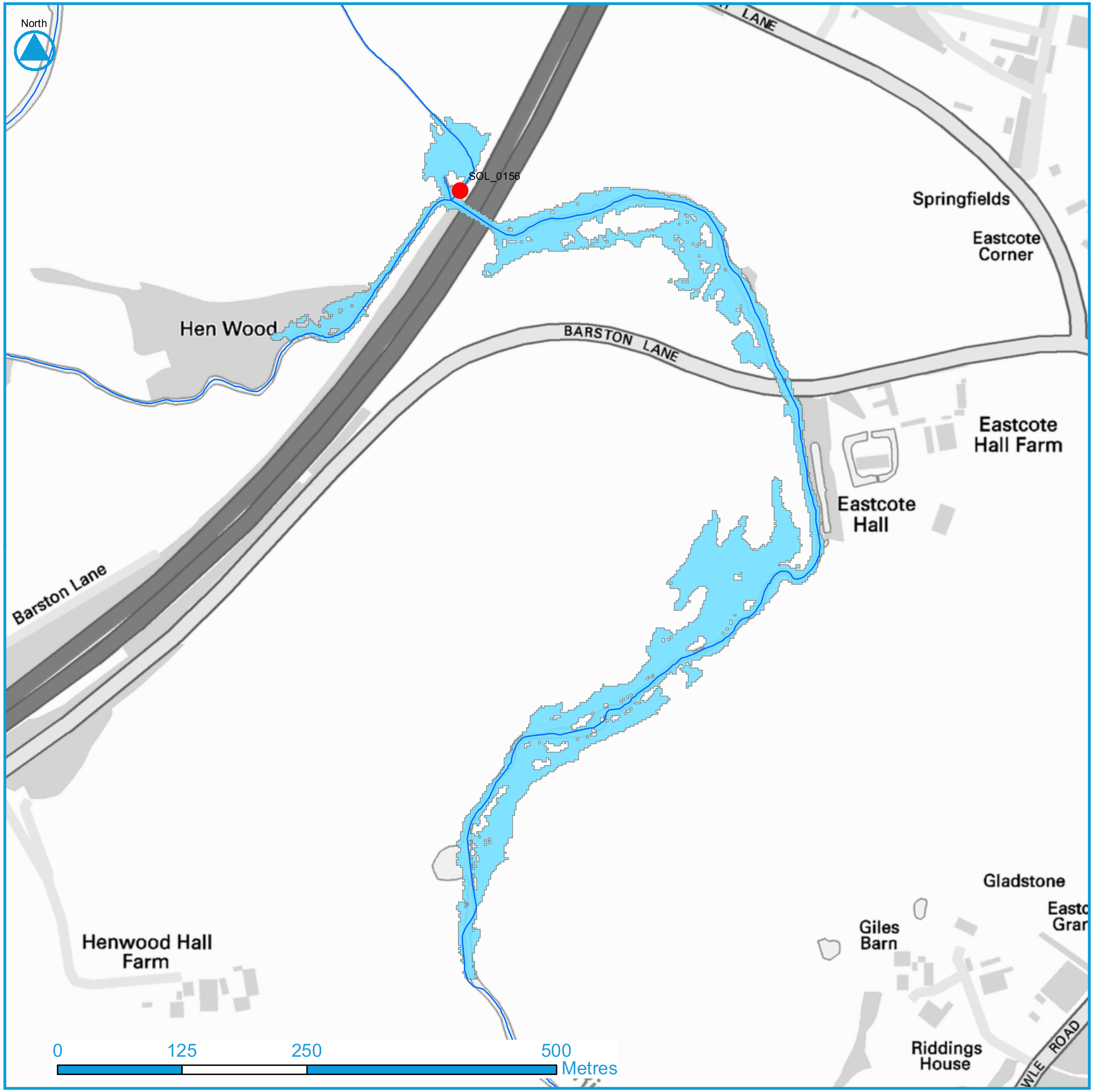
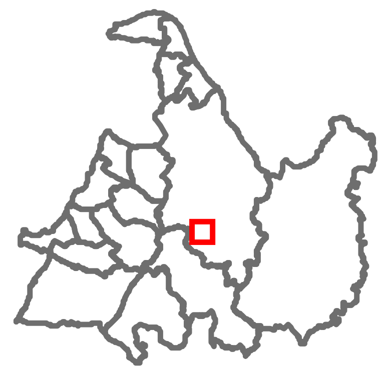


Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0156
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

NRD Property Points
Key Infrastructure
Residential
Non Residential
Flood Extent
Asset Location



X: 418587 **Y:** 279513

Shape: Circular
Capacity (m^3/s): 5.03 **Length (m):** 10.12
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 1000 Year Return Period - 100% Blocked
Area Flooded (m^2): 47,676
Road Length Flooded (m): 22

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

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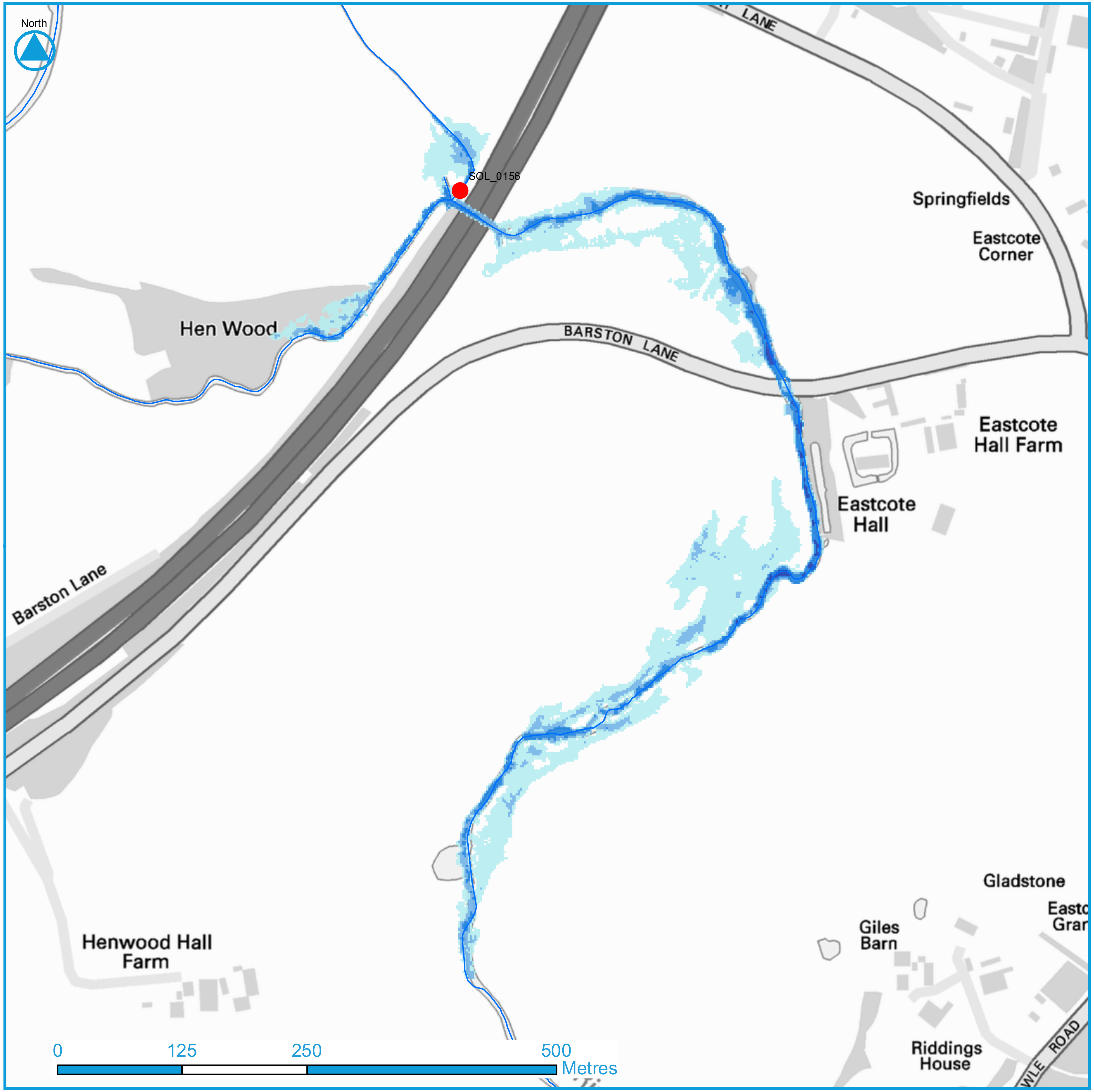


Solihull Metropolitan Borough Council

Asset Blockage Sensitivity Testing

Asset Reference: SOL_0156

SMBC Structure Code: -

Description: -

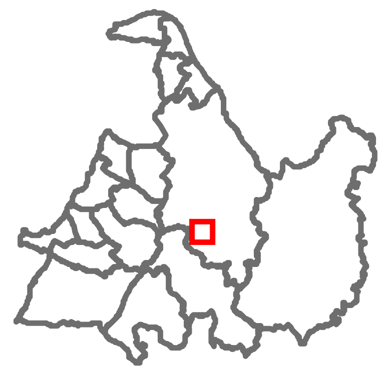
Ward: Bickenhill Ward

Watercourse

- Culvert
- Open Channel

Depth

- 0 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1 m
- 1 - 2 m
- > 2 m
- Asset Location



X: 418587 **Y:** 279513

Shape: Circular

Capacity (m^3/s): 5.03 **Length (m):** 10.12

Height (m): 1.00 **Width (m):** 1.00

Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 1000 Year Return Period - 100% Blocked

Area Flooded (m^2): 47,676

Road Length Flooded (m): 22

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

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Registered Office
South Barn
Broughton Hall
SKIPTON
North Yorkshire
BD23 3AE
United Kingdom

t:+44(0)1756 799919
e:info@jbaconsulting.com

Jeremy Benn Associates Ltd
Registered in England
3246693

ASSET BLOCKAGE SENSITIVITY TESTING
SOLIHULL METROPOLITAN BOROUGH COUNCIL

Asset Reference	SOL_0260
SMBC Structure Code	-
Description	-
Carries	Footpath
Over	Stream
Ward Location	Bickenhill Ward
National Grid Reference	419382 280009

Solihull Metropolitan Borough Council
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Warwickshire
B46 3AD

Revision History

Revision Ref / Date Issued	Amendments	Issued to
Final / October 2016		Edward Bradford

Contract

This report describes work commissioned by Solihull Metropolitan Borough Council, by Commission Order No 485867 dated 30th March 2016. Solihull Council's representative for the contract was Edward Bradford. David Kearney, Nelly Marcy, Anneka Lowis and Jack Dudman carried out this work.

Prepared by .... Jack Dudman BSc MSc

Reviewed by .... Anneka Lowis BSc MSc FRGS

Purpose

This document has been prepared as a Summary Report for the investigation of flood risk (calculation of a 100% blockage and a 'without blockage' scenario) for 504 culvert locations as agreed with Solihull Metropolitan Borough Council. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

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Acknowledgements

JBA would like to acknowledge the support of Edward Bradford of Solihull Metropolitan Borough Council.

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Contents

List of Tables

Abbreviations

DTM .... Digital Terrain Model
JFlow+ .... JBA Consulting's in house two dimensional flood software
LIDAR .... Light Detection and Ranging
NGR .... National Grid Reference
NRD .... National Receptor Database

1 Introduction

This report investigates the possible flood risk associated with an asset on Stream in Bickenhill Ward, with asset reference SOL_0260.

1.1 General Asset Information

1.1.1 Asset

Asset Reference	SOL_0260
Inlet National Grid Reference (NGR)	419382 280009

1.1.2 Dimensions

Asset Length (m)	1.42
Assumed Capacity (m^3)	0.90
Height (m)	1.00
Width (m)	1.00
Shape	Circular
Material	Concrete
Manning's Roughness Coefficient	0.011
Slope	0.0010
Note: The asset data contained within this report is indicative and should be verified by reviewing detailed asset survey reports.	

2 Methodology

2.1 Hydrology

The peak flows for the 6 Return Periods modelled are summarised in Table 2-2.

Table 2-2 Peak Flows

30 year	100 year	1000 year	100 year + 20% CC	100 year + 30% CC	100 year + 50% CC
0.73	0.98	1.68	1.17	1.27	1.47

2.2 Hydraulic Modelling

2.2.1 General Model Assumptions

- Model constructed using JFlow+
- Digital Terrain Model derived from 2 metre composite LIDAR and IHM (used under licence from the Environment Agency).

2.2.2 100% Blockage Modelling Assumptions

For the purpose of blockage, we have assumed a culvert capacity of zero, thus assuming that no water can be conveyed and that all of the flow will be forced out of bank at the culvert inlet.

2.2.3 Without Blockage Modelling Assumptions

The 'without blockage' modelling scenario required the calculation of the culvert capacity, in order to estimate the volume of water conveyed through the structure. Any flows greater than the capacity of the culvert were represented as out of bank flow at the culvert inlet. The culvert capacity was calculated using the Manning's equation.

2.3 Model Scenarios

The model has been run for 6 return periods: 30, 100, 1000-year with three climate change modifications to the 100-year return period of +20%, +30% and +50%. For each return period a 100% blockage ('with blockage') and 0% blockage ('without blockage') scenario were modelled. Depth, hazard and velocity flow grids were produced for each scenario. See below for modelling results.

2.4 Standard of Protection

Design flood flows at each asset inlet were calculated for a range of return periods. The culvert capacity was then compared with these to provide an estimate of each asset's Standard of Protection (SoP). Standard of protection is equal to the highest return period with a peak flow less than the asset capacity.

The SoP for asset ID SOL_0260 is 30 years.

3 Consequence

The modelled depth grids were converted to outlines and these were queried against the National Receptor Dataset (NRD) to obtain counts of flooded properties and lengths of flooded infrastructure.

3.1 Properties at risk

NRD property points were split into three categories; Residential, Non Residential, and Key Infrastructure. The total number of flooded properties and ground floor properties for all events and scenarios are reported in Table 3-1.

Table 3-1 All events – Number of properties flooded

		Model Event											
		100% Blocked						Without Blockage					
Consequence		Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%
Area Flooded (m^2)		69112	77312	100520	81352	83080	92936	0	10832	69424	42292	52392	61176
Properties Affected													
All	Total	0	0	1	0	1	1	0	0	0	0	0	0
	Ground	0	0	1	0	1	1	0	0	0	0	0	0
Res	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0
Non - Res	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0
Key	Total	0	0	1	0	1	1	0	0	0	0	0	0
	Ground	0	0	1	0	1	1	0	0	0	0	0	0

3.2 Infrastructure at risk

The lengths of flooded roads and railway[1] are shown in Table 3-2. This is a simple assessment and does not take into account the fact that some structures may be elevated out of the flooding.

Table 3-2 All events - Infrastructure at risk (m)

	Model Event											
	100% Blocked						Without Blockage					
Infrastructure (m)	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%
Motorway	0	0	0	0	0	0	0	0	0	0	0	0
A Road	0	0	0	0	0	0	0	0	0	0	0	0
B Road	0	0	0	0	0	0	0	0	0	0	0	0
Unclassified Road	93	158	218	179	188	206	0	0	69	5	9	50
Rail	0	0	0	0	0	0	0	0	0	0	0	0

[1] Contains public sector information licensed under the Open Government Licence v3.0.

Appendices

Where the channel capacity of the asset for the relevant blockage scenario is greater than the modelled return period flow all of the flow is conveyed through the structure and no map has been produced.

A 100% Blocked Maps

A.1 Extent – 30 Year Return Period

A.2 Depth – 30 Year Return Period

A.3 Extent – 100 Year Return Period

A.4 Depth – 100 Year Return Period

A.5 Extent – 1000 Year Return Period

A.6 Depth – 1000 Year Return Period

B 0% Blocked Maps

B.1 Extent – 30 Year Return Period

B.2 Depth – 30 Year Return Period

B.3 Extent – 100 Year Return Period

B.4 Depth – 100 Year Return Period

B.5 Extent – 1000 Year Return Period

B.6 Depth – 1000 Year Return Period

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0260
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

NRD Property Points
- Key Infrastructure
- Residential
- Non Residential
- Flood Extent
- Asset Location

X: 419382 **Y:** 280009

Shape: Circular
Capacity (m^3/s): 0.90 **Length (m):** 1.42
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 30 Year Return Period - 100% Blocked

Area Flooded (m^2): 69,112

Road Length Flooded (m): 93

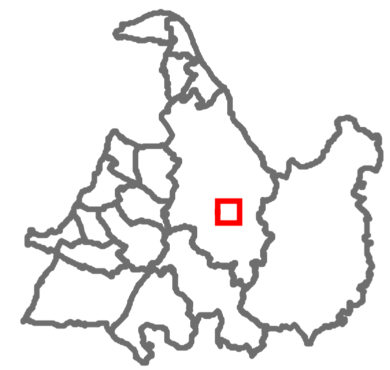
Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0260
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

Depth
- 0 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1 m
- 1 - 2 m
- > 2 m
- Asset Location



X: 419382 **Y:** 280009

Shape: Circular
Capacity (m^3/s): 0.90 **Length (m):** 1.42
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

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Scenario: 30 Year Return Period - 100% Blocked
Area Flooded (m^2): 69,112
Road Length Flooded (m): 93

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

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Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0260
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

NRD Property Points
Key Infrastructure
Residential
Non Residential
Flood Extent
Asset Location

X: 419382 **Y:** 280009

Shape: Circular
Capacity (m^3/s): 0.90 **Length (m):** 1.42
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 100 Year Return Period - 100% Blocked

Area Flooded (m^2): 77,312

Road Length Flooded (m): 158

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

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Solihull Metropolitan Borough Council

Asset Blockage Sensitivity Testing

Asset Reference: SOL_0260

SMBC Structure Code: -

Description: -

Ward: Bickenhill Ward

Watercourse

- Culvert
- Open Channel

Depth

- 0 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1 m
- 1 - 2 m
- > 2 m
- Asset Location

X: 419382 **Y:** 280009

Shape: Circular

Capacity (m^3/s): 0.90 **Length (m):** 1.42

Height (m): 1.00 **Width (m):** 1.00

Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 100 Year Return Period - 100% Blocked

Area Flooded (m^2): 77,312

Road Length Flooded (m): 158

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

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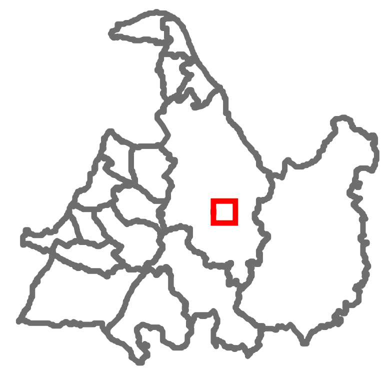
Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0260
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

NRD Property Points
Key Infrastructure
Residential
Non Residential
Flood Extent
Asset Location



X: 419382 **Y:** 280009

Shape: Circular
Capacity (m^3/s): 0.90 **Length (m):** 1.42
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 1000 Year Return Period - 100% Blocked

Area Flooded (m^2): 100,520

Road Length Flooded (m): 218

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	1	1
All	1	1

Solihull Metropolitan Borough Council
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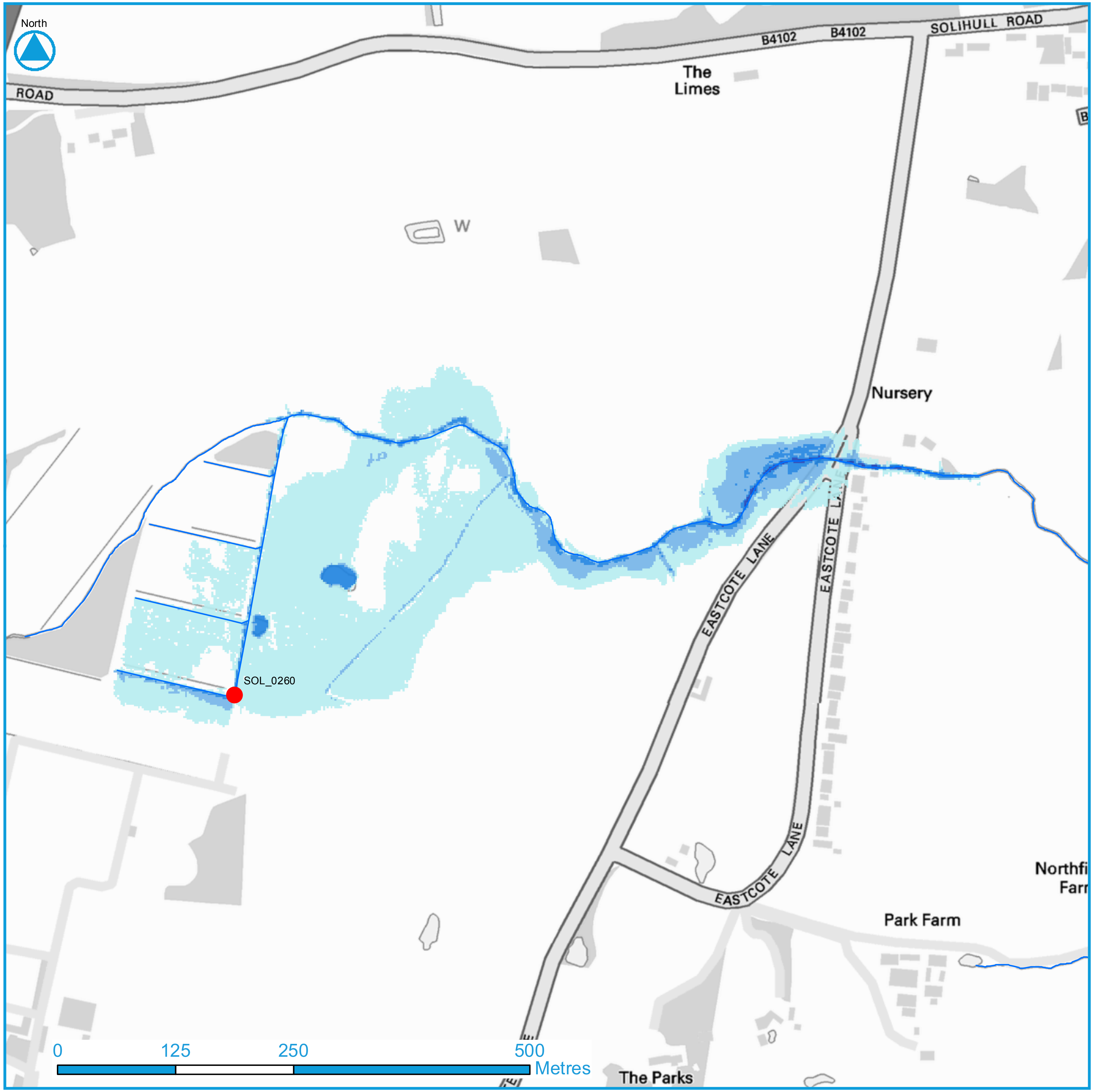

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Asset Blockage Sensitivity Testing

Asset Reference: SOL_0260
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

Depth
- 0 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1 m
- 1 - 2 m
- > 2 m
- Asset Location

X: 419382 **Y:** 280009

Shape: Circular
Capacity (m^3/s): 0.90 **Length (m):** 1.42
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 1000 Year Return Period - 100% Blocked

Area Flooded (m^2): 100,520

Road Length Flooded (m): 218

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	1	1
All	1	1

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0260
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

NRD Property Points
- Key Infrastructure
- Residential
- Non Residential
- Flood Extent
- Asset Location

X: 419382 **Y:** 280009

Shape: Circular
Capacity (m^3/s): 0.90 **Length (m):** 1.42
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 100 Year Return Period - 0% Blocked

Area Flooded (m^2): 10,832

Road Length Flooded (m): 0

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0260
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

Depth
0 - 0.25 m
0.25 - 0.5 m
0.5 - 1 m
1 - 2 m
> 2 m
Asset Location

X: 419382 **Y:** 280009

Shape: Circular
Capacity (m^3/s): 0.90 **Length (m):** 1.42
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 100 Year Return Period - 0% Blocked

Area Flooded (m^2): 10,832

Road Length Flooded (m): 0

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

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Solihull Metropolitan Borough Council

Asset Blockage Sensitivity Testing

Asset Reference: SOL_0260

SMBC Structure Code: -

Description: -

Ward: Bickenhill Ward

Watercourse

- Culvert
- Open Channel

NRD Property Points

- Key Infrastructure
- Residential
- Non Residential
- Flood Extent
- Asset Location

X: 419382 **Y:** 280009

Shape: Circular

Capacity (m^3/s): 0.90 **Length (m):** 1.42

Height (m): 1.00 **Width (m):** 1.00

Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 1000 Year Return Period - 0% Blocked

Area Flooded (m^2): 69,424

Road Length Flooded (m): 69

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0260
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

Depth
0 - 0.25 m
0.25 - 0.5 m
0.5 - 1 m
1 - 2 m
> 2 m
Asset Location

X: 419382 **Y:** 280009

Shape: Circular
Capacity (m^3/s): 0.90 **Length (m):** 1.42
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 1000 Year Return Period - 0% Blocked
Area Flooded (m^2): 69,424
Road Length Flooded (m): 69

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

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SKIPTON
North Yorkshire
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United Kingdom

t:+44(0)1756 799919
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ASSET BLOCKAGE SENSITIVITY TESTING
SOLIHULL METROPOLITAN BOROUGH COUNCIL

Asset Reference	SOL_0263
SMBC Structure Code	-
Description	-
Carries	Footpath
Over	Hollywell Brook
Ward Location	Bickenhill Ward
National Grid Reference	420727 283547

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Warwickshire
B46 3AD

Revision History

Revision Ref / Date Issued	Amendments	Issued to
Final / October 2016		Edward Bradford

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Prepared by .... Jack Dudman BSc MSc

Reviewed by .... Anneka Lowis BSc MSc FRGS

Purpose

This document has been prepared as a Summary Report for the investigation of flood risk (calculation of a 100% blockage and a 'without blockage' scenario) for 504 culvert locations as agreed with Solihull Metropolitan Borough Council. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

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JFlow+ ..... JBA Consulting's in house two dimensional flood software
LIDAR ..... Light Detection and Ranging
NGR ..... National Grid Reference
NRD ..... National Receptor Database

1 Introduction

This report investigates the possible flood risk associated with an asset on Hollywell Brook in Bickenhill Ward, with asset reference SOL_0263.

1.1 General Asset Information

1.1.1 Asset

Asset Reference	SOL_0263
Inlet National Grid Reference (NGR)	420727 283547

1.1.2 Dimensions

Asset Length (m)	42.00
Assumed Capacity (m^3)	5.18
Height (m)	1.00
Width (m)	1.00
Shape	Circular
Material	Concrete
Manning's Roughness Coefficient	0.011
Slope	0.0335
Note: The asset data contained within this report is indicative and should be verified by reviewing detailed asset survey reports.	

2 Methodology

2.1 Hydrology

The peak flows for the 6 Return Periods modelled are summarised in Table 2-2.

Table 2-2 Peak Flows

30 year	100 year	1000 year	100 year + 20% CC	100 year + 30% CC	100 year + 50% CC
2.00	2.52	3.80	3.02	3.27	3.78

2.2 Hydraulic Modelling

2.2.1 General Model Assumptions

- Model constructed using JFlow+
- Digital Terrain Model derived from 2 metre composite LIDAR and IHM (used under licence from the Environment Agency).

2.2.2 100% Blockage Modelling Assumptions

For the purpose of blockage, we have assumed a culvert capacity of zero, thus assuming that no water can be conveyed and that all of the flow will be forced out of bank at the culvert inlet.

2.2.3 Without Blockage Modelling Assumptions

The 'without blockage' modelling scenario required the calculation of the culvert capacity, in order to estimate the volume of water conveyed through the structure. Any flows greater than the capacity of the culvert were represented as out of bank flow at the culvert inlet. The culvert capacity was calculated using the Manning's equation.

2.3 Model Scenarios

The model has been run for 6 return periods: 30, 100, 1000-year with three climate change modifications to the 100-year return period of +20%, +30% and +50%. For each return period a 100% blockage ('with blockage') and 0% blockage ('without blockage') scenario were modelled. Depth, hazard and velocity flow grids were produced for each scenario. See below for modelling results.

2.4 Standard of Protection

Design flood flows at each asset inlet were calculated for a range of return periods. The culvert capacity was then compared with these to provide an estimate of each asset's Standard of Protection (SoP). Standard of protection is equal to the highest return period with a peak flow less than the asset capacity.

The SoP for asset ID SOL_0263 is more than 1000 years.

3 Consequence

The modelled depth grids were converted to outlines and these were queried against the National Receptor Dataset (NRD) to obtain counts of flooded properties and lengths of flooded infrastructure.

3.1 Properties at risk

NRD property points were split into three categories; Residential, Non Residential, and Key Infrastructure. The total number of flooded properties and ground floor properties for all events and scenarios are reported in Table 3-1.

Table 3-1 All events – Number of properties flooded

		Model Event											
		100% Blocked						Without Blockage					
Consequence		Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%
Area Flooded (m^2)		52420	61476	83916	71220	75688	85372	0	0	0	0	0	0
Properties Affected													
All	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0
Res	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0
Non - Res	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0
Key	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0

3.2 Infrastructure at risk

The lengths of flooded roads and railway[1] are shown in Table 3-2. This is a simple assessment and does not take into account the fact that some structures may be elevated out of the flooding.

Table 3-2 All events - Infrastructure at risk (m)

	Model Event											
	100% Blocked						Without Blockage					
Infrastructure (m)	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%
Motorway	0	0	0	0	0	0	0	0	0	0	0	0
A Road	0	0	0	0	0	0	0	0	0	0	0	0
B Road	0	0	0	0	0	0	0	0	0	0	0	0
Unclassified Road	10	65	134	108	116	134	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0

[1] Contains public sector information licensed under the Open Government Licence v3.0.

Appendices

Where the channel capacity of the asset for the relevant blockage scenario is greater than the modelled return period flow all of the flow is conveyed through the structure and no map has been produced.

A 100% Blocked Maps

A.1 Extent – 30 Year Return Period

A.2 Depth – 30 Year Return Period

A.3 Extent – 100 Year Return Period

A.4 Depth – 100 Year Return Period

A.5 Extent – 1000 Year Return Period

A.6 Depth – 1000 Year Return Period

B 0% Blocked Maps

B.1 Extent – 30 Year Return Period

B.2 Depth – 30 Year Return Period

B.3 Extent – 100 Year Return Period

B.4 Depth – 100 Year Return Period

B.5 Extent – 1000 Year Return Period

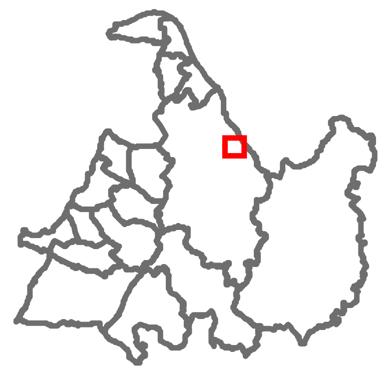
B.6 Depth – 1000 Year Return Period

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0263
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

NRD Property Points
- Key Infrastructure
- Residential
- Non Residential
- Flood Extent
- Asset Location



X: 420727 **Y:** 283547

Shape: Circular
Capacity (m^3/s): 5.18 **Length (m):** 42.00
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 30 Year Return Period - 100% Blocked
Area Flooded (m^2): 52,420
Road Length Flooded (m): 10

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

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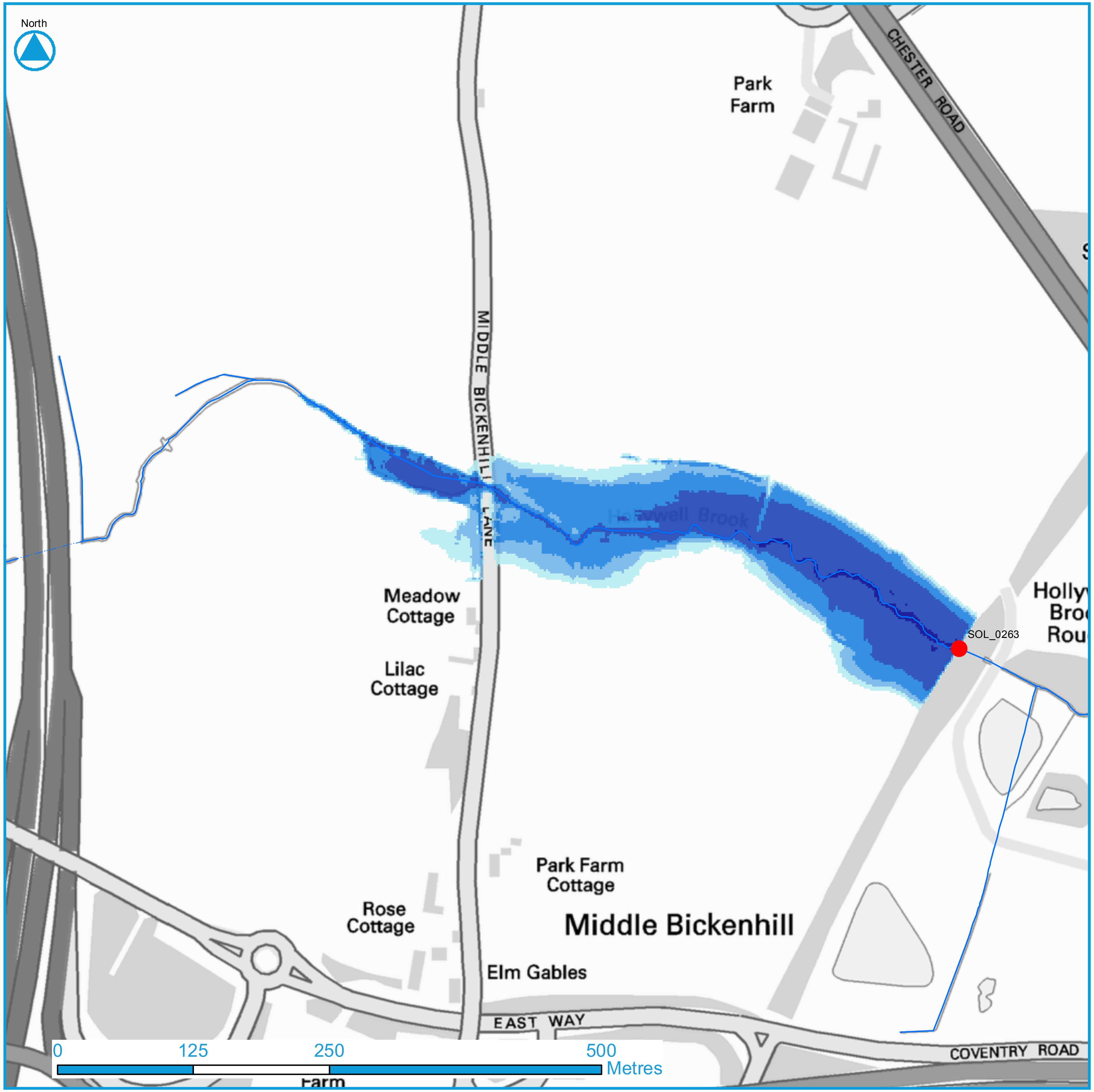


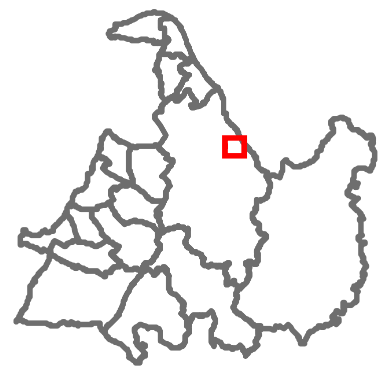
Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0263
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

Depth
0 - 0.25 m
0.25 - 0.5 m
0.5 - 1 m
1 - 2 m
> 2 m
Asset Location



X: 420727 **Y:** 283547

Shape: Circular
Capacity (m^3/s): 5.18 **Length (m):** 42.00
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 30 Year Return Period - 100% Blocked
Area Flooded (m^2): 52,420
Road Length Flooded (m): 10

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

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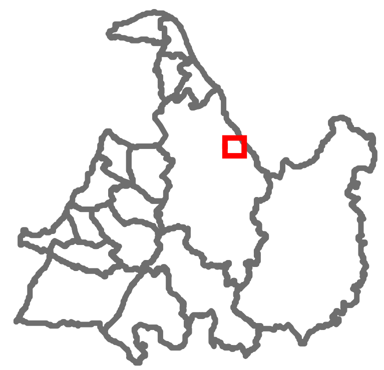
JBA consulting

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0263
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

NRD Property Points
Key Infrastructure
Residential
Non Residential
Flood Extent
Asset Location



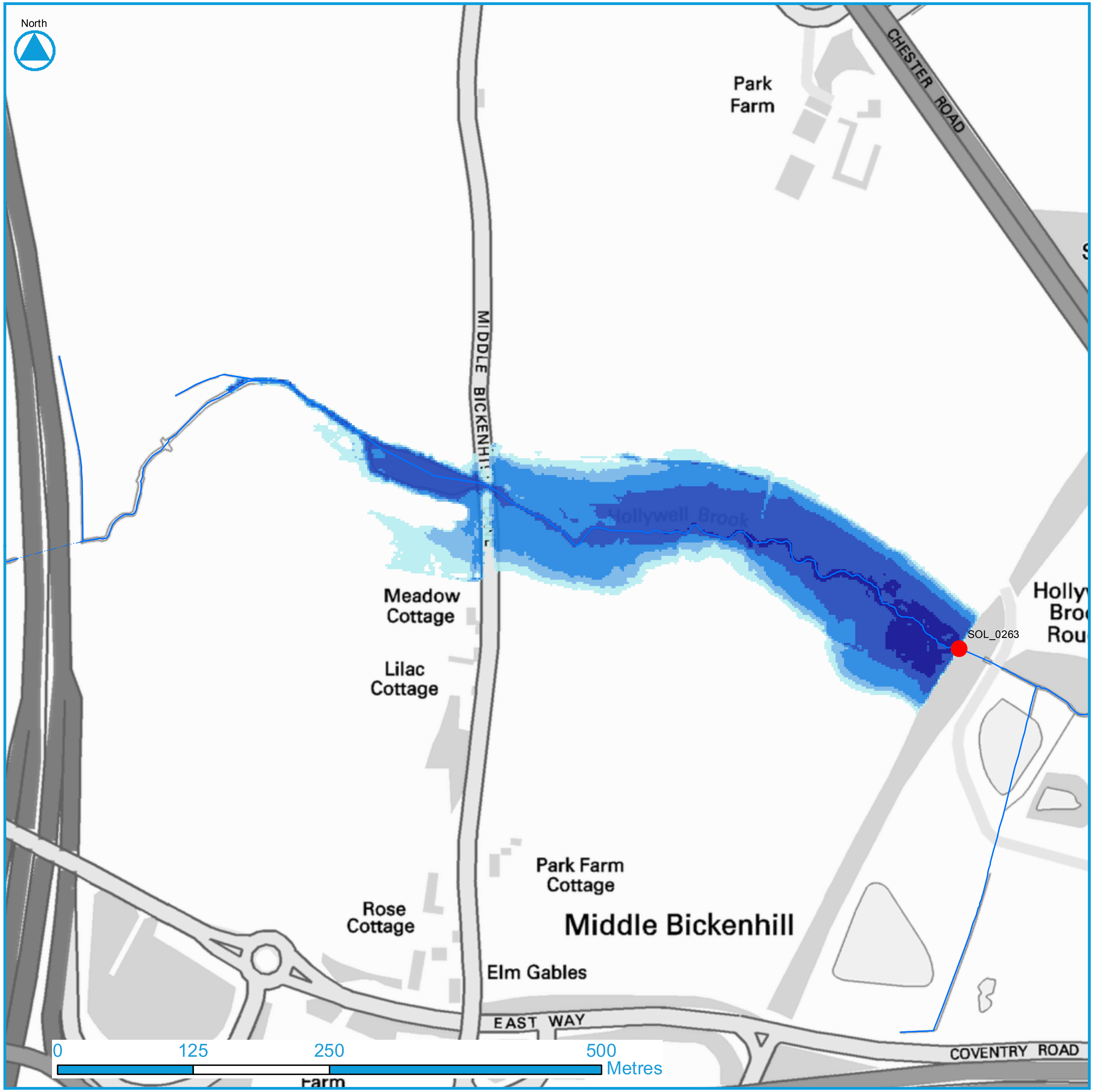
X: 420727 **Y:** 283547

Shape: Circular
Capacity (m^3/s): 5.18
Length (m): 42.00
Height (m): 1.00
Width (m): 1.00
Material: Concrete
Manning's *n*: 0.011

Consequence
Scenario: 100 Year Return Period - 100% Blocked
Area Flooded (m^2): 61,476
Road Length Flooded (m): 65

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

Solihull Metropolitan Borough Council
JBA consulting

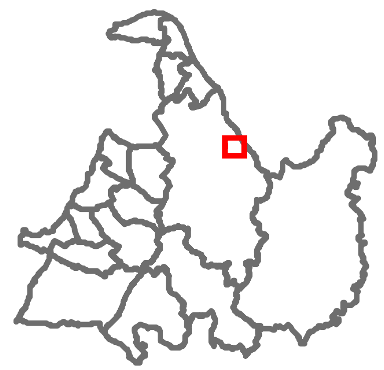


Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0263
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

Depth
0 - 0.25 m
0.25 - 0.5 m
0.5 - 1 m
1 - 2 m
> 2 m
Asset Location



X: 420727 **Y:** 283547

Shape: Circular
Capacity (m^3/s): 5.18 **Length (m):** 42.00
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 100 Year Return Period - 100% Blocked
Area Flooded (m^2): 61,476
Road Length Flooded (m): 65

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

Solihull Metropolitan Borough Council
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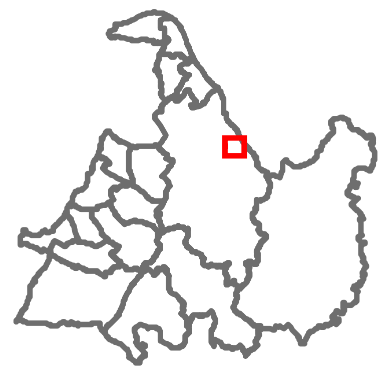
Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0263
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

NRD Property Points
- Key Infrastructure
- Residential
- Non Residential
- Flood Extent
- Asset Location

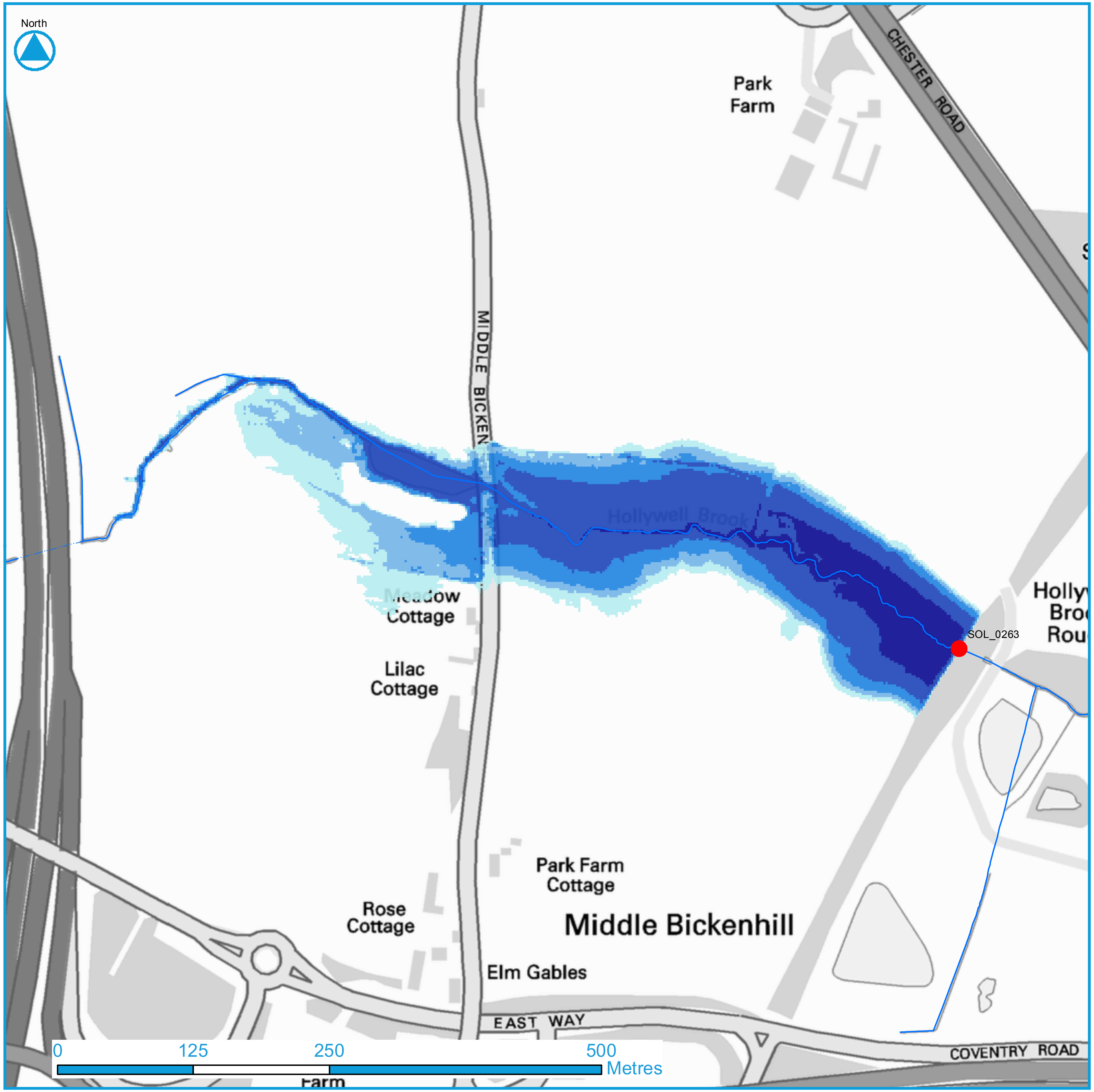


X: 420727 **Y:** 283547

Shape: Circular
Capacity (m^3/s): 5.18 **Length (m):** 42.00
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 1000 Year Return Period - 100% Blocked
Area Flooded (m^2): 83,916
Road Length Flooded (m): 134

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0



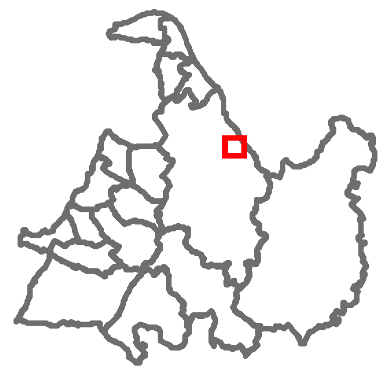
Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0263
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

Depth
0 - 0.25 m
0.25 - 0.5 m
0.5 - 1 m
1 - 2 m
> 2 m
Asset Location



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Shape: Circular
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Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 1000 Year Return Period - 100% Blocked
Area Flooded (m^2): 83,916
Road Length Flooded (m): 134

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

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North Yorkshire
BD23 3AE
United Kingdom

t:+44(0)1756 799919
e:info@jbaconsulting.com

Jeremy Benn Associates Ltd
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ASSET BLOCKAGE SENSITIVITY TESTING
SOLIHULL METROPOLITAN BOROUGH COUNCIL

Asset Reference	SOL_0264
SMBC Structure Code	-
Description	-
Carries	Footpath
Over	Stream
Ward Location	Bickenhill Ward
National Grid Reference	420754 283345

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Highway Services
The Council House
Manor Square
Solihull
B91 3QB

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B46 3AD

Revision History

Revision Ref / Date Issued	Amendments	Issued to
Final / October 2016		Edward Bradford

Contract

This report describes work commissioned by Solihull Metropolitan Borough Council, by Commission Order No 485867 dated 30th March 2016. Solihull Council's representative for the contract was Edward Bradford. David Kearney, Nelly Marcy, Anneka Lowis and Jack Dudman carried out this work.

Prepared by .... Jack Dudman BSc MSc

Reviewed by .... Anneka Lowis BSc MSc FRGS

Purpose

This document has been prepared as a Summary Report for the investigation of flood risk (calculation of a 100% blockage and a 'without blockage' scenario) for 504 culvert locations as agreed with Solihull Metropolitan Borough Council. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

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Acknowledgements

JBA would like to acknowledge the support of Edward Bradford of Solihull Metropolitan Borough Council.

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Contents

List of Tables

Abbreviations

DTM .... Digital Terrain Model
JFlow+ .... JBA Consulting's in house two dimensional flood software
LIDAR .... Light Detection and Ranging
NGR .... National Grid Reference
NRD .... National Receptor Database

1 Introduction

This report investigates the possible flood risk associated with an asset on Stream in Bickenhill Ward, with asset reference SOL_0264.

1.1 General Asset Information

1.1.1 Asset

Asset Reference	SOL_0264
Inlet National Grid Reference (NGR)	420754 283345

1.1.2 Dimensions

Asset Length (m)	4.32
Assumed Capacity (m^3)	5.50
Height (m)	1.00
Width (m)	1.00
Shape	Circular
Material	Concrete
Manning's Roughness Coefficient	0.011
Slope	0.0376
Note: The asset data contained within this report is indicative and should be verified by reviewing detailed asset survey reports.	

2 Methodology

2.1 Hydrology

The peak flows for the 6 Return Periods modelled are summarised in Table 2-2.

Table 2-2 Peak Flows

30 year	100 year	1000 year	100 year + 20% CC	100 year + 30% CC	100 year + 50% CC
2.02	2.55	3.83	3.06	3.32	3.83

2.2 Hydraulic Modelling

2.2.1 General Model Assumptions

- Model constructed using JFlow+
- Digital Terrain Model derived from 2 metre composite LIDAR and IHM (used under licence from the Environment Agency).

2.2.2 100% Blockage Modelling Assumptions

For the purpose of blockage, we have assumed a culvert capacity of zero, thus assuming that no water can be conveyed and that all of the flow will be forced out of bank at the culvert inlet.

2.2.3 Without Blockage Modelling Assumptions

The 'without blockage' modelling scenario required the calculation of the culvert capacity, in order to estimate the volume of water conveyed through the structure. Any flows greater than the capacity of the culvert were represented as out of bank flow at the culvert inlet. The culvert capacity was calculated using the Manning's equation.

2.3 Model Scenarios

The model has been run for 6 return periods: 30, 100, 1000-year with three climate change modifications to the 100-year return period of +20%, +30% and +50%. For each return period a 100% blockage ('with blockage') and 0% blockage ('without blockage') scenario were modelled. Depth, hazard and velocity flow grids were produced for each scenario. See below for modelling results.

2.4 Standard of Protection

Design flood flows at each asset inlet were calculated for a range of return periods. The culvert capacity was then compared with these to provide an estimate of each asset's Standard of Protection (SoP). Standard of protection is equal to the highest return period with a peak flow less than the asset capacity.

The SoP for asset ID SOL_0264 is more than 1000 years.

3 Consequence

The modelled depth grids were converted to outlines and these were queried against the National Receptor Dataset (NRD) to obtain counts of flooded properties and lengths of flooded infrastructure.

3.1 Properties at risk

NRD property points were split into three categories; Residential, Non Residential, and Key Infrastructure. The total number of flooded properties and ground floor properties for all events and scenarios are reported in Table 3-1.

Table 3-1 All events – Number of properties flooded

		Model Event											
		100% Blocked						Without Blockage					
Consequence		Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%
Area Flooded (m^2)		68328	75304	84092	79196	82924	84200	0	0	0	0	0	0
Properties Affected													
All	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0
Res	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0
Non - Res	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0
Key	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0

3.2 Infrastructure at risk

The lengths of flooded roads and railway[1] are shown in Table 3-2. This is a simple assessment and does not take into account the fact that some structures may be elevated out of the flooding.

Table 3-2 All events - Infrastructure at risk (m)

	Model Event											
	100% Blocked						Without Blockage					
Infrastructure (m)	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%
Motorway	0	0	0	0	0	0	0	0	0	0	0	0
A Road	9	9	12	12	12	12	0	0	0	0	0	0
B Road	0	0	0	0	0	0	0	0	0	0	0	0
Unclassified Road	66	71	89	85	88	89	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0

[1] Contains public sector information licensed under the Open Government Licence v3.0.

Appendices

Where the channel capacity of the asset for the relevant blockage scenario is greater than the modelled return period flow all of the flow is conveyed through the structure and no map has been produced.

A 100% Blocked Maps

A.1 Extent – 30 Year Return Period

A.2 Depth – 30 Year Return Period

A.3 Extent – 100 Year Return Period

A.4 Depth – 100 Year Return Period

A.5 Extent – 1000 Year Return Period

A.6 Depth – 1000 Year Return Period

B 0% Blocked Maps

B.1 Extent – 30 Year Return Period

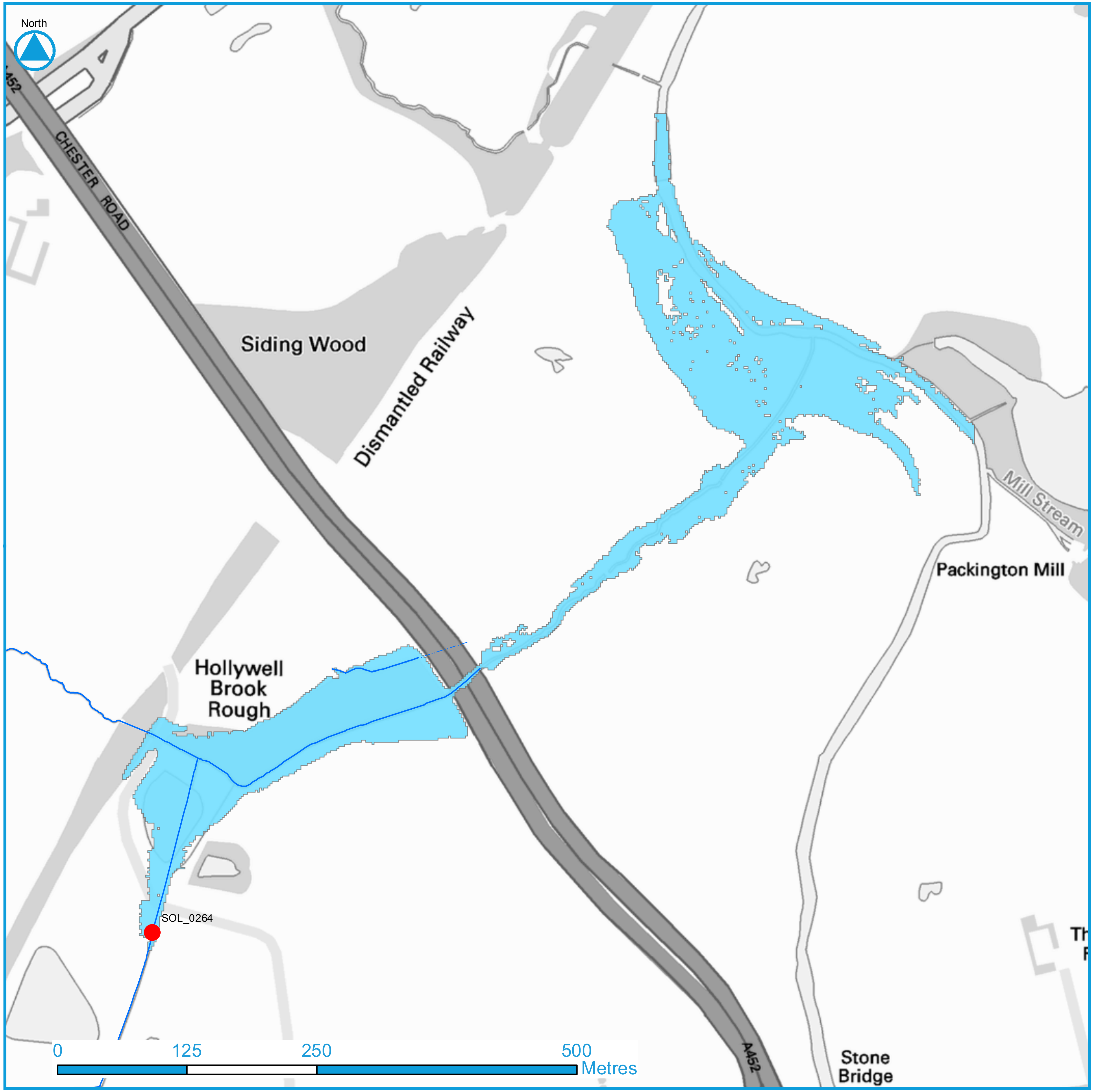
B.2 Depth – 30 Year Return Period

B.3 Extent – 100 Year Return Period

B.4 Depth – 100 Year Return Period

B.5 Extent – 1000 Year Return Period

B.6 Depth – 1000 Year Return Period



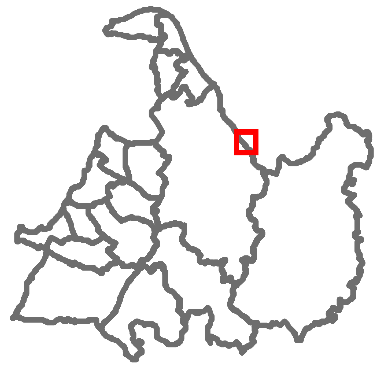
Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0264
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

NRD Property Points
- Key Infrastructure
- Residential
- Non Residential
- Flood Extent
- Asset Location



X: 420754 **Y:** 283345

Shape: Circular
Capacity (m^3/s): 5.50 **Length (m):** 4.32
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

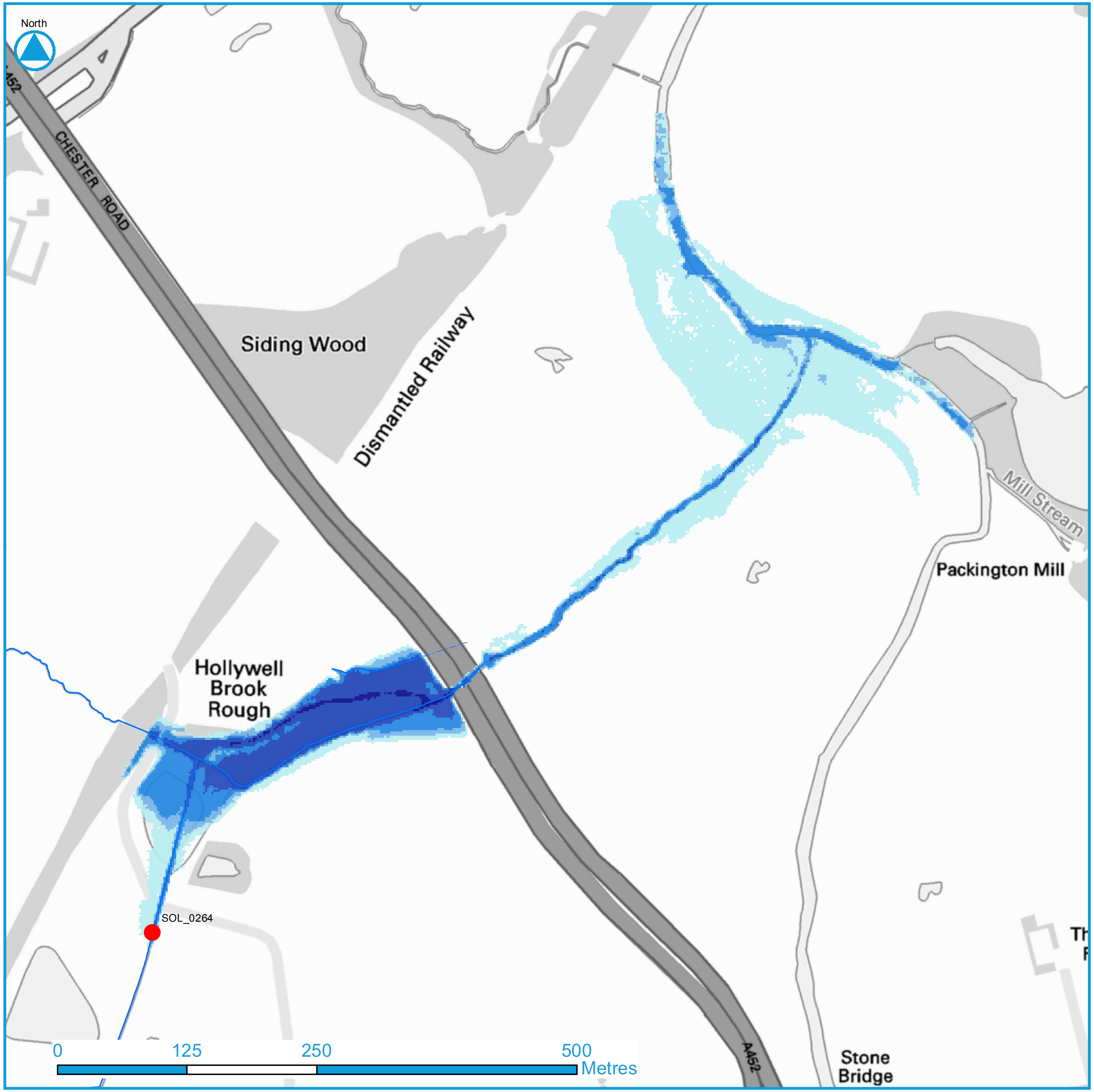
Consequence

Scenario: 30 Year Return Period - 100% Blocked

Area Flooded (m^2): 68,328

Road Length Flooded (m): 76

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

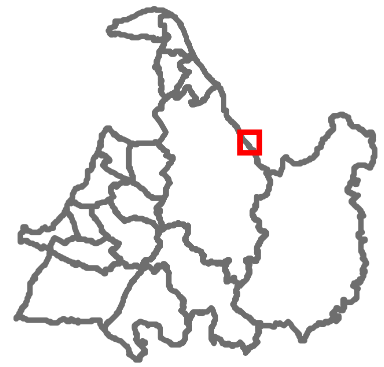


Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0264
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

Depth
0 - 0.25 m
0.25 - 0.5 m
0.5 - 1 m
1 - 2 m
> 2 m
Asset Location



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Shape: Circular
Capacity (m^3/s): 5.50
Length (m): 4.32
Height (m): 1.00
Width (m): 1.00
Material: Concrete
Manning's *n*: 0.011

Consequence
Scenario: 30 Year Return Period - 100% Blocked
Area Flooded (m^2): 68,328
Road Length Flooded (m): 76

Property Count	Total	Ground
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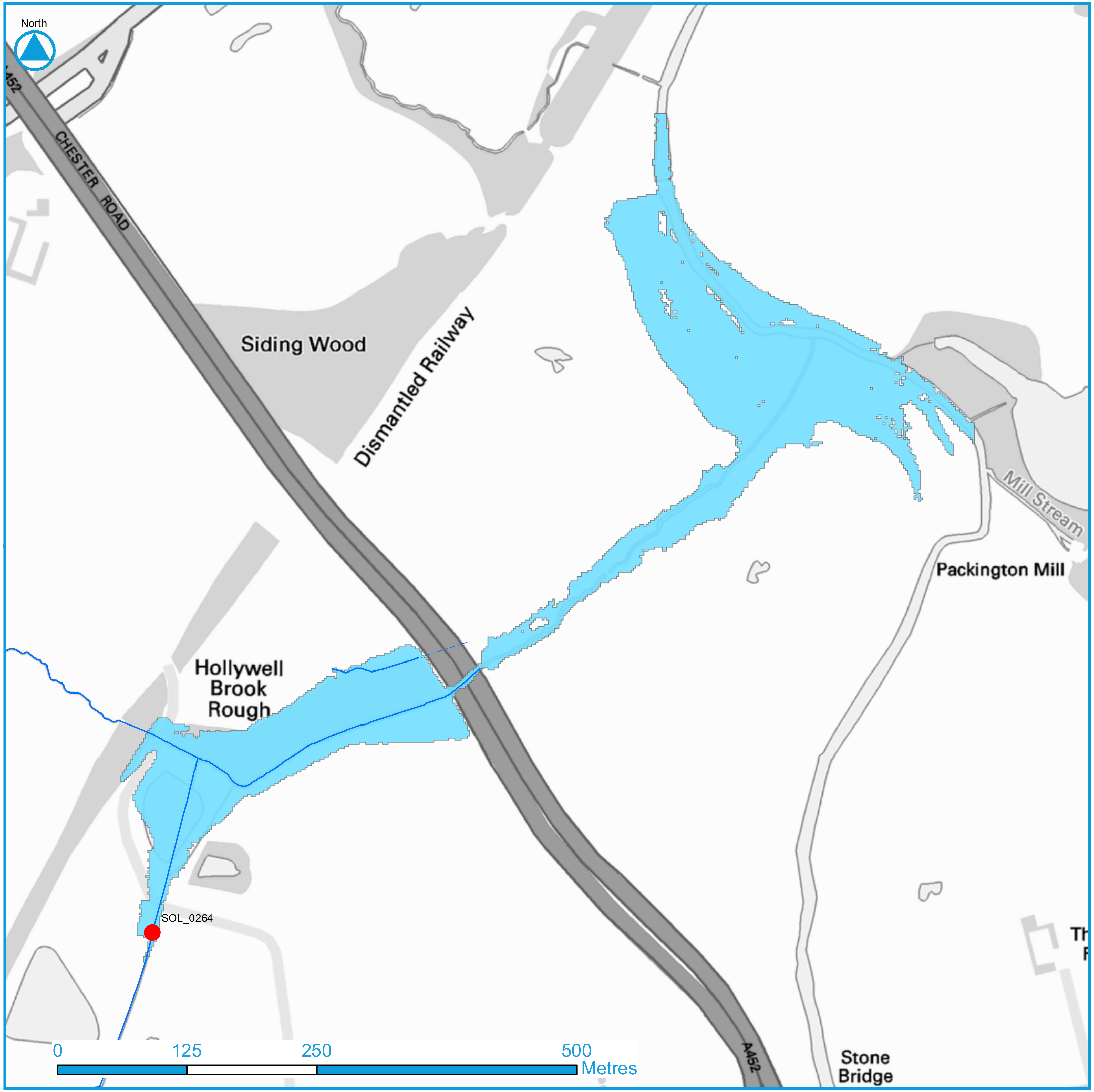
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

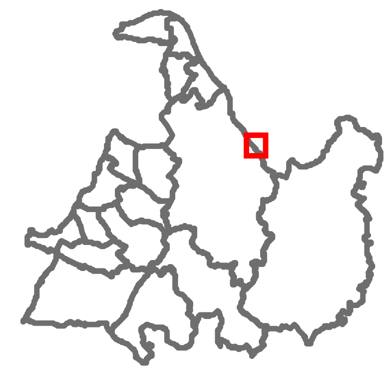


Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0264
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

NRD Property Points
- Key Infrastructure
- Residential
- Non Residential
- Flood Extent
- Asset Location



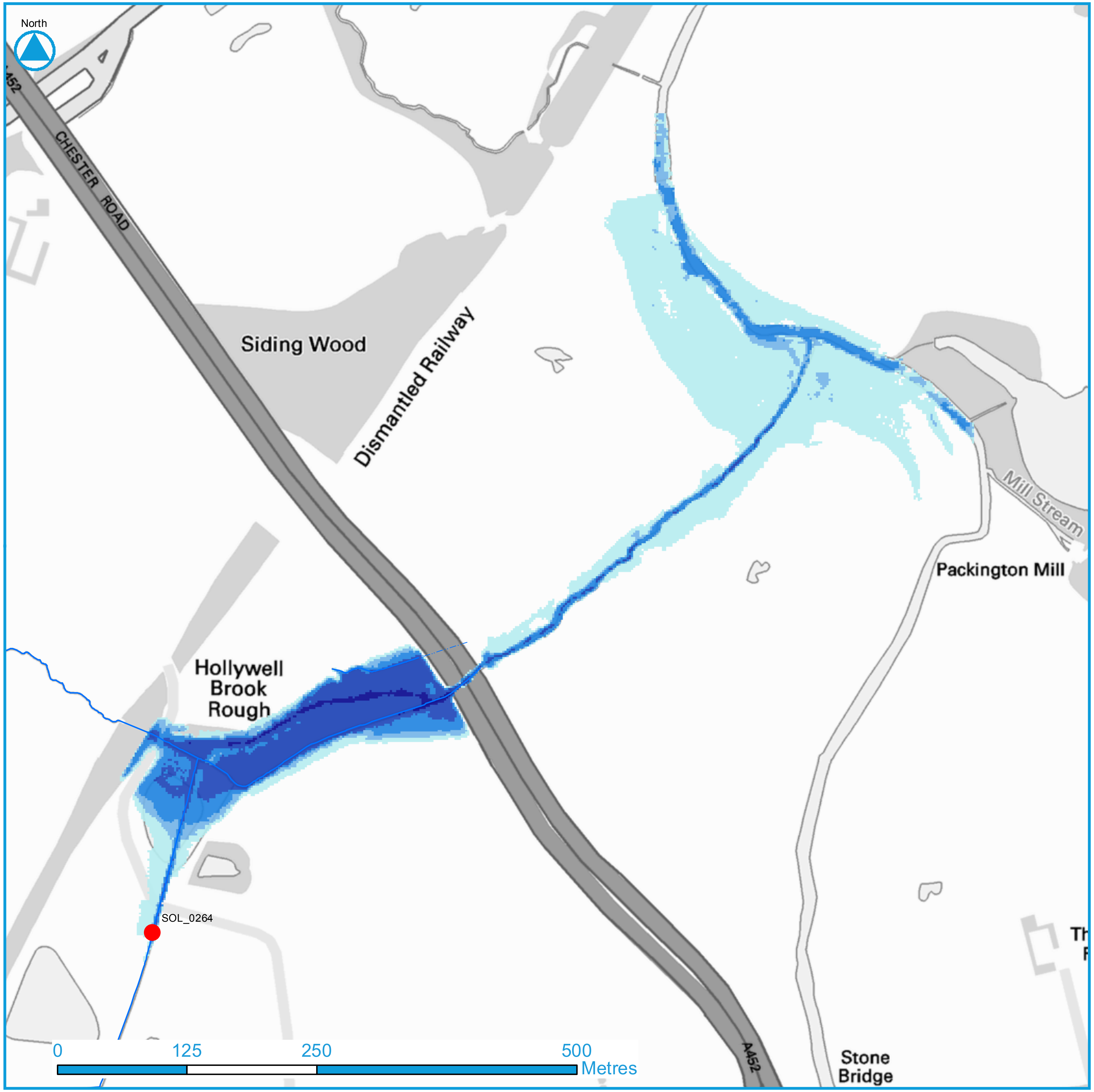
X: 420754 **Y:** 283345

Shape: Circular
Capacity (m^3/s): 5.50 **Length (m):** 4.32
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 100 Year Return Period - 100% Blocked
Area Flooded (m^2): 75,304
Road Length Flooded (m): 80

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0



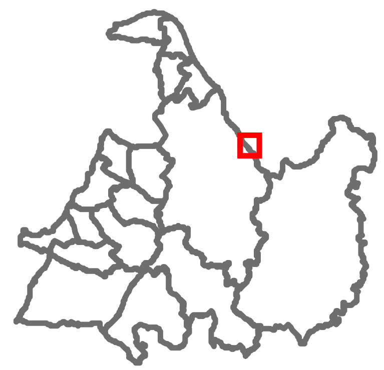
Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0264
SMBC Structure Code: -
Description: -

Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

Depth
- 0 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1 m
- 1 - 2 m
- > 2 m
- Asset Location



X: 420754 **Y:** 283345

Shape: Circular
Capacity (m^3/s): 5.50 **Length (m):** 4.32
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 100 Year Return Period - 100% Blocked
Area Flooded (m^2): 75,304
Road Length Flooded (m): 80

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

Solihull Metropolitan Borough Council
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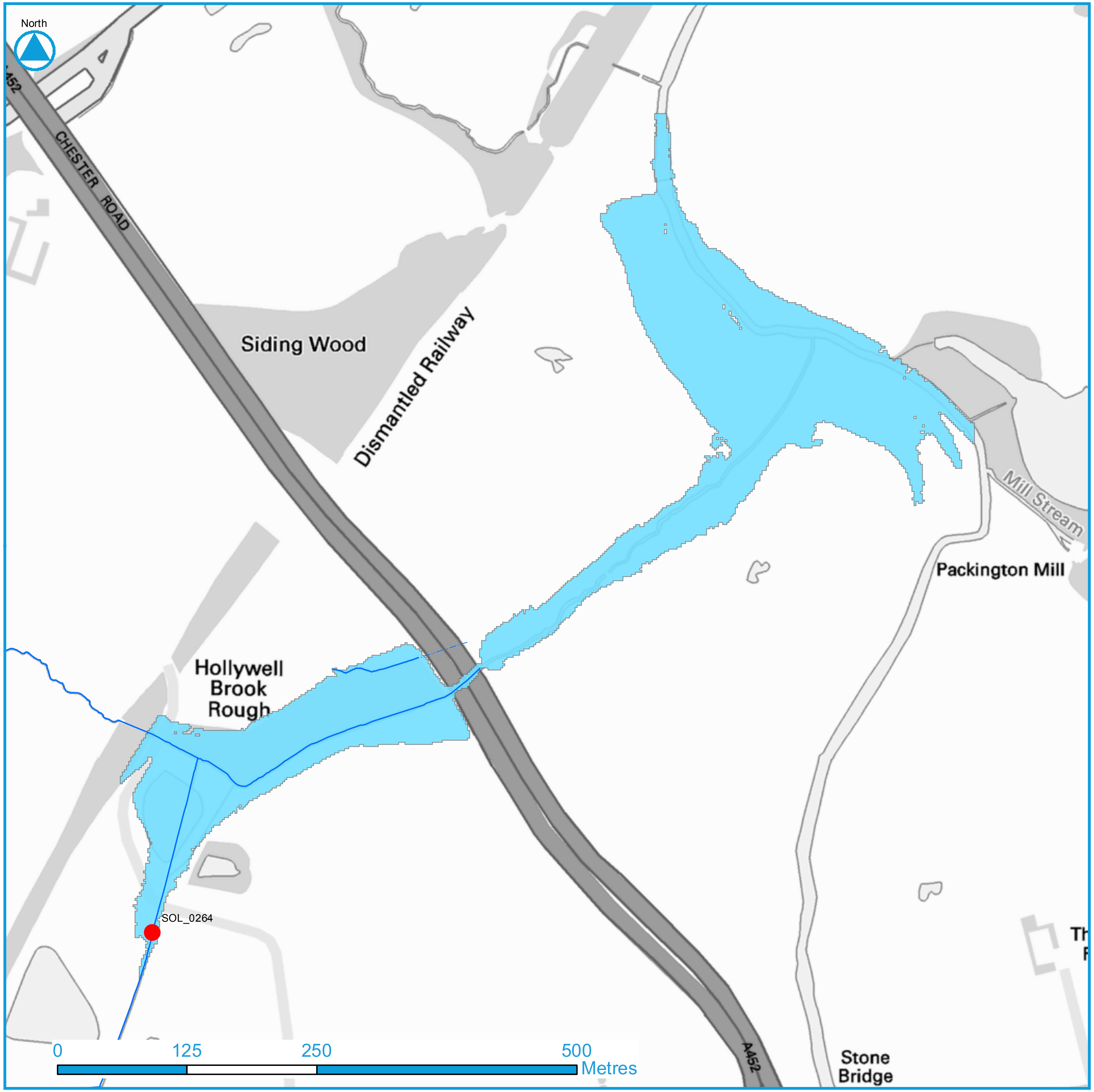

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0264
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

NRD Property Points
Key Infrastructure
Residential
Non Residential
Flood Extent
Asset Location

X: 420754 **Y:** 283345

Shape: Circular
Capacity (m^3/s): 5.50 **Length (m):** 4.32
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 1000 Year Return Period - 100% Blocked
Area Flooded (m^2): 84,092
Road Length Flooded (m): 101

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

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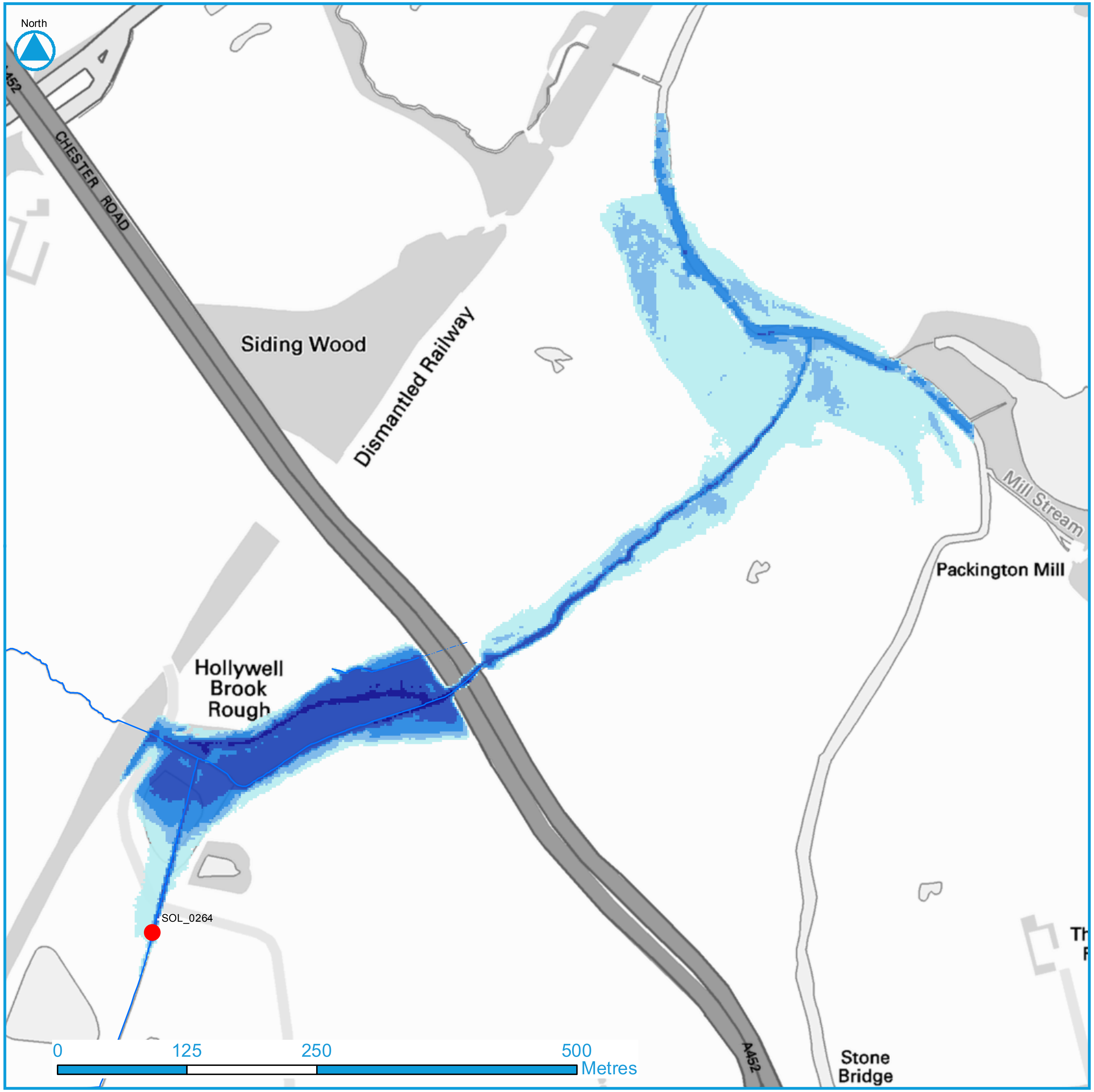

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0264
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

Depth
- 0 - 0.25 m
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- 1 - 2 m
- > 2 m
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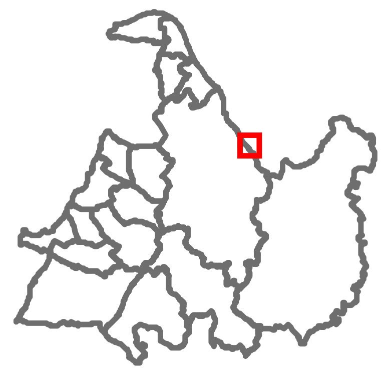

X: 420754 **Y:** 283345

Shape: Circular
Capacity (m^3/s): 5.50 **Length (m):** 4.32
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 1000 Year Return Period - 100% Blocked

Area Flooded (m^2): 84,092

Road Length Flooded (m): 101

Property Count	Total	Ground
Residential	0	0
Non Residential	0	0
Key Infrastructure	0	0
All	0	0

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United Kingdom

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e:info@jbaconsulting.com

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3246693

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ASSET BLOCKAGE SENSITIVITY TESTING
SOLIHULL METROPOLITAN BOROUGH COUNCIL

Asset Reference	SOL_0265
SMBC Structure Code	SMBC/50059
Description	A45 Gantry 4
Carries	Sign Gantry
Over	A45
Ward Location	Bickenhill Ward
National Grid Reference	420662 283104

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Warwickshire
B46 3AD

Revision History

Revision Ref / Date Issued	Amendments	Issued to
Final / October 2016		Edward Bradford

Contract

This report describes work commissioned by Solihull Metropolitan Borough Council, by Commission Order No 485867 dated 30th March 2016. Solihull Council's representative for the contract was Edward Bradford. David Kearney, Nelly Marcy, Anneka Lowis and Jack Dudman carried out this work.

Prepared by .... Jack Dudman BSc MSc

Reviewed by .... Anneka Lowis BSc MSc FRGS

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JFlow+ .... JBA Consulting's in house two dimensional flood software
LIDAR .... Light Detection and Ranging
NGR .... National Grid Reference
NRD .... National Receptor Database

1 Introduction

This report investigates the possible flood risk associated with an asset on A45 in Bickenhill Ward, with asset reference SOL_0265.

1.1 General Asset Information

1.1.1 Asset

Asset Reference	SOL_0265
Inlet National Grid Reference (NGR)	420662 283104

1.1.2 Dimensions

Asset Length (m)	91.48
Assumed Capacity (m^3)	4.53
Height (m)	1.00
Width (m)	1.00
Shape	Circular
Material	Cast Iron
Manning's Roughness Coefficient	0.013
Slope	0.0357
Note: The asset data contained within this report is indicative and should be verified by reviewing detailed asset survey reports.	

2 Methodology

2.1 Hydrology

The peak flows for the 6 Return Periods modelled are summarised in Table 2-2.

Table 2-2 Peak Flows

30 year	100 year	1000 year	100 year + 20% CC	100 year + 30% CC	100 year + 50% CC
2.02	2.55	3.83	3.06	3.32	3.83

2.2 Hydraulic Modelling

2.2.1 General Model Assumptions

- Model constructed using JFlow+
- Digital Terrain Model derived from 2 metre composite LIDAR and IHM (used under licence from the Environment Agency).

2.2.2 100% Blockage Modelling Assumptions

For the purpose of blockage, we have assumed a culvert capacity of zero, thus assuming that no water can be conveyed and that all of the flow will be forced out of bank at the culvert inlet.

2.2.3 Without Blockage Modelling Assumptions

The 'without blockage' modelling scenario required the calculation of the culvert capacity, in order to estimate the volume of water conveyed through the structure. Any flows greater than the capacity of the culvert were represented as out of bank flow at the culvert inlet. The culvert capacity was calculated using the Manning's equation.

2.3 Model Scenarios

The model has been run for 6 return periods: 30, 100, 1000-year with three climate change modifications to the 100-year return period of +20%, +30% and +50%. For each return period a 100% blockage ('with blockage') and 0% blockage ('without blockage') scenario were modelled. Depth, hazard and velocity flow grids were produced for each scenario. See below for modelling results.

2.4 Standard of Protection

Design flood flows at each asset inlet were calculated for a range of return periods. The culvert capacity was then compared with these to provide an estimate of each asset's Standard of Protection (SoP). Standard of protection is equal to the highest return period with a peak flow less than the asset capacity.

The SoP for asset ID SOL_0265 is more than 1000 years.

3 Consequence

The modelled depth grids were converted to outlines and these were queried against the National Receptor Dataset (NRD) to obtain counts of flooded properties and lengths of flooded infrastructure.

3.1 Properties at risk

NRD property points were split into three categories; Residential, Non Residential, and Key Infrastructure. The total number of flooded properties and ground floor properties for all events and scenarios are reported in Table 3-1.

Table 3-1 All events – Number of properties flooded

		Model Event											
		100% Blocked						Without Blockage					
Consequence		Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%
Area Flooded (m^2)		37536	40064	71976	43552	45228	76064	0	0	0	0	0	0
Properties Affected													
All	Total	16	16	16	16	16	16	0	0	0	0	0	0
	Ground	16	16	16	16	16	16	0	0	0	0	0	0
Res	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0
Non - Res	Total	15	15	15	15	15	15	0	0	0	0	0	0
	Ground	15	15	15	15	15	15	0	0	0	0	0	0
Key	Total	1	1	1	1	1	1	0	0	0	0	0	0
	Ground	1	1	1	1	1	1	0	0	0	0	0	0

3.2 Infrastructure at risk

The lengths of flooded roads and railway[1] are shown in Table 3-2. This is a simple assessment and does not take into account the fact that some structures may be elevated out of the flooding.

Table 3-2 All events - Infrastructure at risk (m)

	Model Event											
	100% Blocked						Without Blockage					
Infrastructure (m)	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%
Motorway	0	0	0	0	0	0	0	0	0	0	0	0
A Road	0	0	135	56	88	139	0	0	0	0	0	0
B Road	0	0	0	0	0	0	0	0	0	0	0	0
Unclassified Road	404	448	949	482	495	998	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0

[1] Contains public sector information licensed under the Open Government Licence v3.0.

Appendices

Where the channel capacity of the asset for the relevant blockage scenario is greater than the modelled return period flow all of the flow is conveyed through the structure and no map has been produced.

A 100% Blocked Maps

A.1 Extent – 30 Year Return Period

A.2 Depth – 30 Year Return Period

A.3 Extent – 100 Year Return Period

A.4 Depth – 100 Year Return Period

A.5 Extent – 1000 Year Return Period

A.6 Depth – 1000 Year Return Period

B 0% Blocked Maps

B.1 Extent – 30 Year Return Period

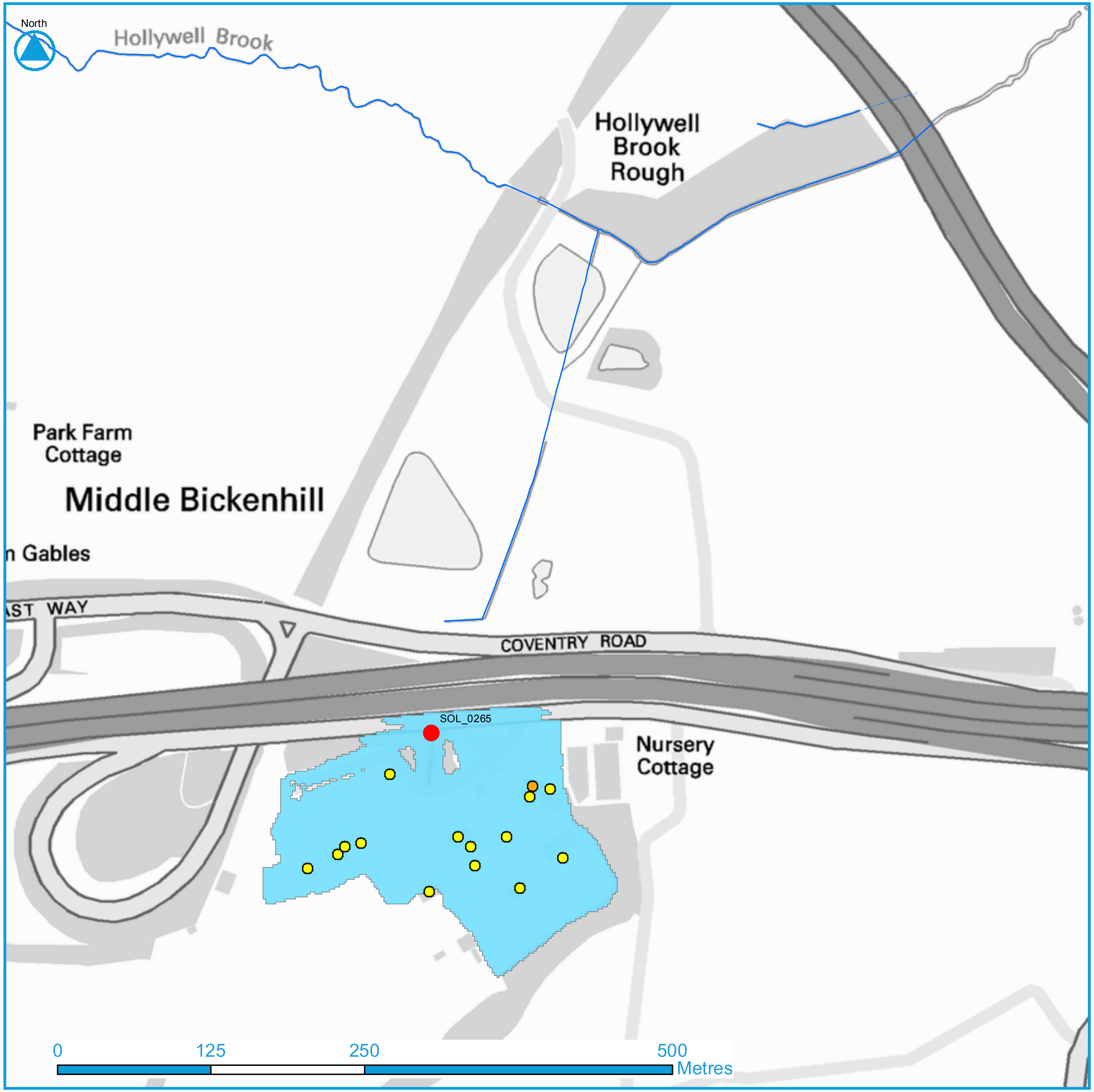
B.2 Depth – 30 Year Return Period

B.3 Extent – 100 Year Return Period

B.4 Depth – 100 Year Return Period

B.5 Extent – 1000 Year Return Period

B.6 Depth – 1000 Year Return Period

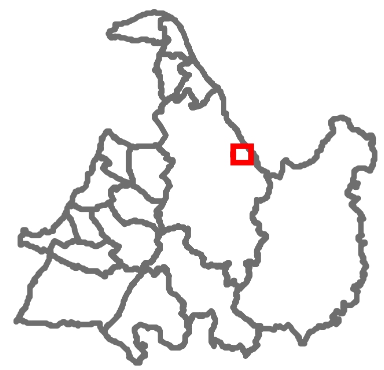


Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0265
SMBC Structure Code: SMBC/50059
Description: A45 Gantry 4
Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

NRD Property Points
- Key Infrastructure
- Residential
- Non Residential
- Flood Extent
- Asset Location



X: 420662 **Y:** 283104

Shape: Circular
Capacity (m^3/s): 4.53 **Length (m):** 91.48
Height (m): 1.00 **Width (m):** 1.00
Material: Cast Iron **Manning's *n*:** 0.013

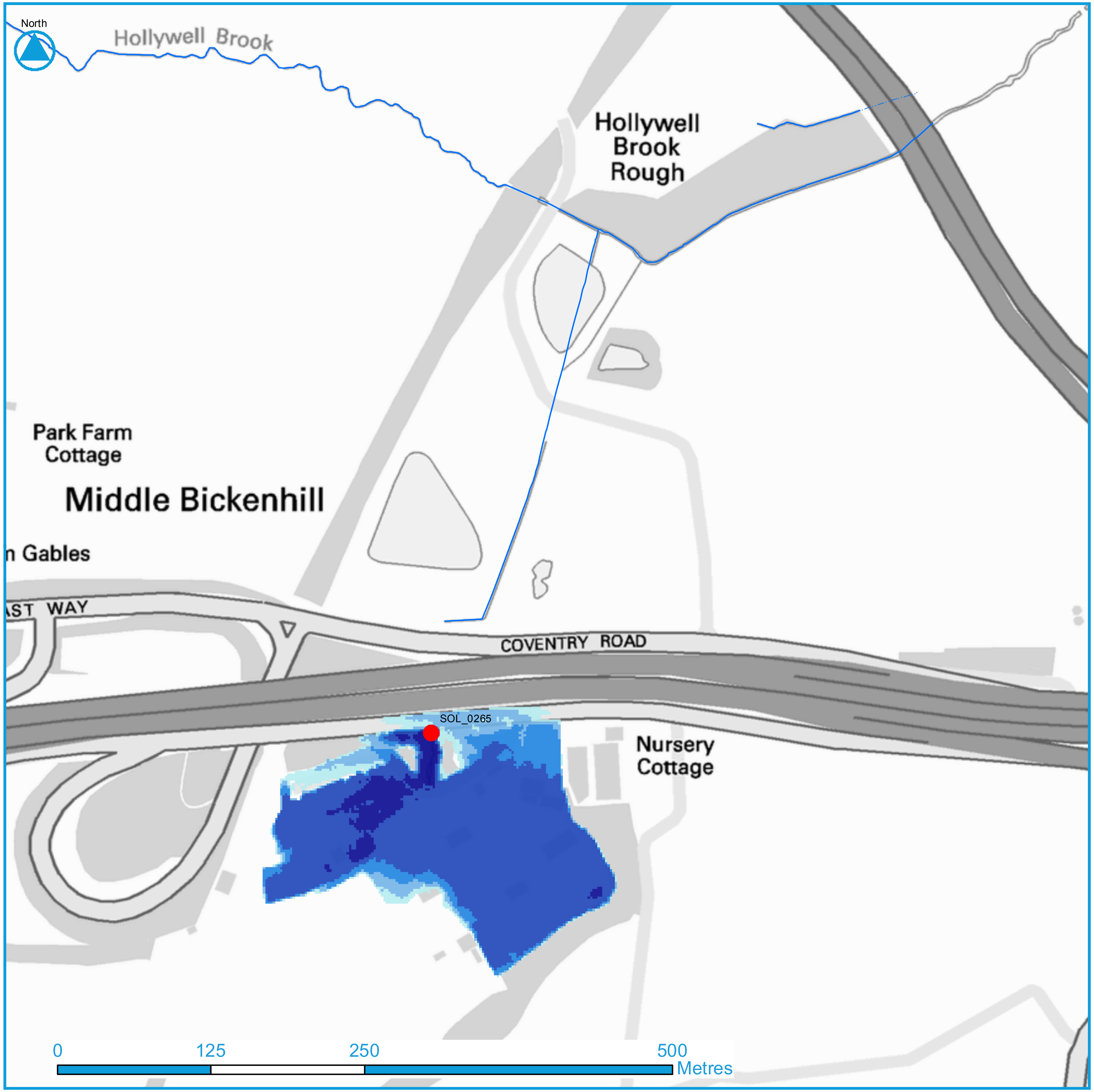
Consequence

Scenario: 30 Year Return Period - 100% Blocked

Area Flooded (m^2): 37,536

Road Length Flooded (m): 404

Property Count	Total	Ground
Residential	0	0
Non Residential	15	15
Key Infrastructure	1	1
All	16	16



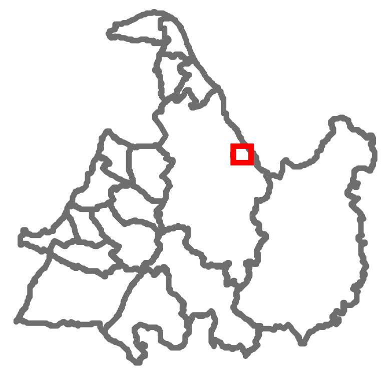
Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0265
SMBC Structure Code: SMBC/50059
Description: A45 Gantry 4
Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

Depth
- 0 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1 m
- 1 - 2 m
- > 2 m

Asset Location



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All	16	16

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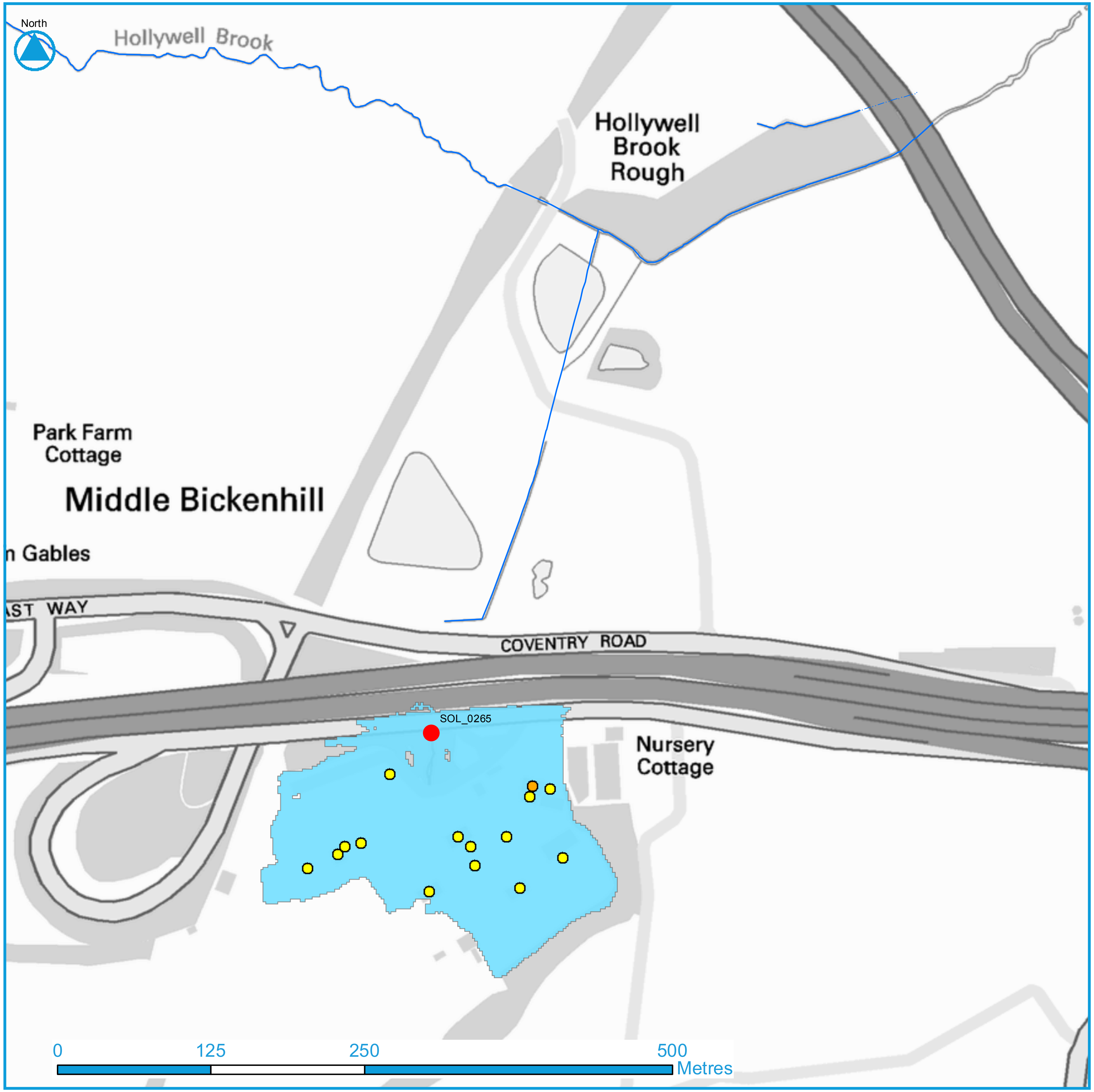

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0265
SMBC Structure Code: SMBC/50059
Description: A45 Gantry 4
Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

NRD Property Points
- Key Infrastructure
- Residential
- Non Residential
- Flood Extent
- Asset Location

X: 420662 **Y:** 283104

Shape: Circular
Capacity (m^3/s): 4.53 **Length (m):** 91.48
Height (m): 1.00 **Width (m):** 1.00
Material: Cast Iron **Manning's *n*:** 0.013

Consequence
Scenario: 100 Year Return Period - 100% Blocked
Area Flooded (m^2): 40,064
Road Length Flooded (m): 448

Property Count	Total	Ground
Residential	0	0
Non Residential	15	15
Key Infrastructure	1	1
All	16	16

Solihull METROPOLITAN BOROUGH COUNCIL URBS IN RURE
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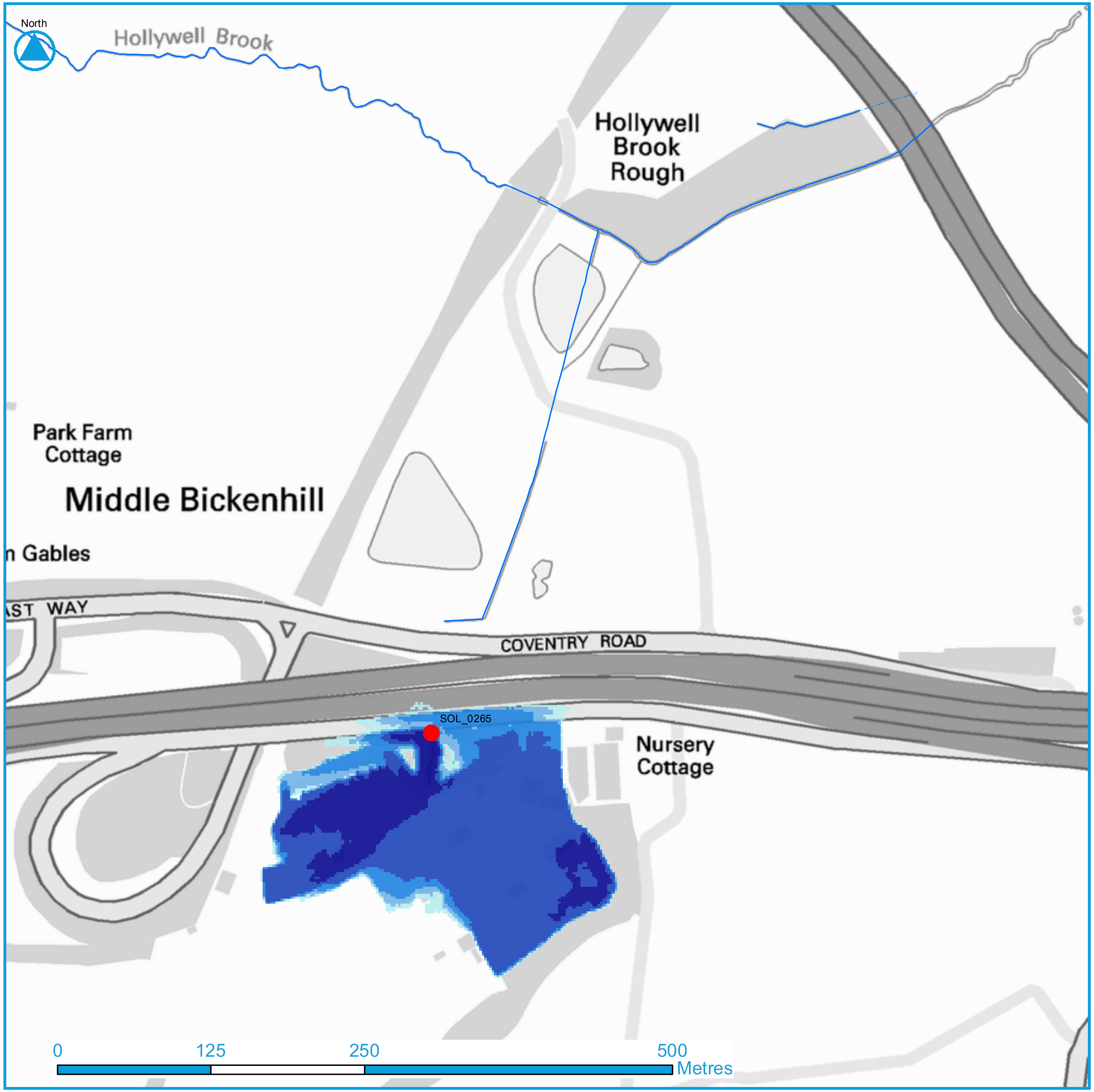
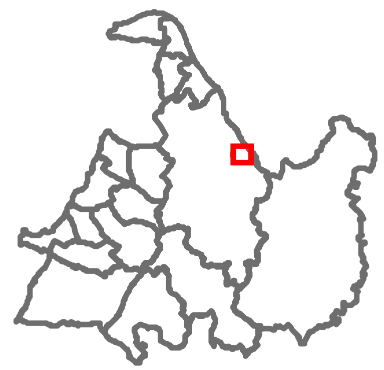


Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0265
SMBC Structure Code: SMBC/50059
Description: A45 Gantry 4
Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

Depth
- 0 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1 m
- 1 - 2 m
- > 2 m
- Asset Location



X: 420662 **Y:** 283104

Shape: Circular
Capacity (m^3/s): 4.53 **Length (m):** 91.48
Height (m): 1.00 **Width (m):** 1.00
Material: Cast Iron **Manning's *n*:** 0.013

Consequence
Scenario: 100 Year Return Period - 100% Blocked
Area Flooded (m^2): 40,064
Road Length Flooded (m): 448

Property Count	Total	Ground
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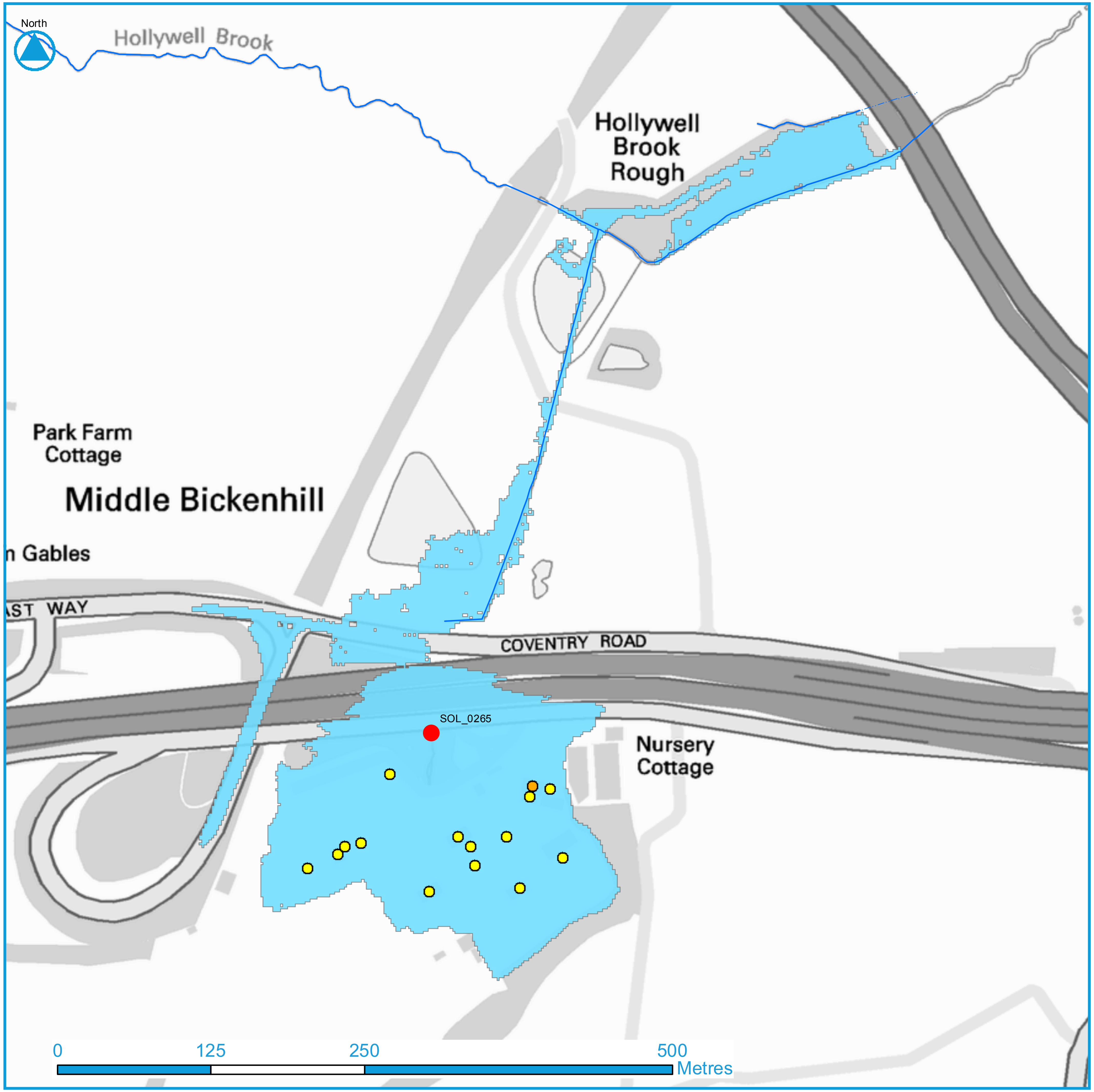

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0265
SMBC Structure Code: SMBC/50059
Description: A45 Gantry 4
Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

NRD Property Points
- Key Infrastructure
- Residential
- Non Residential
- Flood Extent
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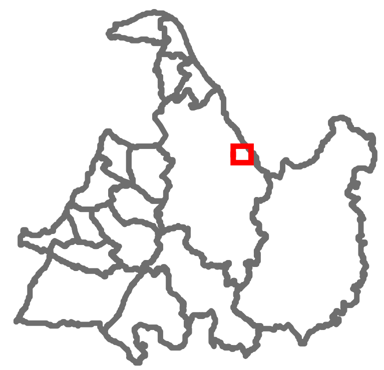


X: 420662 **Y:** 283104

Shape: Circular
Capacity (m^3/s): 4.53 **Length (m):** 91.48
Height (m): 1.00 **Width (m):** 1.00
Material: Cast Iron **Manning's *n*:** 0.013

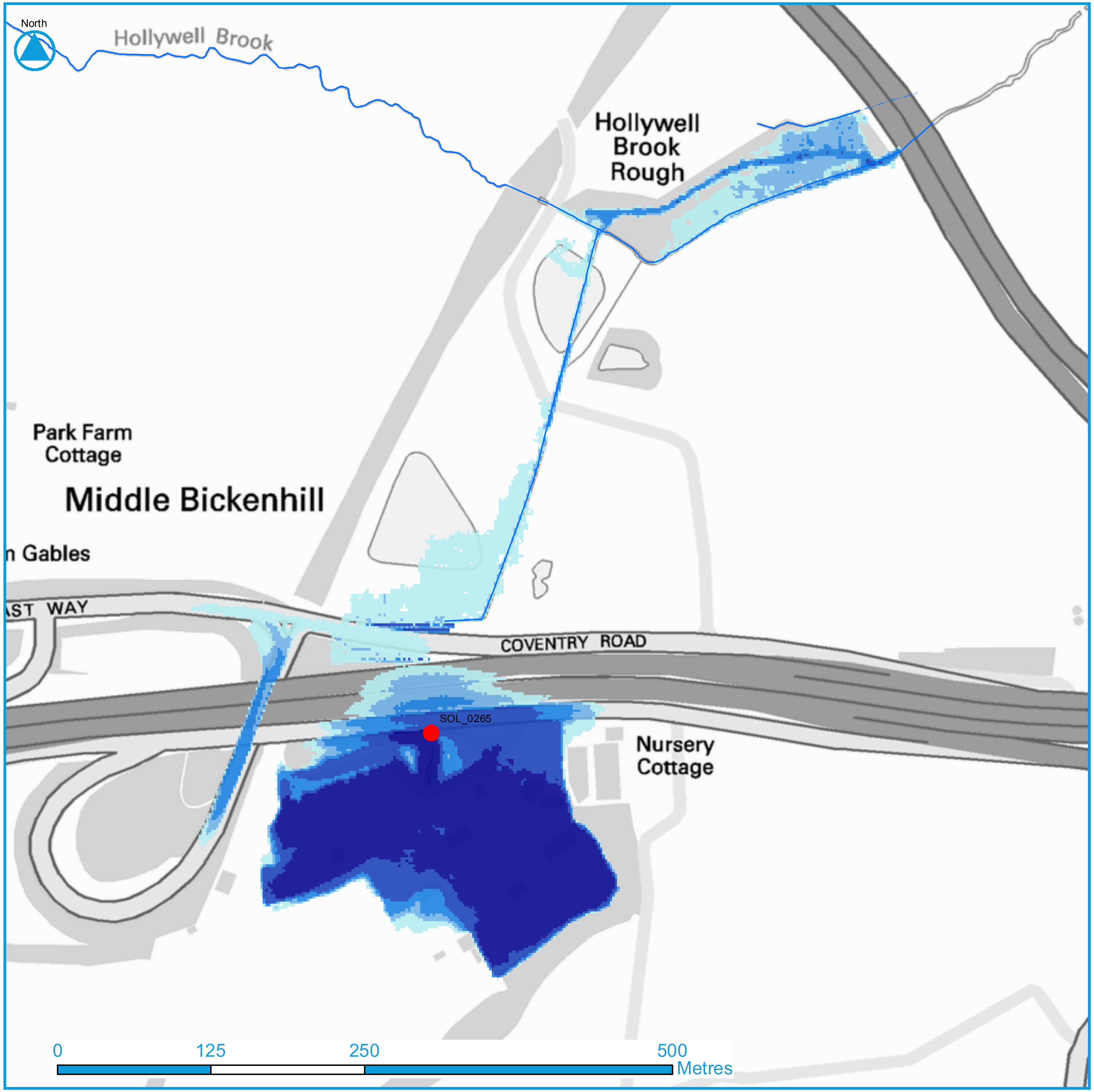
Consequence

Scenario: 1000 Year Return Period - 100% Blocked

Area Flooded (m^2): 71,976

Road Length Flooded (m): 1,083

Property Count	Total	Ground
Residential	0	0
Non Residential	15	15
Key Infrastructure	1	1
All	16	16



Solihull Metropolitan Borough Council

Asset Blockage Sensitivity Testing

Asset Reference: SOL_0265

SMBC Structure Code: SMBC/50059

Description: A45 Gantry 4

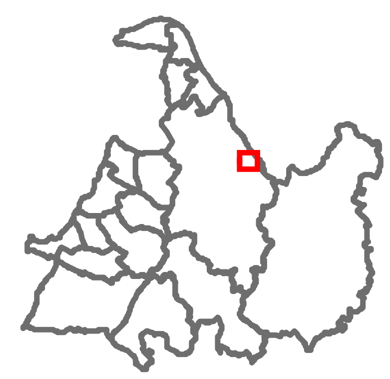
Ward: Bickenhill Ward

Watercourse

- Culvert
- Open Channel

Depth

- 0 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1 m
- 1 - 2 m
- > 2 m
- Asset Location



X: 420662 **Y:** 283104

Shape: Circular

Capacity (m^3/s): 4.53 **Length (m):** 91.48

Height (m): 1.00 **Width (m):** 1.00

Material: Cast Iron **Manning's *n*:** 0.013

Consequence

Scenario: 1000 Year Return Period - 100% Blocked

Area Flooded (m^2): 71,976

Road Length Flooded (m): 1,083

Property Count	Total	Ground
Residential	0	0
Non Residential	15	15
Key Infrastructure	1	1
All	16	16

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ASSET BLOCKAGE SENSITIVITY TESTING
SOLIHULL METROPOLITAN BOROUGH COUNCIL

Asset Reference	SOL_0399
SMBC Structure Code	-
Description	-
Carries	Railway and NEC
Over	Stream to Pendigo Lake
Ward Location	Bickenhill Ward
National Grid Reference	419028 283321

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Highway Services
The Council House
Manor Square
Solihull
B91 3QB

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B46 3AD

Revision History

Revision Ref / Date Issued	Amendments	Issued to
Final / October 2016		Edward Bradford

Contract

This report describes work commissioned by Solihull Metropolitan Borough Council, by Commission Order No 485867 dated 30th March 2016. Solihull Council's representative for the contract was Edward Bradford. David Kearney, Nelly Marcy, Anneka Lowis and Jack Dudman carried out this work.

Prepared by .... Jack Dudman BSc MSc

Reviewed by .... Anneka Lowis BSc MSc FRGS

Purpose

This document has been prepared as a Summary Report for the investigation of flood risk (calculation of a 100% blockage and a 'without blockage' scenario) for 504 culvert locations as agreed with Solihull Metropolitan Borough Council. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

JBA Consulting has no liability regarding the use of this report except to Solihull Metropolitan Borough Council.

Acknowledgements

JBA would like to acknowledge the support of Edward Bradford of Solihull Metropolitan Borough Council.

Copyright

Contents

List of Tables

Abbreviations

DTM .... Digital Terrain Model
JFlow+ .... JBA Consulting's in house two dimensional flood software
LIDAR .... Light Detection and Ranging
NGR .... National Grid Reference
NRD .... National Receptor Database

1 Introduction

This report investigates the possible flood risk associated with an asset on Stream to Pendigo Lake in Bickenhill Ward, with asset reference SOL_0399.

1.1 General Asset Information

1.1.1 Asset

Asset Reference	SOL_0399
Inlet National Grid Reference (NGR)	419028 283321

1.1.2 Dimensions

Asset Length (m)	222.85
Assumed Capacity (m^3)	2.01
Height (m)	1.00
Width (m)	1.00
Shape	Circular
Material	Concrete
Manning's Roughness Coefficient	0.011
Slope	0.0050
Note: The asset data contained within this report is indicative and should be verified by reviewing detailed asset survey reports.	

2 Methodology

2.1 Hydrology

The peak flows for the 6 Return Periods modelled are summarised in Table 2-2.

Table 2-2 Peak Flows

30 year	100 year	1000 year	100 year + 20% CC	100 year + 30% CC	100 year + 50% CC
0.57	0.76	1.30	0.91	0.99	1.14

2.2 Hydraulic Modelling

2.2.1 General Model Assumptions

- Model constructed using JFlow+
- Digital Terrain Model derived from 2 metre composite LIDAR and IHM (used under licence from the Environment Agency).

2.2.2 100% Blockage Modelling Assumptions

For the purpose of blockage, we have assumed a culvert capacity of zero, thus assuming that no water can be conveyed and that all of the flow will be forced out of bank at the culvert inlet.

2.2.3 Without Blockage Modelling Assumptions

The 'without blockage' modelling scenario required the calculation of the culvert capacity, in order to estimate the volume of water conveyed through the structure. Any flows greater than the capacity of the culvert were represented as out of bank flow at the culvert inlet. The culvert capacity was calculated using the Manning's equation.

2.3 Model Scenarios

The model has been run for 6 return periods: 30, 100, 1000-year with three climate change modifications to the 100-year return period of +20%, +30% and +50%. For each return period a 100% blockage ('with blockage') and 0% blockage ('without blockage') scenario were modelled. Depth, hazard and velocity flow grids were produced for each scenario. See below for modelling results.

2.4 Standard of Protection

Design flood flows at each asset inlet were calculated for a range of return periods. The culvert capacity was then compared with these to provide an estimate of each asset's Standard of Protection (SoP). Standard of protection is equal to the highest return period with a peak flow less than the asset capacity.

The SoP for asset ID SOL_0399 is more than 1000 years.

3 Consequence

The modelled depth grids were converted to outlines and these were queried against the National Receptor Dataset (NRD) to obtain counts of flooded properties and lengths of flooded infrastructure.

3.1 Properties at risk

NRD property points were split into three categories; Residential, Non Residential, and Key Infrastructure. The total number of flooded properties and ground floor properties for all events and scenarios are reported in Table 3-1.

Table 3-1 All events – Number of properties flooded

		Model Event											
		100% Blocked						Without Blockage					
Consequence		Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%
Area Flooded (m^2)		12236	13604	17312	14588	14996	16056	0	0	0	0	0	0
Properties Affected													
All	Total	7	7	7	7	7	7	0	0	0	0	0	0
	Ground	7	7	7	7	7	7	0	0	0	0	0	0
Res	Total	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0
Non - Res	Total	5	5	5	5	5	5	0	0	0	0	0	0
	Ground	5	5	5	5	5	5	0	0	0	0	0	0
Key	Total	2	2	2	2	2	2	0	0	0	0	0	0
	Ground	2	2	2	2	2	2	0	0	0	0	0	0

3.2 Infrastructure at risk

The lengths of flooded roads and railway[1] are shown in Table 3-2. This is a simple assessment and does not take into account the fact that some structures may be elevated out of the flooding.

Table 3-2 All events - Infrastructure at risk (m)

	Model Event											
	100% Blocked						Without Blockage					
Infrastructure (m)	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%	Q30	Q100	Q1000	Q100 +20%	Q100 +30%	Q100 +50%
Motorway	0	0	0	0	0	0	0	0	0	0	0	0
A Road	0	0	0	0	0	0	0	0	0	0	0	0
B Road	0	0	0	0	0	0	0	0	0	0	0	0
Unclassified Road	61	115	237	146	160	199	0	0	0	0	0	0
Rail	0	0	0	0	0	0	0	0	0	0	0	0

[1] Contains public sector information licensed under the Open Government Licence v3.0.

Appendices

Where the channel capacity of the asset for the relevant blockage scenario is greater than the modelled return period flow all of the flow is conveyed through the structure and no map has been produced.

A 100% Blocked Maps

A.1 Extent – 30 Year Return Period

A.2 Depth – 30 Year Return Period

A.3 Extent – 100 Year Return Period

A.4 Depth – 100 Year Return Period

A.5 Extent – 1000 Year Return Period

A.6 Depth – 1000 Year Return Period

B 0% Blocked Maps

B.1 Extent – 30 Year Return Period

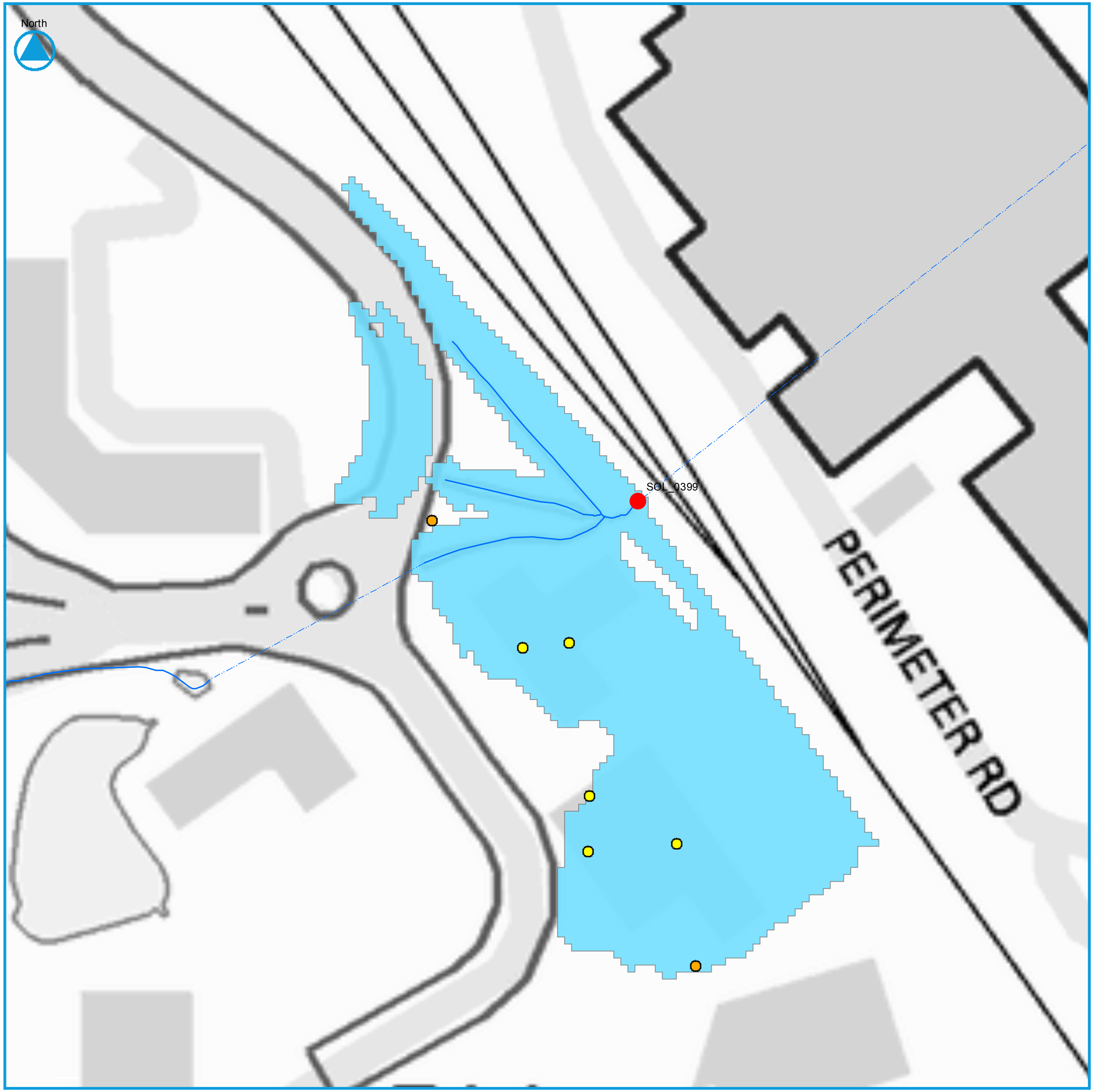
B.2 Depth – 30 Year Return Period

B.3 Extent – 100 Year Return Period

B.4 Depth – 100 Year Return Period

B.5 Extent – 1000 Year Return Period

B.6 Depth – 1000 Year Return Period

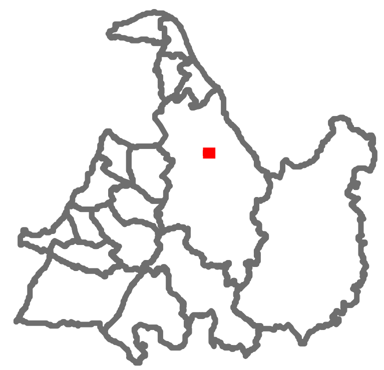


Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0399
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

NRD Property Points
Key Infrastructure
Residential
Non Residential
Flood Extent
Asset Location



X: 419028 **Y:** 283321

Shape: Circular
Capacity (m^3/s): 2.01 **Length (m):** 222.85
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 30 Year Return Period - 100% Blocked
Area Flooded (m^2): 12,236
Road Length Flooded (m): 61

Property Count	Total	Ground
Residential	0	0
Non Residential	5	5
Key Infrastructure	2	2
All	7	7

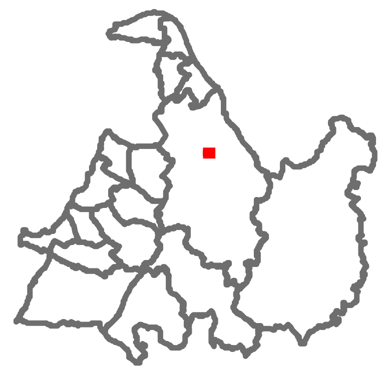
Solihull METROPOLITAN BOROUGH COUNCIL URBS IN RURE
JBA consulting

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0399
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

Depth
- 0 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1 m
- 1 - 2 m
- > 2 m
- Asset Location



X: 419028 **Y:** 283321

Shape: Circular
Capacity (m^3/s): 2.01 **Length (m):** 222.85
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 30 Year Return Period - 100% Blocked

Area Flooded (m^2): 12,236

Road Length Flooded (m): 61

Property Count	Total	Ground
Residential	0	0
Non Residential	5	5
Key Infrastructure	2	2
All	7	7

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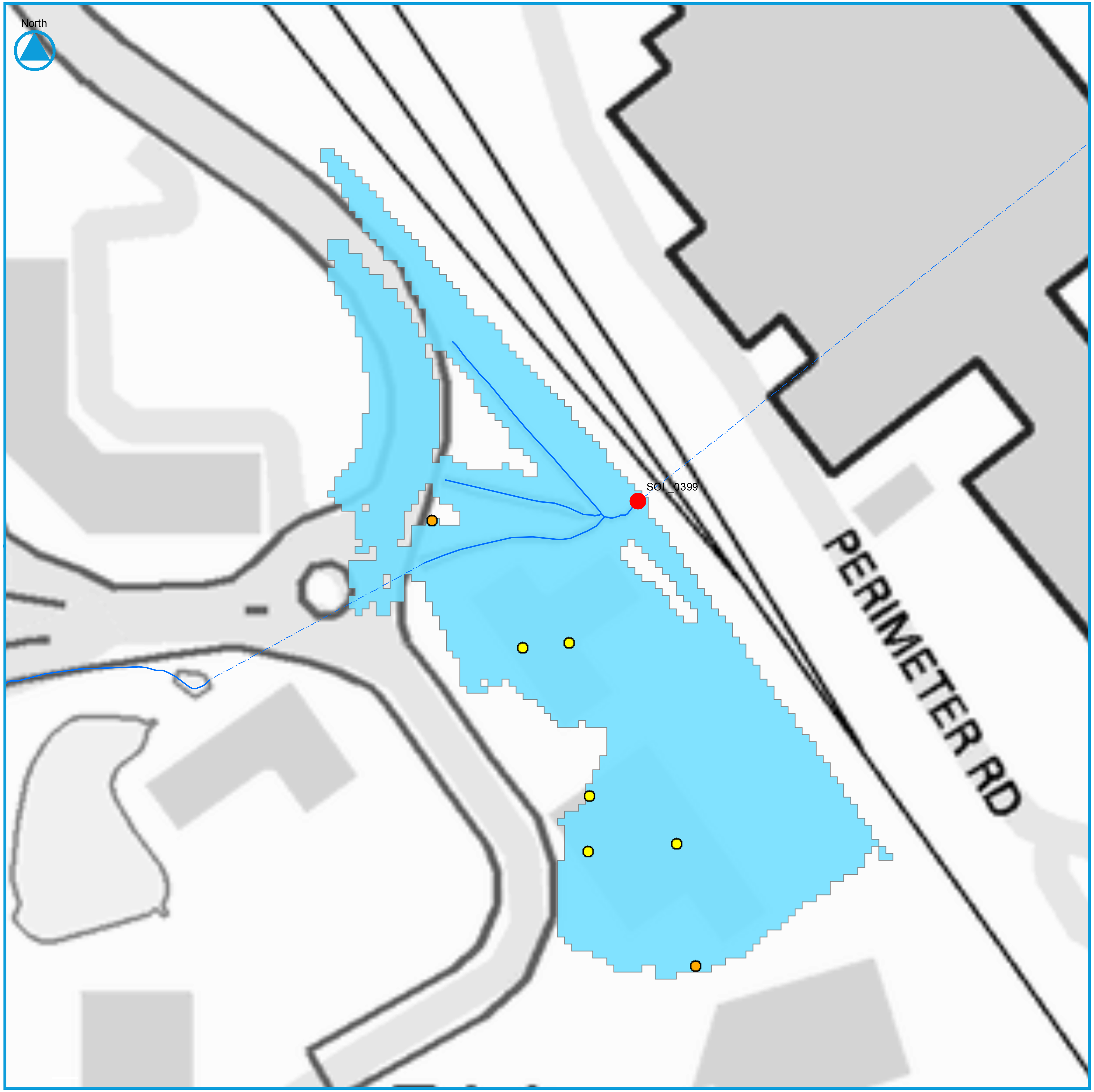

Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0399
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Ward: Bickenhill Ward

Watercourse
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- Open Channel

NRD Property Points
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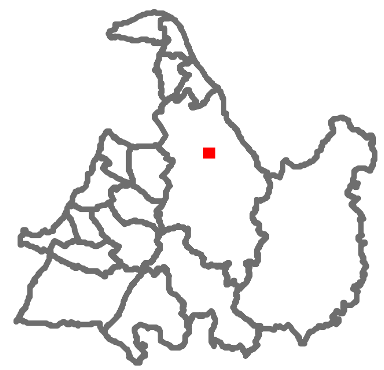
- Residential
- Non Residential
- Flood Extent
- Asset Location



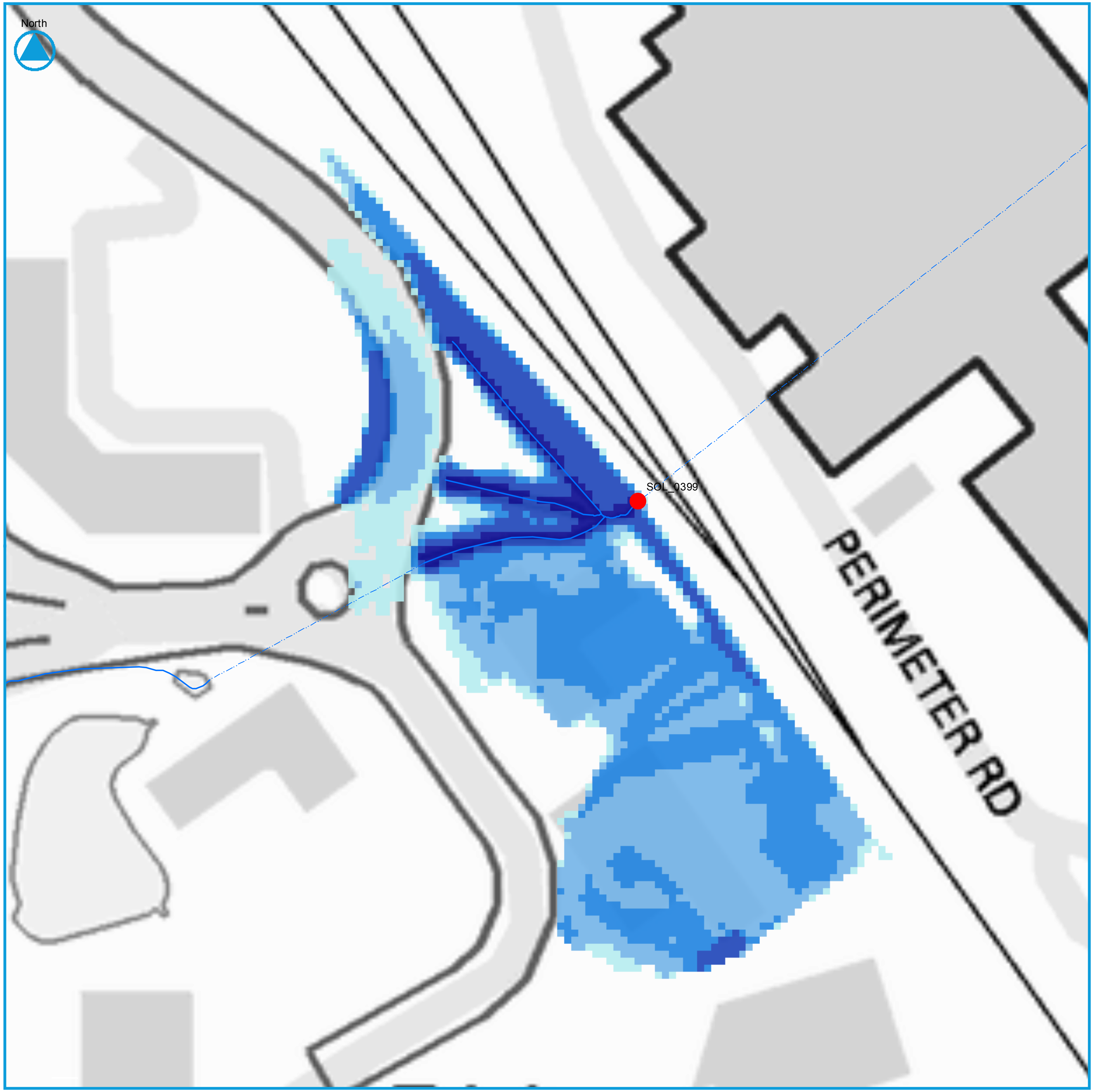
X: 419028 **Y:** 283321

Shape: Circular
Capacity (m^3/s): 2.01 **Length (m):** 222.85
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 100 Year Return Period - 100% Blocked
Area Flooded (m^2): 13,604
Road Length Flooded (m): 115

Property Count	Total	Ground
Residential	0	0
Non Residential	5	5
Key Infrastructure	2	2
All	7	7

Solihull METROPOLITAN BOROUGH COUNCIL
JBA consulting

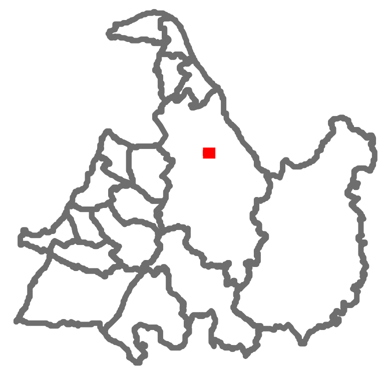


Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0399
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

Depth
0 - 0.25 m
0.25 - 0.5 m
0.5 - 1 m
1 - 2 m
> 2 m
Asset Location

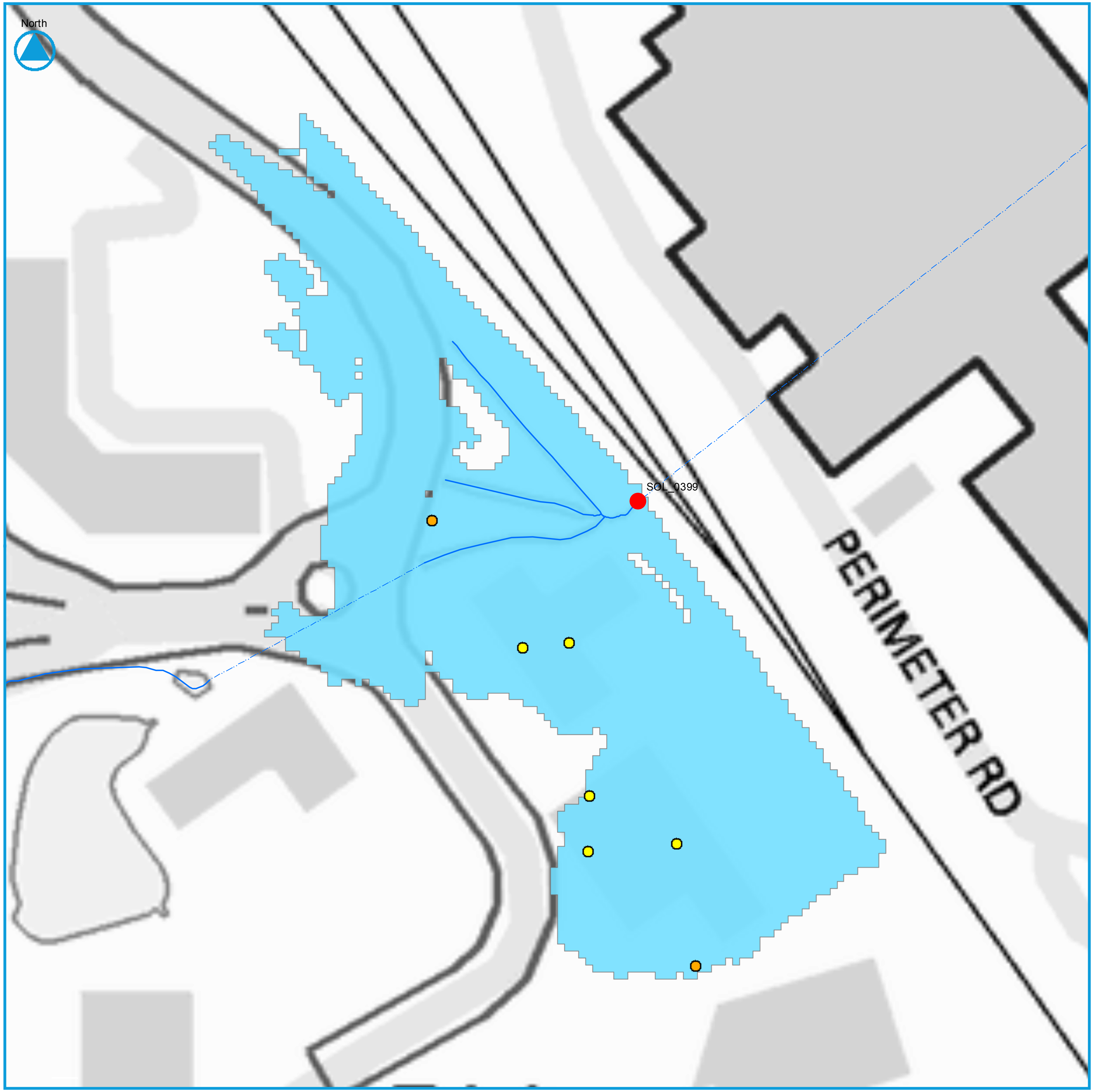


X: 419028 **Y:** 283321

Shape: Circular
Capacity (m^3/s): 2.01 **Length (m):** 222.85
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 100 Year Return Period - 100% Blocked
Area Flooded (m^2): 13,604
Road Length Flooded (m): 115

Property Count	Total	Ground
Residential	0	0
Non Residential	5	5
Key Infrastructure	2	2
All	7	7

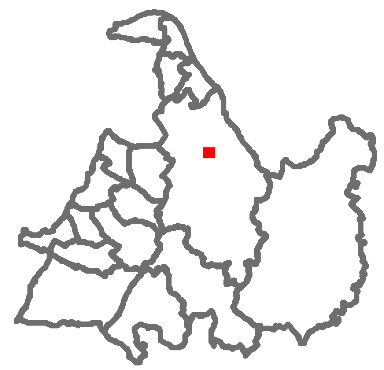


Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0399
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
Culvert
Open Channel

NRD Property Points
Key Infrastructure
Residential
Non Residential
Flood Extent
Asset Location



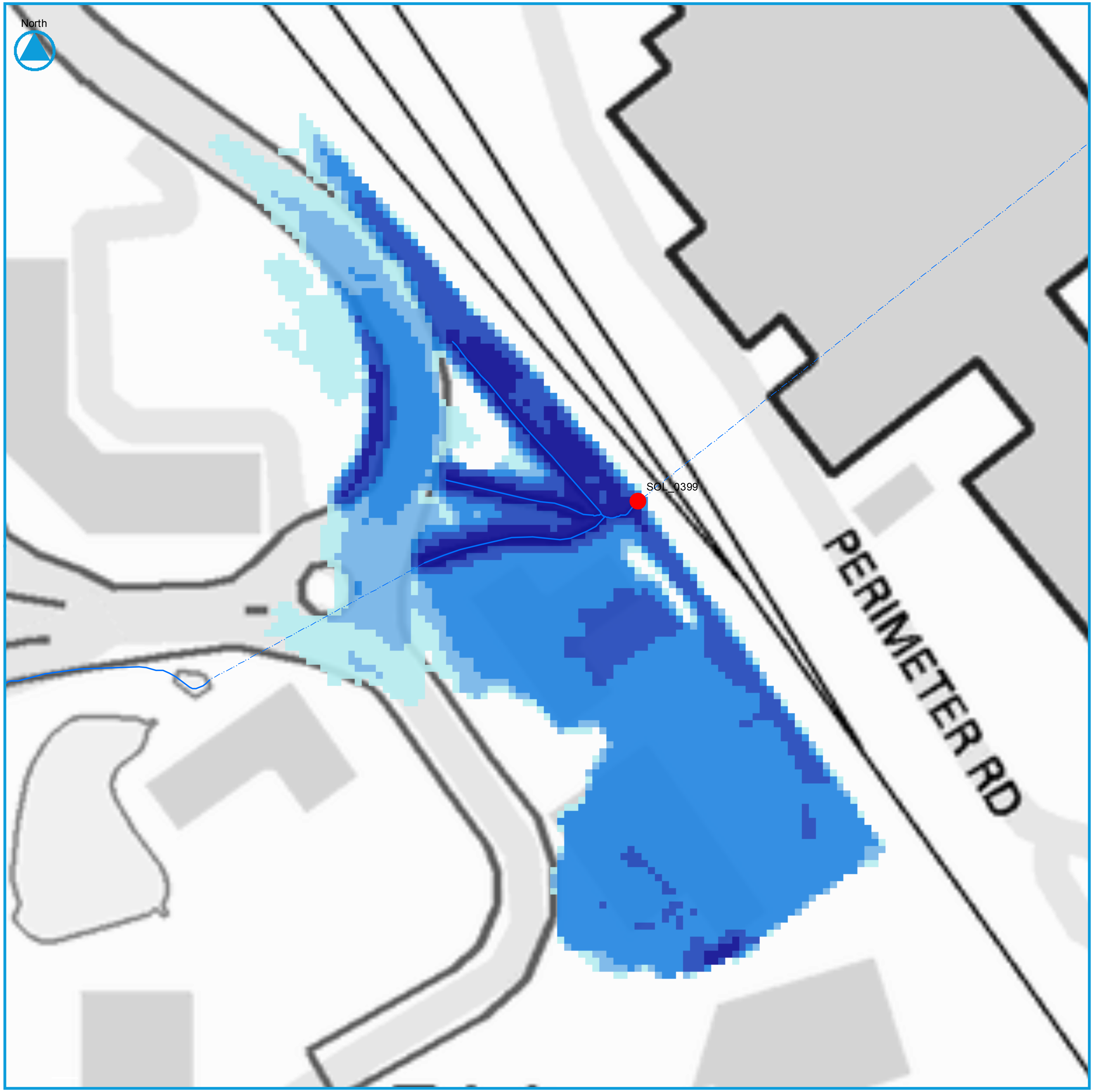
X: 419028 **Y:** 283321

Shape: Circular
Capacity (m^3/s): 2.01 **Length (m):** 222.85
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence
Scenario: 1000 Year Return Period - 100% Blocked
Area Flooded (m^2): 17,312
Road Length Flooded (m): 237

Property Count	Total	Ground
Residential	0	0
Non Residential	5	5
Key Infrastructure	2	2
All	7	7

Solihull Metropolitan Borough Council
JBA consulting

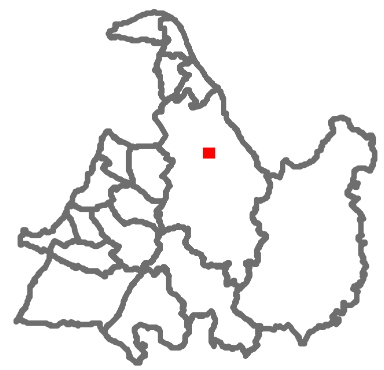


Solihull Metropolitan Borough Council
Asset Blockage Sensitivity Testing

Asset Reference: SOL_0399
SMBC Structure Code: -
Description: -
Ward: Bickenhill Ward

Watercourse
- Culvert
- Open Channel

Depth
- 0 - 0.25 m
- 0.25 - 0.5 m
- 0.5 - 1 m
- 1 - 2 m
- > 2 m
- Asset Location



X: 419028 **Y:** 283321

Shape: Circular
Capacity (m^3/s): 2.01 **Length (m):** 222.85
Height (m): 1.00 **Width (m):** 1.00
Material: Concrete **Manning's *n*:** 0.011

Consequence

Scenario: 1000 Year Return Period - 100% Blocked

Area Flooded (m^2): 17,312

Road Length Flooded (m): 237

Property Count	Total	Ground
Residential	0	0
Non Residential	5	5
Key Infrastructure	2	2
All	7	7

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Broughton Hall
SKIPTON
North Yorkshire
BD23 3AE
United Kingdom

t:+44(0)1756 799919
e:info@jbaconsulting.com

Jeremy Benn Associates Ltd
Registered in England
3246693

Visit our website
www.jbaconsulting.com

Appendix F: Culvert sizing

Hydrology Technical Note

To		From	
		Prepared by	Lucy Rushmer
		Updated by	
Copies to		Date	12th April 2018
Job No	60543032		
Subject	M62 Junction 42 Improvements Hydrological Assessment – Culvert sizing		

1. BACKGROUND

Improvements are being made to Junction 6 of the M42 motorway near Solihull in Birmingham. A new southern junction has been proposed as part of the scheme, which requires three existing culverts to be extended to accommodate the junction improvement works. The three watercourses that will be impacted by the proposed scheme improvements are as follows:

1. Hollywell Brook flowing under the M42;
2. Unnamed Drain under the west branch of the A45;
3. Unnamed Drain under Bickenhill Lane.

In order to provide the structural design team with an estimation of peak flows which are necessary for sizing the culverts, a high level hydrological analysis has been undertaken at these three locations. Based on the results of this analysis, standard methods have been used to derive possible culvert size requirements. There is insufficient information however at present to undertake formal design calculations for sizing culverts.

2. HYDROLOGICAL ANALYSIS

The fluvial catchments upstream of the existing culverts for the three locations were selected using the FEH Web Service. Table 1 summarises the locations and catchment areas; the catchment boundaries are also shown in

Figure 1.

Table 1 Details of the watercourses intersecting the proposed route

Location	Watercourse	Area of upstream catchment (km^2)	Grid reference (Easting, Northing)	
Holywell Brook	Holywell Brook catchment area upstream of the M42	4.25	419850	283650
Unnamed drain under A45	Unnamed drain flowing under west branch of A45, flowing north towards Pendigo Lake	0.49	419450	283500
Unnamed drain under Bickenhill Lane	Unnamed drain flowing under Bickenhill Lane	0.17	418785	283227

Figure 1 Map showing catchments of the locations where watercourses intersect with the proposed route

In order to estimate peak flows, the FEH statistical and ReFH2 methods were applied for each catchment. Design event peak flows were calculated for the following events, and a summary of the procedures used is described further below:

- 1 in 2 year (50% Annual Exceedance probability (AEP));
- 1 in 5 year (20% AEP);
- 1 in 10 year (10% AEP);
- 1 in 20 year (5% AEP);
- 1 in 25 year (4% AEP);
- 1 in 30 year (3.3% AEP);
- 1 in 50 year (2% AEP);
- 1 in 75 year (1.3% AEP);
- 1 in 100 year (1% AEP);
- 1 in 200 year (0.5% AEP); and
- 1 in 1,000 year (0.1% AEP) events.

As part of the scheme design, it is likely that allowances for climate change will be a requirement of the statutory bodies. This will ultimately need to be applied for the design standard of the scheme. The allowance will be determined in consultation with the relevant statutory bodies, and may be linked to freeboard provision at the crossing structures. Furthermore, a range of climate change allowances may need to be tested for multiple design events, to demonstrate the potential impact of climate change across different timescales and climate projections.

In order to provide an idea of potential impacts of climate change allowances on the culvert sizing sensitivity testing has been undertaken. These and other effects are considered later in Section 4.

2.1 FEH statistical method

The FEH statistical method calculates peak flows as a product of a QMED estimate and a flood growth curve. Wherever possible, local data should be used to improve the QMED estimate and this is discussed further in the following sections.

2.2 QMED

None of the study watercourses are gauged, and suitable donor sites could not be identified. The nearby gauging stations had catchment areas that were too large relative to the subject sites. As such, QMED has been estimated from catchment descriptors for each site.

2.3 Pooling Group and Growth Curve

For all three sites, the catchment descriptors were considered similar enough that the same pooling group could be used for each. The pooling group was based on the largest catchment – Holywell Brook. WINFAP-FEH (version 4) was used to create an initial pooling group for this site. Six sites were removed from the initial pooling group; three because they were discordant; one due to short record length, and two because their SAAR was considered too high relative to the subject site. A further four suitable sites were subsequently added to maintain the required record length of >500 years.

Data from the pooling group was used to generate a growth curve and associated flood frequency curves, using the Generalised Logistic distribution to generate peak flows for the required return period design events.

2.4 Flood Frequency Curve / Fittings

To calculate the flood frequency curves / fittings (or peak flow estimates) for the sites, the QMED values for the three sites were multiplied by their associated growth curves (refer to Table 2).

2.5 ReFH2 Method

ReFH2 rainfall-runoff boundaries were generated for each site, based on parameters calculated from catchment descriptors. The critical storm durations were identified and set (based on the standard FEH approximation formula). For each site, the ReFH2 boundaries were used to calculate peak flows for the same return periods as for the FEH statistical method, (refer to Table 2).

Table 2 Estimated peak flows at each site

Return Period (years)	Holywell Brook		Unnamed drain under A45		Unnamed drain under Bickenhall Lane	
	FEH Statistical	ReFH2	FEH Statistical	ReFH2	FEH Statistical	ReFH2
2	0.66	1.07	0.22	0.29	0.09	0.13
5	0.93	1.41	0.32	0.39	0.13	0.17
10	1.14	1.67	0.39	0.47	0.15	0.21
20	1.37	1.97	0.47	0.56	0.19	0.25
25	1.45	2.07	0.49	0.60	0.20	0.26
30	1.52	2.17	0.52	0.62	0.21	0.28
50	1.73	2.46	0.59	0.71	0.23	0.32
75	1.91	2.73	0.65	0.79	0.26	0.35
100	2.05	2.94	0.70	0.85	0.28	0.38
200	2.43	3.51	0.83	1.02	0.33	0.46
1000	3.59	5.04	1.22	1.49	0.48	0.67

3. CULVERT SIZE ANALYSIS

A calculation and a check (using a different method) were used to make a rough assessment of the culvert size required for the 1 in 100 year design event. The higher ReFH2 values have been used throughout this assessment as opposed to the FEH statistical outputs. Their application is described below.

3.1 Method 1- Manning's equation (pipe flow)

Approach

The calculation spreadsheet requires the user to specify slope (which was estimated from a LiDAR CAD drawing), roughness (Colebrook-White) and pipe diameter to calculate full bore discharge.

The culvert lengths and slopes for each watercourse were determined to be as follows:

Table 3 Estimated culvert gradients and lengths

Name	Approximate watercourse slope (from LiDAR CAD drawing)	Length (m)
Holywell Brook	0.014	62.6 (historic drawing)
Unnamed drain under A45	0.010	65
Unnamed Drain under Bickenhill Lane	0.022	62

Due to the lack of detailed information, peak flow estimates using the ReFH2 method were targeted, and a 'trial and error' approach was used to determine suitable diameters which could convey those target flows (see Table 4 below).

Table 4 Estimated required pipe diameters from spreadsheet trial and error

Site		Required diameter for a circular conduit / pipe (concrete) - full bore	ReFH2 (target) m^3/s	Calculated capacity m^3/s
Network 11	Holywell Brook	1260	4.38	4.6
Network 6	Unnamed drain under A45	680	0.71	0.8
Network 13	Unnamed Drain under Bickenhill Lane	480	0.38	0.4

Assumptions and limitations

- The slope was based on estimates from contoured LiDAR data and may therefore be inaccurate. In addition, it is not always the case that a designed culvert under a proposed road will be set to the same slope as the existing watercourse;
- The calculation has assumed a concrete finish to the pipe;
- The calculation has been based on full bore flow. It may be that there is a requirement to provide some freeboard within the pipe; therefore, the calculated diameter would need to be increased to suit; and
- The spreadsheet does not account for any inlet losses or backwater effects from downstream, or take into account velocity head and subsequent impact on required culvert size and losses.

3.2 Method 2 – Manning's equation (box culvert)

Approach

Box culvert dimensions have been calculated using the Manning's equation (as per standard hydraulic theory). Not enough information was available to determine the dimensions of the existing culverts apart from that at Holywell Brook.

A 'goal seek' function was then applied in which the box culvert span and rise were determined in order to achieve the required peak flow. The ReFH2 based peak flow was only used in application of this method, since this hydrological assessment approach gave the highest flows. The calculated sizes are given below in Table 5.

Table 5 Required spans and heights for a box culvert using Manning's calculation

Site		Required dimensions for a box conduit (concrete) - full bore			
		Span (assumed)	Rise (min)	ReFH2 (target) m^3/s	Calculated capacity - m^3/s
Network 11	Holywell Brook	1000mm	1300mm	4.38	4.4
Network 6	Unnamed drain under A45	1000mm	400mm	0.71	0.7
Network 13	Unnamed Drain under Bickenhill Lane	500mm	400mm	0.38	0.4

Assumptions and limitations

- The slope was based on estimates from contoured LiDAR data and may therefore be inaccurate. In addition, it is not always the case that a designed culvert under a proposed road will be set to the same slope as the existing watercourse;
- The calculation has assumed a concrete finish to the pipe (Manning's 'n' roughness of 0.015);
- The calculation has been based on full bore flow. It may be that there is a requirement to provide some freeboard within the pipe; therefore, the calculated diameter would need to be increased to suit; and
- The calculation does not account for any inlet losses or backwater effects from downstream.

3.3 Method 3 – small orifice equation

Approach

The pipe size has been calculated using the small orifice equation (as per standard hydraulic theory). For this process, a 'goal seek' function was applied in which the pipe diameter was determined in order to achieve the required peak flow. The ReFH2 based peak flow was only used in application of this method, since this hydrological assessment approach gave the highest flows. The calculated diameters are given below in Table 6.

Table 6 Required diameters using the small orifice calculation

Site		Required diameter for a circular conduit / pipe (concrete) – full bore	ReFH2 (target) m^3/s	Calculated m^3/s
Network 11	Holywell Brook	2470mm	4.38	4.4
Network 6	Unnamed drain under A45	1130mm	0.71	0.8
Network 13	Unnamed Drain under Bickenhill Lane	710m	0.38	0.4

Assumptions and limitations

- The slope was based on estimates from contoured LiDAR data and may therefore be inaccurate. In addition, it is not always the case that a designed culvert under a proposed road will be set to the same slope as the existing watercourse;
- The calculation has assumed a concrete finish to the pipe (Manning's 'n' roughness of 0.015);
- The calculation has been based on full bore flow. It may be that there is a requirement to provide some freeboard within the pipe; therefore, the calculated diameter would need to be increased to suit; and
- The calculation does not account for any inlet losses or backwater effects from downstream.

3.4 Manning's pipe capacity check using design tables

Approach

The pipe size has been checked through the use of the "Tables for the hydraulic design of pipes, sewers and channels 7th edition, volume 2", produced by HR Wallingford. The pipe sizes full bore capacity was checked for the suggested pipe diameters to ascertain whether or not they were in line with targets. The tabulated outputs are shown below in Table 7.

Table 7 Culvert capacity check using Wallingford tables

Site	Holywell Brook	Unnamed drain under A45	Unnamed Drain under Bickenhill Lane
Required capacity (m^3/s)	4.38	0.71	0.38
Calculated full bore capacity using Manning's equation	4.42	0.74	0.4
Manning's suggested pipe diameter (mm)	1260	677	479
Gradient	0.014	0.01	0.022
Selected pipe size from tables (mm)	1275	700	500
mQ from tables	7.049	1.204	0.728
m = Manning's n x 100	1.5	1.5	1.5
Full bore capacity from tables	4.70	0.80	0.49

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4. SUMMARY

Initial hydrological analysis and culvert sizing has been undertaken based on limited data. In particular, a number of assumptions have been made in determining indicative sizes of culvert at the three sites.

The calculated culvert sizes using Manning's formula are indicative of a minimum size and do not take into account standard off the shelf unit sizes, whether the culverts are inlet or outlet controlled and what the losses are at each end.

The checks on the suggested culvert sizes using Wallingford tables line up with the results obtained through calculation.

More detailed engineering calculations and / or hydraulic modelling is required at subsequent design stages to confirm the sizes of culverts, as well as:

- Confirmation of design flows;
- Confirmation of standard of service;
- Confirmation of freeboard requirements;
- Confirmation of any local works to channel bed through the road embankment; and
- Confirmation of any inlet and outlet arrangements (such as headwall/wingwalls).

Prior to this, a detailed survey of the existing levels is required to confirm what is on the ground. In addition, the final design of crossing structures will also need to take account of any environmental constraints and mitigation that is required.

5. GLOSSARY

AEP	Annual Exceedance Probability
BFIHOST	Base Flow Index derived using the Hydrology of Soil Types (HOST) classification
FEH	Flood Estimation Handbook
LiDAR	Light Detection And Ranging
LLFA	Lead Local Flood Authority
QMED	Median flow
ReFH	The Revitalised Flood Hydrograph method
ReFH2	The Revitalised Flood Hydrograph method version 2
URBEXT 2000	Extent of urban and suburban land cover in the year 2000 expressed as a fraction
WFD	Water Framework Directive (2000/60/EC)