LAND OFF WHITFORD ROAD, BROMSGROVE

Flood Risk Assessment and Drainage Strategy

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1 EXECUTIVE SUMMARY

RPS Consulting Services Limited has been commissioned to undertake a Flood Risk Assessment on behalf of Catesby Strategic Land Limited for a proposed mixed use development at land off Whitford Road, Bromsgrove. The site covers an area of approximately 23.4 hectares and currently comprises greenfield land.

Catesby Strategic Land Limited are seeking outline planning permission for a proposed development of up to 490 dwellings and small retail (class A1) shop; together with two new accesses onto Whitford Road; provision of new public open space; landscaping; and sustainable urban drainage. This report has been completed to support the application.

The site is identified by the Environment Agency flood map, which is available online, as being fully located within Flood Zone 1. Such areas are assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%) in any one year.

An FRA is required to comply with the National Planning Policy Framework (NPPF) and the associated Planning Practice Guidance as the Application Site is over 1 hectare in size.

As part of the site appraisal process, it has been necessary to demonstrate that the proposed development can be achieved with no risk of flooding and without increasing flood risk to third parties. This report describes the methods used and the results of this study.

The report takes into account the recommendations of the NPPF and its associated Planning Practice Guidance. It confirms that the whole site is located within Flood Zone 1 and is acceptable in all other respects as to flood risk, such that this does not present a constraint to site development.

The Drainage Strategy demonstrates that the site can sustainably manage surface water arising from the development up to the 1 in 100 year +40% climate change storm event, with an 8% allowance for Urban Creep. The proposed attenuation basins and swale will provide a suitable level of surface water treatment, prior to a restricted discharge from the site.

2 INTRODUCTION

2.1 Project Brief

RPS Consulting Services Limited has been commissioned to carry out an assessment to satisfy Worcestershire County Council (WCC) as the Lead Local Flood Authority (LLFA) and the Environment Agency's (EA) requirements for a Flood Risk Assessment (FRA) for a proposed mixed use development at land off Whitford Road, Bromsgrove.

The FRA is prepared in full accordance with the National Planning Policy Framework (NPPF) and the associated Planning Practice Guidance (PPG) (February 2019). The FRA is required to identify the 1% (1 in 100 year) and 1% +allowance for climate change flood extents and levels for the site and ensure that all aspects of development are clear of the 1% +allowance for climate change floodplain.

2.2 Assessment Procedure

This report has been prepared in accordance with the requirements of the NPPF. This assessment also gives due consideration to the guidance provided in the CIRIA publication, *C624, Development and Flood Risk: Guidance for the Construction Industry, 2004*, C753 The SuDS Manual and *The Floods and Water Management Act 2010.*

An assessment of the flood risk to the proposed development has been completed based on the best information available at the date of this report. The assessment herein is deemed appropriate to satisfy the requirements of the EA and LLFA, the scale and nature of the development, and the available data. The key elements of this assessment are as follows:

- Desk study scoping exercise;
- Consultation with relevant authorities;
  - EA on 19th May 2020;
  - NWWM on 19th May 2020;
- Review of site topography and development proposals;
- Identification of data corresponding to appropriate design flood events;
- Consideration of climate change;
- Consideration of flood risks to and from the development;
- Calculation of the impact of the development on surface water run-off; and
- Recommended surface water management measures.

2.3 National Planning Policy Framework (NPPF)

The NPPF sets out Government's planning policies for England and how these are expected to be applied. The purpose of the policy is ultimately to achieve sustainable development.

In relation to flood risk, the NPPF stresses the importance of taking into account the consequences, and not just the probability, of future flooding events. It clarifies the sequential test as a risk based approach to be applied at all stages of the planning process, to steer new development to areas at the lowest probability of flooding.

The EA is a statutory consultee for Planning Applications designated as 'major' or located within a Flood Zone and will give comment and recommendations to the Local Planning Authority (LPA) for any proposed developments affecting a watercourse.

The NPPF confirms that Strategic Flood Risk Assessments (SFRAs) should be carried out by the LPA to inform the preparation of Local Development Documents (LDDs), having regard to catchment wide flooding issues which affect the area. The SFRA will provide the information needed to apply the sequential approach.

2.4 Requirements of the National Planning Policy Framework

For an FRA proportionate to the risk and appropriate to the scale, nature and location of the development the following will need to be considered;

- the risk of flooding arising from the development in addition to the risk of flooding to the development;
- the impacts of climate change;
- the potential adverse and beneficial effects of flood risk management infrastructure including raised defences, flow channels, flood storage areas and other artificial features together with the consequences of their failure;
- the vulnerability of those that could occupy and use the development, taking account of the Sequential and Exception Tests and the vulnerability classification, including arrangements for safe access where appropriate;
- a quantification of the different types of flooding (whether from natural and human sources and including joint and cumulative effects) and identify flood risk reduction measures, so that assessments are fit for the purpose of the decisions being made;
- the effects of a range of flooding events including extreme events on people, property, the natural and historic environment and river and coastal processes;
- 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 development or land use;
- the ability of water to soak into the ground may change with development, along with how the proposed layout of the development may affect drainage systems; and
- be supported by appropriate data and information, including historical information on previous events.

2.5 Requirements of the Lead Local Flood Authority

The Lead Local Flood Authority (LLFA) is a statutory consultee on all major planning applications for surface water management. For Bromsgrove, Redditch and Wyre Forest District Councils this consultee role is fulfilled by North Worcestershire Water Management (NWWM) on behalf of Worcestershire County Council.

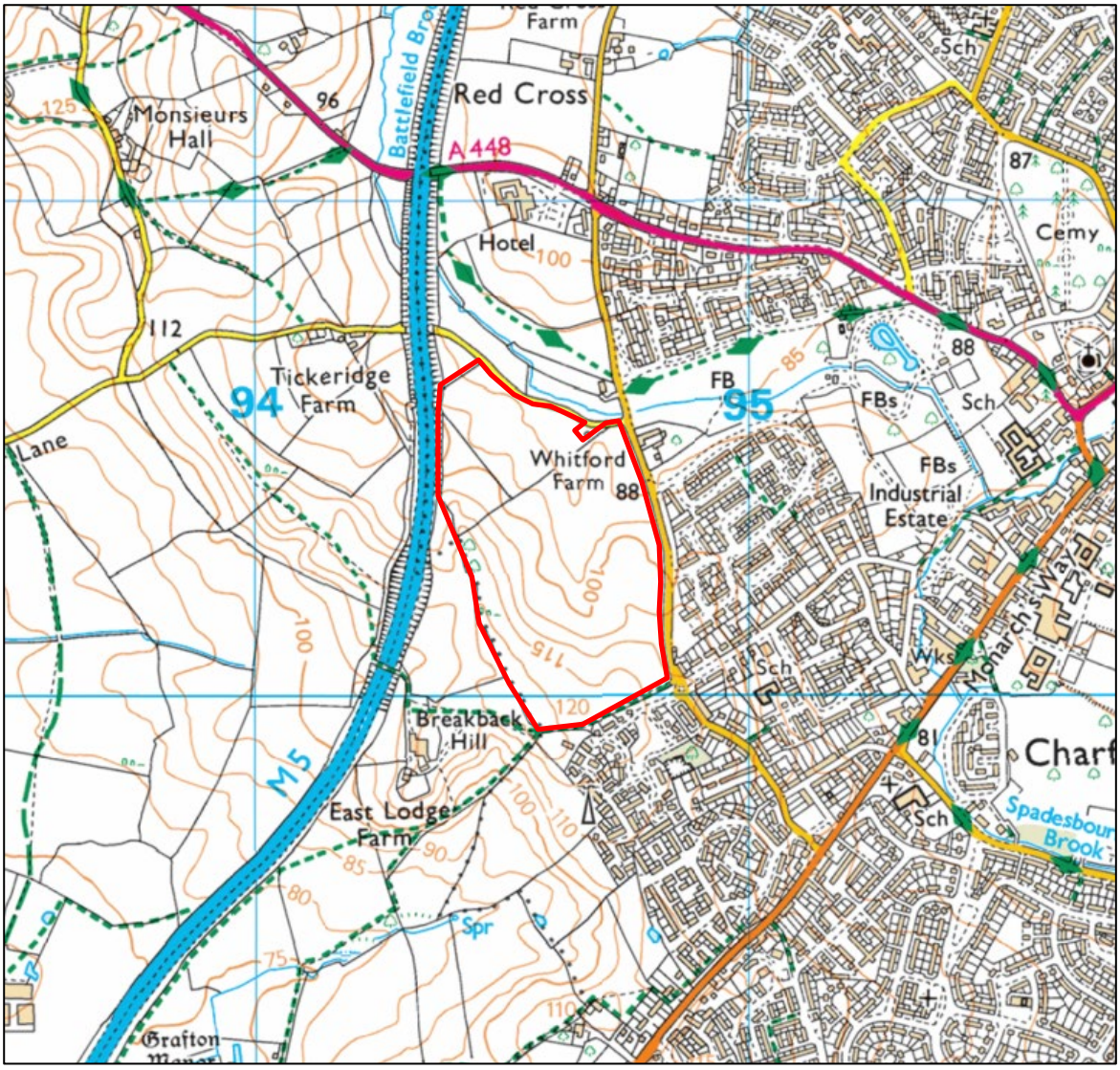
Redditch, Bromsgrove and Wyre Forest District Councils have joined together to provide a shared service for water management and associated issues. The North Worcestershire Water Management (NWWM) service is hosted and based at Wyre Forest and deals with flooding, drainage, ordinary watercourses and surface water issues.

SuDS provide a way of managing rainwater by mimicking natural drainage. It is NWWM policy that all new developments consider the use of SuDS. For all new major development this is a national requirement. NWWM also provide guidance on the specific requirements of surface water drainage including those for climate change and urban creep. These have been obtained via consultation, with the details provided in Section 4.6.

3 SITE DETAILS

3.1 Site Overview

The Application Site is shown in Figure 3.1 below. The site is located to the west of Whitford Road, Bromsgrove (National Grid Reference 394621, 270300) and covers an area of approximately 23.4 hectares (ha). The consultees associated with this location are provided in Table 3.1.



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Approximate site boundary indicated in red, for location purposes only.

Figure 3.1: Site Location Plan

Table 3.1: Site Specific Data and Consultees

OS NGR	SO946703
Local Planning Authority (LPA)	Bromsgrove District Council (BDC)
Lead Local Flood Authority (LLFA)	Worcestershire County Council (WCC) (see Section 2.5)
Sewer Utility Company	Severn Trent Water (STW)

3.2 Site Description and Surrounding Area

The site is located to the west of Bromsgrove, comprising a parcel of land of irregular shape. The site covers an area of approximately 23.4 ha. The land generally falls towards the north east, from a level of approximately 123m Above Ordnance Datum (AOD), to approximately 87m AOD. The topographical survey is included within Appendix A for reference.

The site comprises of agricultural grassland bounded mostly by hedgerow and is considered an existing greenfield site. It is bordered by the M5 motorway and agricultural land to the west, and Whitford Road with residential development to the east. Further agricultural land and residential housing are to the south of the site with Timberhonger Lane to the north.

Beyond Timberhonger Lane lies the Battlefield Brook an EA designated Main River. At its closest the Brook is located approximately 20m north of the site. There are no know watercourses within the redline boundary of the site.

3.3 Development Proposals

Catesby Strategic Land Limited are seeking outline planning permission for a proposed development of up to 490 dwellings and small retail (class A1) shop; together with two new accesses onto Whitford Road; provision of new public open space; landscaping; and sustainable urban drainage. This report has been completed to support the application.

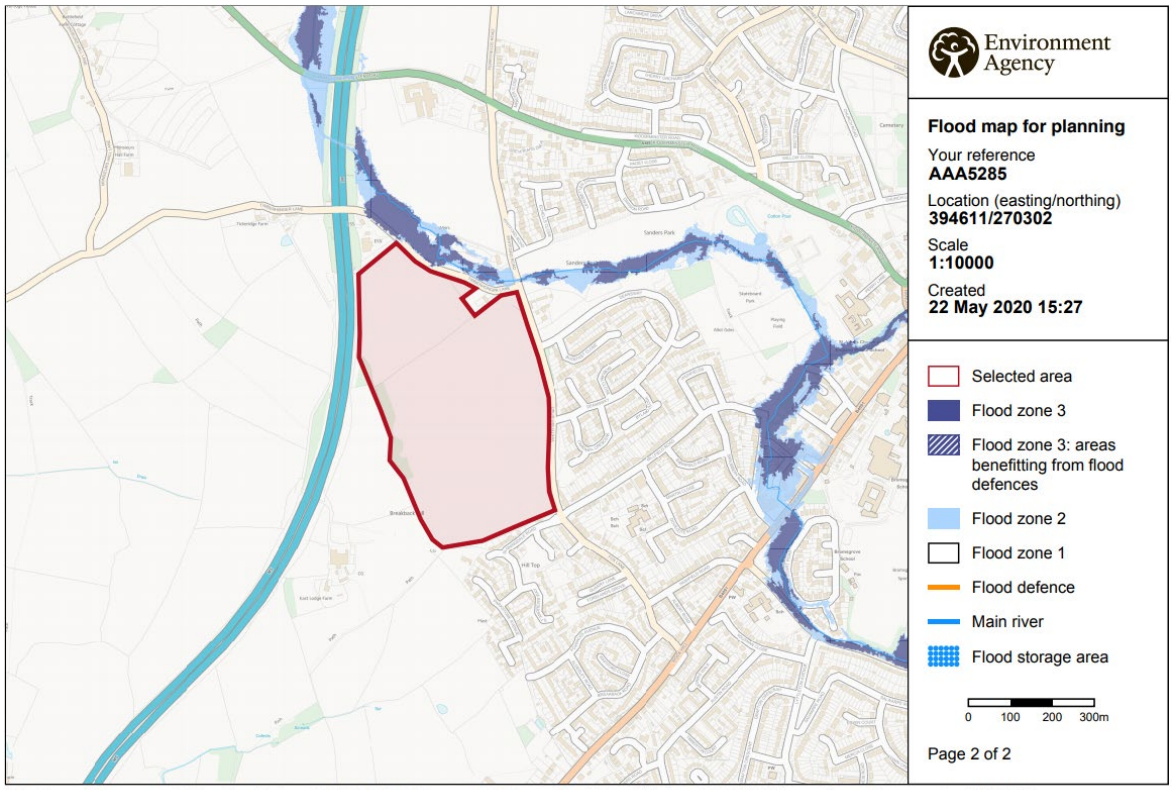
The Planning Layout is included within Appendix B for reference.

4 SCOPING STUDY

4.1 Published Flood Zone

The EA is responsible for managing the risk of flooding from main rivers, reservoirs, estuaries and the sea and provides an online information service through the Flood Map for Planning hosted on the 'GOV.UK' website (https://flood-map-for-planning.service.gov.uk/). This data is not intended to provide detailed flood information for individual properties, but the information can be used as part of a flood risk assessment to inform a planning application. An extract of the Flood Map for Planning obtained from the 'GOV.UK' website is provided below in Figure 4.1.

The map demonstrates that the site is entirely located within Flood Zone 1. Land in Flood Zone 1 is assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%), the lowest classification of fluvial flood risk. Fluvial flood risk is considered further within Section 5.2, below.



Approximate site boundary indicated in red, for location purposes only.

Figure 4.1: EA Flood Map for Planning (accessed 22.05.2020)

4.2 Bromsgrove District and Redditch Borough Strategic Flood Risk Assessment - Level 1, 2009

A Level 1 SFRA was completed for Bromsgrove District Council (BDC) and Redditch Borough Council (RBC), by Royal Haskoning in January 2009.

The information contained within the SFRA is used as a tool by the LPA for the production of development briefs, setting constraints, identifying locations of emergency planning measures and requirements for FRAs. It also provides an assessment and categorisation of flood risk on a district/borough wide basis in accordance with the NPPF. SFRA'S can be used to provide an indication of the likely flood risk issues at a site from all sources of flooding.

In relation to the Battlefield Brook the SFRA states that '*flooding has occurred down much of its length, although most notably on its easterly upstream fork in Catshill and Marlbrook*' (upstream of the Application Site), however '*further downstream, where the Brook enters Sanders Park under Whitford Road, it suffers from low flow. As a result there is an EA bore hole and pump by the Whitford Road Bridge to assist the flow if necessary*.'

The Application Site falls within an area identified as a greenfield site and identified with potential for development. The SFRA refers to the potential development site as Site A9 'Whitford Road', and states:

'There are also a number of potential sites proposed on currently undeveloped areas (Greenfield sites). If these sites are chosen for development then it will be necessary to pay closer attention to the disposal of surface water in order to ensure that the development does not contribute additional runoff to receiving watercourses and thereby increase the risk of flooding to other areas.

However, it is anticipated that current awareness of sustainable drainage techniques (SuDS), which will be required as a prerequisite of any future development, will actually reduce the rate of runoff from the proposed sites. The provision of SuDS is the first method of disposal to be considered for surface water.

The Bromsgrove Council Drainage Engineer has identified the following Greenfield sites as being potentially problematic in terms of increased runoff downstream: A1, A10, A6, A5, A4, A2, A9, A11, A13 and A8. Due to drainage and sewer restrictions, all these sites will have to accommodate and dispose of all surface runoff collected within their area using SuDS.'

The information and requirements of the Level 1 SFRA will be addressed within this report.

4.3 Bromsgrove District and Redditch Borough Strategic Flood Risk Assessment - Level 2, 2012

A Level 2 SFRA was completed in June 2012 by MWH. The SFRA recommends policies and guidance to allow development when it has been proven that they will be safe for the lifetime of the development and they will not increase flood risk elsewhere. The document was prepared to consider all sources of flooding.

The Application Site falls within an area identified within the Level 2 SFRA as '*BDC80 Whitford Road, Bromsgrove'*. The Level 2 SFRA provides a summary of the SFRA findings in relation to site BDC80 on page A-30 (see Figures 4.1 and 4.3). The Level 2 SFRA states that:

'Less than 0.1% of the site lies in Flood Zone 3a and less than 0.1% in Flood Zone 3b, built development in these areas should be avoided. Development should be directed to areas at lower risk of flooding within the site.

Following discussions with the EA, it was agreed that if flooding occurs in less than 5% of the site, this is considered minor for the purposes of the Sequential Test and development should not be precluded.'

Table 6-2: '*Percentage of Site at High Risk of Flooding' identifies that up to 5% of the site is at high risk of flooding and therefore development is considered appropriate.*

Table 8-1: *'Sewer Flooding Adjacent to Development Sites' does not identify any sewer flooding adjacent to the site.*

It should be noted that the small amount of flood risk (Flood Zone 3a and Flood Zone 3b) associated with the extreme north west corner of site BDC80, falls outside of the Application Site covered by this FRA (see Figure 3.1).

MWH

BUILDING A BETTER WORLD

BROMSGROVE DISTRICT COUNCIL DEVELOPMENT SITES

BDC 80 (Whitford Road)

General Site Information:				
Development Type:	Residential			
Vulnerability Classification:	Less Vulnerable (Industrial)		More Vulnerable (Residential)	✓
	Highly Vulnerable		Water Compatible	
Planning Permission Granted (as July 2010)	No			
Size:	24ha			
Floodplain:	Battlefield Brook flows to north of site. Flooding shown on Timberhonger Lane			
Watercourse within site:	No			
Brownfield/Greenfield:	Greenfield			
Potential Flood Risk:				
Flooding Mechanism:	Fluvial	✓	Surface water	✓
	Sewer		Groundwater	
	Fluvial flooding identified to immediate north of site. Groundwater flooding coverage identified as 25 – 50% per km^2 from superficial deposits (from raised water level in local watercourse).			
Flood Zones*:	Flood Zone 1 – 99.9%; Flood Zone 2 – <0.1%; Flood Zone 3a – <0.1%; Flood Zone 3b – < 0.1%			
Flood Defence:	No defences affecting the site.			
Flood Depth	Not Applicable			
Flow Velocity	Not Applicable			
Period of Inundation	Not Applicable			
Localised flooding	Localised flooding indicated on Environment Agency Flood Maps on			

Figure 4.2: Extract from Level 2 SFRA (1 of 2)

MWH

BUILDING A BETTER WORLD

BROMSGROVE DISTRICT COUNCIL DEVELOPMENT SITES

	Timberhonger Lane to immediate north of the site.
Sequential Test Findings	
The site lies almost entirely within Flood Zone 1 which is considered appropriate for all development types as long as an appropriate buffer zone is left between the development and the watercourse.	
Exception Test findings	
No increase to flood risk	This is a greenfield site and therefore opportunities should be explored for reducing the existing downstream flood risk through appropriate design and layout of any development.
Safety	There are no flooding issues identified with this site.
Reducing flood risk	It is essential that the existing, greenfield runoff rates from the site are maintained. This could be adequately achieved through the use of SuDS and enhancements to the watercourse, such as creating flood attenuation and storage. A site specific flood risk assessment and drainage impact assessment should be carried out
Recommendations:	
Exception Test Applicable?	No
Spatial Planning	Runoff from the site should not exceed existing greenfield rates and should ideally improve on current volume and rates of runoff. Sustainable drainage systems (SuDS) should be promoted to attenuate and store surface water runoff from the proposed site. SuDS should be monitored in areas where groundwater flooding coverage is between 25 - 50% per km^2.
Development Control	All proposed development within the site will require a site-specific FRA and drainage impact assessment. Opportunities should also be sought through the design and layout for reducing the flood risk in the area. The local planning authority should promote the attenuation of peak runoff from the development area, in order to achieve greenfield runoff rates, or ideally betterment, and ensure that the capacity of the drainage system downstream of the site is not compromised. To achieve this, a management train approach to SUDS should be implemented which includes source, site and regional controls. Appropriate landscaping should also be utilised to improve drainage efficiency within the site and to direct flow paths away from development to flood storage areas.
Summary	
The site lies predominantly within Flood Zone 1, low probability. It is therefore assessed as appropriate for residential development. The existing site is greenfield and therefore any runoff from the proposed development should be limited to the existing rate, as a minimum requirement and preferably betterment of existing runoff volumes and rates, in order to minimise the impact on Battlefield Brook/public sewerage system. A precautionary approach should be adopted to flood risk to ensure that development does not adversely impact on existing flood risk. SuDS should be incorporated into the proposed development to attenuate and store runoff from the site. A site specific FRA and drainage impact assessment should be prepared.	

Site	Area (Ha)	Use	No of possible houses
BDC 80 (Whitford Road)	24	Residential	470

L2 SFRA – Redditch Borough Council and Bromsgrove District Council Appendices *Page A-31*

Figure 4.2: Extract from Level 2 SFRA (2 of 2)

The information provided in the Level 2 SFRA applies a precautionary approach to flood risk, in accordance with the guidance in NPPF, PPS25 and Environment Agency advice, and it is essential that more detailed site specific assessments are carried out.

The SFRA requires that a site-specific FRA must demonstrate that the proposed land use is acceptable and that the development can be designed to be safe and reduce flood risk. The FRA must consider flooding from all sources:

- fluvial flooding;

- flooding from the sea;
- flooding from land;
- surface water flooding;
- flooding from groundwater;
- flooding from sewers; and
- flooding from reservoirs, canals and artificial sources.

The requirements of the Level 2 SFRA will be addressed within this FRA.

4.4 Worcestershire County Council Preliminary Flood Risk Assessment (PFRA), 2011

A Preliminary Flood Risk Assessment (PFRA) is a high level screening exercise. It involves collecting information on past (historic) and future (potential) floods, assembling it into a preliminary assessment report, and using it to identify Flood Risk Areas where the risk of flooding is significant. This PFRA is based on existing and available information which brings together information from national and local sources including the Flood Map for Surface Water, Strategic Flood Risk/Consequence Assessments and local historical flood event records.

Worcestershire County Council (WCC) completed a PFRA as part of a LLFA's duties to manage local flood risk and deliver the requirements of the Flood Risk Regulations (2009). The PFRA provides a broad overview of flooding over the administrative area of Worcestershire. The Application Site is not specifically referenced within the report.

4.5 Redditch Borough Council and Bromsgrove District Council Outline Water Cycle Study, May 2012

An Outline Water Cycle Study (WCS) was completed in May 2012 for RBC and BDC by MWH. The aim of the study was to assess the water cycle capacity constraints to planned growth and development (housing and employment land) and to identify infrastructure requirements and mitigation measures, where appropriate. The study provides an important part of the evidence base for the LDDs of both Councils.

The Application Site is identified as: 'BDC80 Whitford Road, Bromsgrove'.

Table 6-2: 'Summary of Issues and Possible Measures at Development Sites Constrained by Wastewater Collection Infrastructure Capacity' states there is no known existing sewer flooding, but there is a small diameter sewerage system. Local upsizing might be required.

The potential impact on the existing Severn Trent Water (STW) public foul sewerage system in

the vicinity of the site will be considered as part of this report.

4.6 Consultation with Lead Local Flood Authority (LLFA)

The Lead Local Flood Authority (LLFA) is a statutory consultee on all major planning applications for surface water management. For Bromsgrove, Redditch and Wyre Forest District Councils this consultee role is fulfilled by North Worcestershire Water Management (NWWM) on behalf of Worcestershire County Council.

NWWM were consulted on 19th May 2020 regarding the proposed development, and the response is provided within Appendix C for reference.

The response notes that '*An FRA was provided as part of the planning application reference 16/1132; in general this is still fit for purpose however the climate change allowances used are not in line with the current guidance'.*

In terms of flood risk the response confirms the following points.

- the site steeply slopes from South to North and ultimately drains into the Battlefield Brook, which flows to the North of the site;

- the site itself falls entirely within flood zone 1 (low risk of fluvial flooding);
- there is a portion of the site (a strip from South to North) which is at low risk of surface water flooding;
- NWWM hold no reports of flooding on the site or in the immediate vicinity however but are aware of some instances of highway flooding nearby.

With regard to drainage the NWWM response provides the following information.

- the site lies partially within zones II (outer protection) and III (total catchment) for a local aquifer – therefore NWWM suggest that care is taken to ensure no contaminated runoff is discharged to the ground;
- on the other hand though, as the aquifer is heavily abstracted, drainage of clean roof water into the ground via SuDS would be welcomed;
- should a final discharge point be required into the Battlefield Brook, NWWM would need to be sure that all sediments and pollutants have been removed, and that discharge is to an agreed attenuated volume;
- for the climate change allowances NWWM would expect to see values of 40%, and an appropriate allowance for urban creep should also be included.

The NWWM requirements and guidance will be used to inform this FRA and Drainage Strategy, with application of the latest climate change and urban creep allowances.

4.7 Consultation with Environment Agency

The EA were consulted on 19th May 2020 regarding the proposed development and the enquiry is provided in Appendix D for reference. The response from the EA will be provided once received.

The EA were consulted for a Flood Risk Assessment on this site in 2016. At that time the response outlined no site specific requirements and mapping provided confirmed that the site is located within Flood Zone 1. The EA confirmed that the LLFA should be contacted to provide surface and groundwater flooding information of which historical events should be included within the PFRA.

The EA have previously been consulted regarding an assessment of the blockage risk to the Battlefield Brook where it passes under the Whitford Road (outside of the Application Site boundary). This assessment was approved by the EA as part of the original Planning Application and is reproduced in section 5.2 below.

The EA confirmed that the FRA and assessment of blockage risk demonstrates that the site is not at risk of flooding from the Battlefield Brook. Consequently, the proposed development is not considered to be at risk of fluvial flooding from the Battlefield Brook.

The information provided by the EA will be fully considered within this report.

4.8 National Planning Policy Framework – The Sequential Test

- As set out in the NPPF and the associated PPG, the aim of the Sequential Test is to steer new development to areas with the lowest probability of flooding. SFRAs provide the basis for applying the sequential test, where information is not available in a SFRA the Sequential Test will be based on the EA Flood Zones.
- As noted within Section 4.1 and Figure 4.1, the Proposed Development site is fully located within Flood Zone 1; these are areas assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%), the lowest classification of fluvial flood risk.
- The associated PPG (Table 2 Paragraph: 066 Reference ID: 7-066-20140306) shows the proposed residential development as having a Flood Risk Vulnerability classification of “more vulnerable” for the residential units and “less vulnerable” for the commercial units.

- Therefore, based on the EA Flood Zone classification of the development location, PPG Table 3 (Paragraph: 067 Reference ID: 7-067-20140306) re produced as Table 4.1 below, shows residential development and commercial development are both appropriate.

Table 4.1: NPPF PPG Table 3: Flood Risk Vulnerability and Flood Zone 'Compatibility'

Flood Zone	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	✓	✗	✗	✗

Proposed Development Site Classification Highlighted for Reference.

Key:

✓ *Development is appropriate* ✗ *Development should not be permitted*

4.9 Mechanisms of Flooding

To understand the risk of flooding to a site, it is imperative that potential sources of flooding be clearly defined. The likelihood and severity of flooding depends on the characteristics of the flood sources and the degree to which the site is currently, or can potentially, be protected against flooding from these sources.

Table 4.2 reviews the potential risk of flooding from different sources for the proposed development site.

Table 4.2: Potential Risk of Flooding to the Proposed Development

Source of Flooding	Potential			Comments
	High	Med	Low	
Fluvial (Rivers)			**X**	All land identified for development is located within Flood Zone 1 the lowest classification of fluvial flood risk.
Tidal / Coastal			**N/A**	Application Site is located far inland and not considered at risk of tidal flooding.
Pluvial (drainage system)			**X**	Low risk as drainage systems will be designed to accommodate flows up to the 1 in 100 year + climate change event.
Surface water runoff			**X**	Application Site is identified to be mainly 'very low' risk with a small localised area of medium risk on the western boundary and a thin band of 'low' risk within the site. The proposed sustainable drainage system will ensure the risk is mitigated throughout the site.
Ponding			**X**	The potential risk of ponding is assessed as low risk due to proposed sustainable drainage system.
Groundwater			**X**	The site is not considered to be at significant risk from groundwater flooding.
Canal			**X**	Nearest canal is approx. 3.0km to the south west and generally lower than the Application Site.
Reservoir			**X**	Proposed development is located outside of the maximum flood extent area for reservoir breaches.

5 FLOOD RISK ASSESSMENT

5.1 Introduction

Following the scoping exercise, the potential flood risks to the Application Site have been investigated in greater detail, to ascertain whether the risks are acceptable to the nature of the Proposed Development.

5.2 Fluvial (Rivers)

The Application Site is fully located in Flood Zone 1 as previously shown in Figure 4.1. Land located in Flood Zone 1 is assessed as having a less than 1 in 1000 annual probability of river or sea flooding (<0.1%).

The Battlefield Brook an EA designated Main River is located at its closest approximately 20m to the north of the site beyond Timberhonger Lane. The Brook crosses under the M5 motorway before flowing in an easterly direction to the north of the site. It meets Spadesbourne Brook in Bromsgrove approximately 925m downstream of the site. It then flows south eastwards and into Sugar Brook near Charford which then flows southwards into the River Salwarpe approximately 2km south of the site.

The extent of flooding shown on EA mapping does not show flood water extending into the site beyond Timberhonger Lane. The road appears to create a natural barrier topographically to water levels.Site levels increase relatively steeply moving away from Timberhonger Lane. Generally levels are around 1m higher on the southern hedge line adjacent to Timberhonger Lane than they are on the hedge line to the north of the Lane; and consequently fluvial flood water is prevented from entering the site.

The Halcrow CH2M FRA dated 29th May 2013 (document reference: 461451-017 version 1c) included an assessment of the blockage risk to the Battlefield Brook where it passes under Whitford Road (outside of the Application Site boundary). This assessment was approved by the EA as part of the original Planning Application and has been reproduced below:

'The Battlefield Brook passes under the Whitford Road (outside of the Application site boundary) to the north east of the site in a 5.325m wide unscreened culvert, the height of the culvert varies between 1.59m downstream and 1.35m upstream due to varying bed/channel levels. The channel level of the upstream side of the culvert is 84.45m AOD and the soffit level is 85.80m AOD.

The site levels are a minimum of 87m AOD and proposed property levels will be a minimum of 89m AOD. In the unlikely event of a blockage of the Whitford Road culvert (located outside of the Application site), the water would flow over the Whitford Road and continue along the natural route of the watercourse away from the site.

The maximum carriageway level identified on the TOPO survey prior to water passing over Whitford Road is 86.72m AOD and therefore there is a level difference of 2.88m between carriageway and proposed property levels. Therefore in the event of a blockage any flood water would flow over and along Whitford Road away from the site and ultimately back into the watercourse, and thus would not pose a risk to the proposed development.'

The EA confirmed that the FRA and assessment of blockage risk demonstrates that the site is not at risk of flooding from the Battlefield Brook.Consequently, the proposed development is not considered to be at risk of fluvial flooding from the Battlefield Brook.

5.3 Pluvial, Surface Runoff and Ponding

Pluvial flooding is defined as flooding which results from rainfall-generated overland flow, before the runoff enters any watercourse or sewer. It is usually associated with high intensity rainfall events (typically >30mm/h) but can also occur with lower intensity rainfall or melting snow where the ground is saturated, frozen, developed or otherwise has low permeability resulting in overland flow and ponding in depressions in the topography. Urban pluvial flooding arises from high intensity 'extreme' rainfall events. In such situations underground sewerage and drainage systems and surface watercourses may be completely overwhelmed.

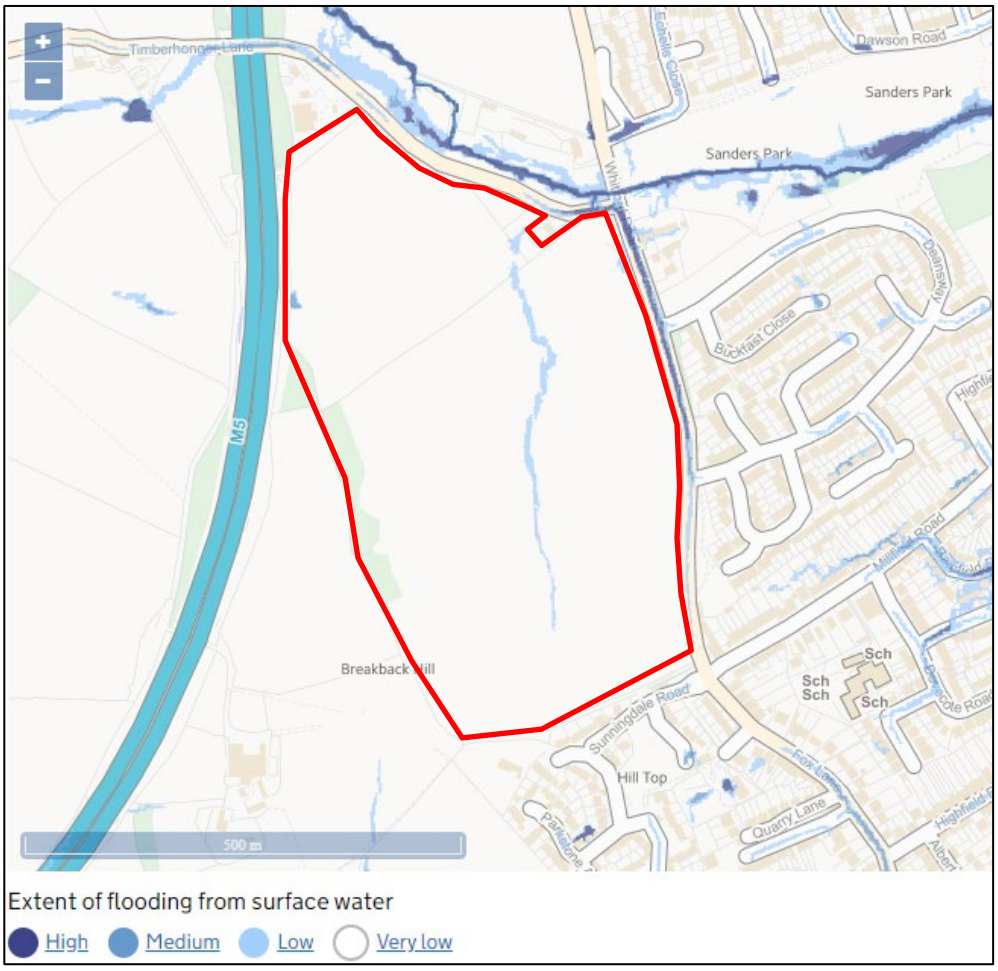
Surface water flood risk is defined by the EA as:

- 'Very low' risk of surface water flooding; land assessed as having less than 1 in 1,000 (0.1%) chance of flooding in any given year.
- 'Low' risk of surface water flooding; land assessed as having between 1 in 100 (1%) and 1 in 1,000 (0.1%) chance of flooding in any given year.
- 'Medium' risk of surface water flooding; land assessed as having between 1 in 30 (3.3%) and 1 in 100 (1%) chance of flooding in any given year.
- 'High' risk of surface water flooding; land assessed as having greater than 1 in 30 (3.3%) chance of flooding in any given year.

Under the existing conditions all surface water currently falling within the site will soakaway, be intercepted by vegetation and evaporate or flow overland towards Timberhonger Lane and if not intercepted by existing highway drainage reach the Battlefield Brook to the north.

The M5 motorway is partially in cutting along the western boundary of the site which limits the potential for overland flows from land to the west. Both Whitford Road and Timberhonger Lane are lower than the Application Site and therefore any surface water not intercepted by existing highway drainage will again flow towards the Battlefield Brook. There is potential for a small amount of surface water to enter the site from the small triangle of land to the south west located between the Application Site and M5.

As illustrated within Figure 5.1 below, the vast majority of the application site is assessed as 'very low' risk of surface water flooding.



Approximate site boundary indicated in red, for location purposes only.

Figure 5.1:EA Flood Map for Surface Water (accessed 22.05.2020)

A very small isolated area of potential 'medium risk' surface water flooding is evident on the extreme western boundary. This is tightly constrained and appears to be very localised ponding of water at the base of the M5 motorway southbound embankment.

A thin linear strip of potential 'low risk' surface water flooding is identified within the site boundary flowing in a northerly direction. The potential flow route will be as a result of surface water run-off generated within the site itself.

This linear strip of flooding correlates with the contours shown on the Topographical Survey for the site (Appendix A). An extract from the survey is included for reference as Figure 5.2.

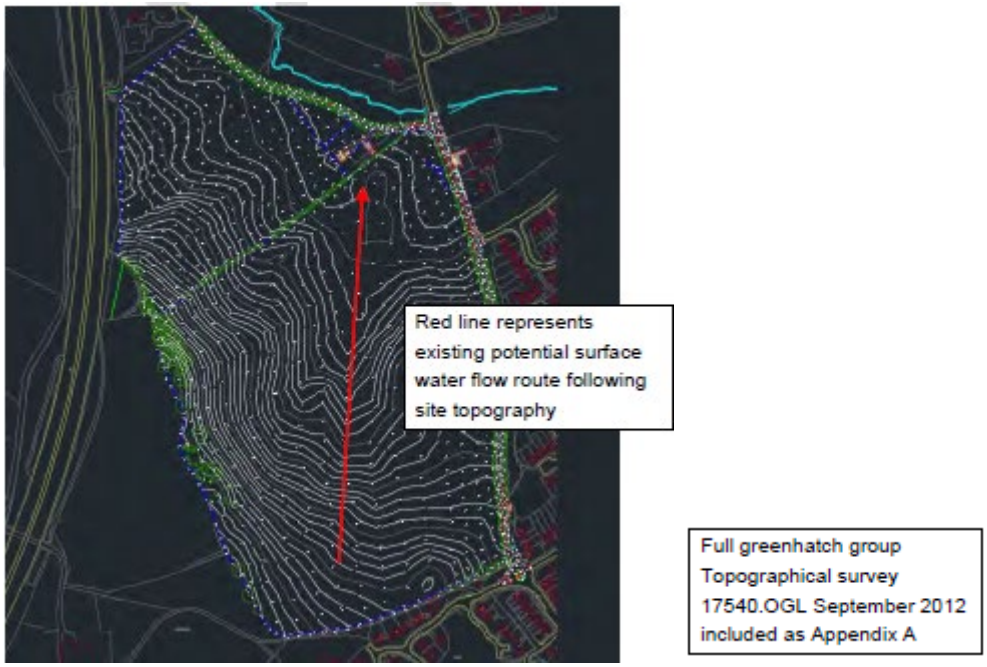


Figure 5.2:Extract from Topographical Survey showing potential Surface Water Flow Route

The mapping also shows some potential surface water flooding associated with the Battlefield Brook to the north; this is expected as surface water will naturally travel along the topographically lowest areas. None of this flooding enters or flows within the boundary of the Application Site.

Apart from the small strip of potential surface water flooding the remainder of the site is identified as 'very low' risk.

5.4 Groundwater

Groundwater flooding is defined as flooding caused by the emergence of water originating from underground. This water may emerge from either point or diffuse locations. Groundwater flooding is a significant but localised issue that has attracted an increasing amount of public concern in recent years. Unlike flooding from rivers and the sea, groundwater flooding does not pose a significant risk to life. It is however associated with significant damage to property, with some types of groundwater flooding persisting over many weeks.

The Level 1 SFRA completed for BDC and RBC, by Royal Haskoning in January 2009 states the following in relation to groundwater flooding:

'Groundwater flooding is not a particular cause for concern within Bromsgrove District as the underlying aquifer tends to drain when water levels within it become too high. The EA has also stated that due to the high levels of abstraction from this aquifer for water supply, the groundwater levels have never reached the surface. There are no reports of groundwater flooding within the District.'

In addition, the Site Factsheet for BDC80(Whitford Road) within the Level 2 SFRA does not list Groundwater as a potential flood risk (Figure 4.2). This was further evidenced by Level 2 SFRA Appendix 5 'Areas at risk of groundwater flooding by type and coverage' (Appendix E).

In December 2012 RSK produced a Preliminary Risk Assessment and Environmental Site Assessment (Reference: 312220 – R1 (00)). In relation to groundwater the report states the following:

'The hydrogeology of the site is likely to be characterised by the presence of an unconfined deep aquifer situated within the bedrock sandstone. Existing boreholes indicate groundwater strike at approximately 10m depth.

The groundwater is expected to follow the topography and flow towards the north-east and Battlefield Brook.

Rising groundwater levels can result in flooding if not properly controlled. In certain areas groundwater levels are rising owing to reduced groundwater abstraction by industry.

The site is classed as having a low risk from rising groundwater.'

The site is not considered to be at significant risk from groundwater flooding.

At the detailed design stage, the advice of a suitably qualified geotechnical engineer should be sought regarding any necessary mitigation to ensure groundwater does not pose a risk during the construction or operational phases of the development.

5.5 Canal flooding

The Worcester & Birmingham Canal is the closest canal to the Application Site. It is approximately 3 km away at the closest point near Stoke Pound. The site is generally at a higher elevation than the canal, therefore if a breach did occur the site is not considered to be at significant risk.

5.6 Reservoir flooding

An area is considered at risk from reservoir flooding if peoples' lives could be threatened by an uncontrolled release of water from a reservoir. If a location is at risk, flooding from reservoirs is extremely unlikely. There has been no loss of life in the UK from reservoir flooding since 1925.

Long term flood risk information is hosted on the 'GOV.UK' website (https://flood-warninginformationservice.gov.uk/long-term-flood-risk/map). The assessment provides mapping to illustrate the probability that a location will flood and the possible causes of flooding including flood risk from reservoirs.

The Flood Risk from Reservoirs Map in Figure 5.3 demonstrates that the whole site is outside of the maximum flood extent. No major reservoirs are located within close vicinity of the site. Therefore, reservoir flooding will not pose a risk to the development site.

Figure 5.3:EA Flood Map, Flood risk from Reservoirs (accessed 22.05.2020)

6 RECOMMENDED FLOOD MITIGATION

6.1 Introduction

This section discusses mitigation options that should be considered in order to reduce the severity of flood risk and to minimise the potential hazards associated with any residual flood risk.

6.2 Design Levels

The proposed development area is fully within Flood Zone 1 and therefore not considered to be at risk of flooding from any source. On this basis it is not deemed necessary to propose any minimum finished floor level or land raising relating to flood risk.

However, Halcrow CH2M FRA dated 29th May 2013 (document reference: 461451-017 version 1c) identified that: 'proposed property levels will be a minimum of 89m AOD.' This was based on an assessment of the blockage risk to the Battlefield Brook where it passes under Whitford Road (outside of the Application Site boundary) and ensures that the site is not at risk of flooding from the Battlefield Brook.

This minimum finished floor level will be respected within RPS designs and further protects the site from any residual risk of fluvial flooding.

6.3 Site Topography and Flood Routing

Where possible, levels should fall away from buildings, and areas where water could dam up against structures should be avoided, even if drainage is provided.

The development proposals will be designed to ensure that any overland flows are routed away from buildings, intercepted by gullies and or drainage channels.

If any permeable areas are not formally drained, the risk of these areas flooding should be assessed. It should then be demonstrated that flood flow routes and depths would not affect property, car park areas or other such infrastructure. Flood flow routes should be incorporated as part of detailed engineering designs. Overland flows should be routed towards gullies where applicable and not into third party land.

The site falls to the north and as such drainage proposals will ensure that surface water is intercepted before it is able to flow uncontrolled into the adjoining land, where, dependent upon local topography, it may cause or contribute to localised flood or ponding issues.

Implementing a surface water drainage system for the site suitable of conveying flows up to and including the 1 in 100 year + 40% for climate change event, will protect third parties as surface water will be intercepted and not be allowed to run-off at an uncontrolled rate. Moreover, restricting the rate at which surface water is discharged may provide a betterment in any downstream flood risk as run-off from the site will no longer be released in an uncontrolled manner.

A cut off drain or similar may be required along the site's southern boundary to intercept any surface water run-off flowing into the site from steeply sloping areas to the south.

6.4 Sustainable Drainage Systems

It is a planning requirement to consider utilising SuDS, if it is appropriate to the specific site conditions. These systems are diverse, but generally aim to provide drainage systems that may facilitate flood and/or pollution control, related to run-off. Such systems are generally 'soft engineering' and as a result can be financially, as well as environmentally, attractive engineering solutions.

Details of the potential use of SuDS are further investigated in Section 7 – Drainage Strategy.

6.5 Flood Resistance and Resilience

A basic level of flood resistance and resilience can be achieved by following good building practice and complying with the requirements of the Building Regulations 2010.

The proposed development is fully located within Flood Zone 1. It is not deemed necessary to incorporate any flood proofing measures outlined in the EA's Floodline Publication 'Damage Limitation'.

6.6 Residual Risk

A residual risk remains for the proposed development from rainfall events greater than the 1 in 100 year + 40% design criteria of the proposed drainage system. The risk will be mitigated, as on-site sewers shall be designed in accordance with Building Regulations and the latest Sewers for Adoption criteria, as appropriate, to take account of overland flood flow routes and to divert any excess surface water around and away from proposed buildings.

Where feasible and appropriate, finished floor levels will be set 150mm above adjacent site levels which further mitigates any residual pluvial flood risk.

7 DRAINAGE STRATEGY

7.1 Introduction

To demonstrate that all forms of flooding have been considered as required by the NPPF a drainage strategy has been developed. The aim of including this strategy as part of the FRA is so that it can easily be seen that the Proposed Development will not adversely affect the surface water regime in the area and that overall the current situation will be improved.

7.2 Existing Surface Water Drainage

Sewer records from STW are provided in Appendix F for reference, indicating that there are no public surface water sewers located within the boundary of the site. There are surface water sewers within the vicinity of the site, most notably a 225/300mm diameter public surface water sewer located to the east of the site in Whitford Road. This discharges to the Battlefield Brook via a headwall to the north east of the site beyond Timberhonger Lane before the Brook passes under Whitford Road.

The greenfield nature of the site means that surface water will slowly soak into the ground (infiltrate), be intercepted by vegetation or run off by way of overland flow, according to the soil characteristics and following the topography of the site. Due to the steeply sloping nature of the site, most surface water is presumed to flow overland when vegetation is cut short.

Greenfield runoff rates for the site have been calculated by way of Interim Code of Practice for Sustainable Drainage Systems (ICP SUDS). This implements a pro rata IOH124 methodology, for sites below 50ha in size. The calculation has been included for reference within Appendix G and outputs are summarised within Table 7.1, below, based upon a hypothetical 1ha area.

Return Period	Greenfield Runoff Rate (l/s)
Q1	3.6
QBar	4.4
Q30	8.6
Q100	11.3

Table 7.1: Greenfield Runoff (for hypothetical 1ha area)

7.3 Existing Foul Water Drainage

STW sewer records are provided in Appendix F for reference, indicating that there are no public foul water sewers located within the site boundary. There are foul water sewers within the vicinity of the site, most notably a 225mm diameter public foul water sewer located in Deans Way to the east of the proposed development site.

7.4 Proposed Surface Water Drainage

Under the terms of Section 3 of Approved Document H3 of the Building Regulations 2010 (2015 edition), soakaways should be utilised as the primary means of surface water disposal. If infiltration testing undertaken in accordance with BRE DG 365 (2016) provides an unfavourable infiltration rate across the site or contaminated ground is present within the site, other methods of sustainable

drainage should be considered. A surface water connection to an existing watercourse should be considered prior to a connection into the public sewerage system.

As discussed an Outline Planning Application was made for the site previously under BDC reference 13/0479. Halcrow CH2M completed the original FRA dated 29th May 2013 (document reference: 461451-017 version 1c). The drainage strategy produced to accompany the FRA and application was met with no objections from the EA or LLFA and as such this report will take the following approach utilising information provided as part of the original application, and where available provide additional supporting information. As noted by the Bromsgrove Council Drainage Engineer in the Level 1 SFRA the site will have to accommodate and dispose of all surface runoff collected within its area using SuDS, and that has informed this surface water drainage proposal.

In terms of groundwater, the site lies partially within zones II (outer protection) and III (total catchment) for a local aquifer. RSK provided supplementary soakaway investigation results in November 2013 (reference 312557-01(00)) which included the following:

- A study of the local geology of the site;
- Excavation of six trial pits, to depths of between 1.36m and 2.70m below current ground level; and
- In-situ soakage testing at each of the exploratory locations.

A copy of RSK's report is included for reference as Appendix H and an extract provided below:

"The results of the in-situ soakage testing indicate that the infiltration rate of the shallow soils exhibits considerable variability across the site. The testing undertaken at SA2 and SA6 indicates that these locations would be most suitable for the adoption of shallow pit soakaways to discharge surface run-off; and that an infiltration rate in the order of 10^{-4} m/s would be appropriate for design purposes.

The testing undertaken at SA1, SA3 and SA5 indicates that these locations may be suitable for the adoption of shallow pit soakaways to discharge surface run-off; however a lower rate of infiltration, in the order to 10^{-6} m/s, is recommended for design purposes.

In contrast, the testing undertaken at SA4 indicates that this location is unlikely to be suitable for the adoption of shallow pit soakaways, as the rate of infiltration recorded was negligible."

As discussed within Section 4.4 the falls within a SPZ. Halcrow had correspondence with the EA in relation to this and the use of infiltration based SuDS techniques and it was confirmed that:

"The discharge of clean roof water to ground is considered acceptable both within and outside SPZ1 provided that all roof water down-pipes are sealed against pollutants entering the system from surface run-off, effluent disposal or other forms of discharge". The response also stated *"Where infiltration SuDS are to be used for surface run-off from roads, car parking and public or amenity areas, they should have a suitable series of treatment steps to prevent the pollution of groundwater".*

As noted by NWWM, the aquifer is heavily abstracted and drainage of clean roof water into the ground via SuDS would be welcomed. Consequently, surface water for all events up to the 1 in 30 year (excluding highways) is to be disposed of via soakaways.

The Illustrative Drainage Strategy showing proposals based upon a discharge to the Battlefield Brook to the north of the site, is provided in Appendix I. The surface water drainage strategy has been designed based upon the following parameters;

- Total Site Area = 23.400 ha
- Total Developable Area = 16.220 ha
- QBAR Greenfield Runoff Rate = 4.4 l/s/ha
- An 8% Urban Creep allowance has been applied to the impermeable area of the site.
- Surface water attenuation is designed to the 1 in 100 year +40% Climate Change event.
- Surface water for all events up to the 1 in 30 year (excluding highways) is to be disposed of via soakaways.

- All events over and above the 1 in 30 year event up to the 1 in 100 year +40% Climate Change event.

Development Area & Rainfall event	Attenuation Location	Discharge Rate	Attenuation Requirement
Carriageways 2.25ha 1 in 100yr + 40%	Within basin 1 and 2	9.9 litres/sec	1,505m^3
60% of developable area plus 8% urban creep (excluding carriageways) 9.053ha 1 in 30 yr.	Via infiltration	Not proposed	2,780m^3
60% of developable area plus 8% urban creep (excluding carriageways) 9.053ha Over 1 in 30yr up to 1 in 100 yr. + 40%	Within basin 1 and 2	39.8 litres/sec	5,905m^3 **Total = 3,125m^3** (5,905 – 2,780)
		Total = **49.7 litres/sec**	**Total = 4,630m^3** (1,505 + 3,125)

Table 7.2: Summary of Attenuation Volumes

It is proposed that surface water will be captured within a gravity sewer system and attenuated prior to discharge within two attenuation basins located in the north east corner of the site. Flows will then be discharged at the restricted rate (49.7 l/s) by way of a flow control (Hydrobrake) to the Battlefield Brook located to the north of the site.

A surface water outfall is proposed into the Battlefield Brook located to the north of Timberhonger Lane. It is noted from consultation with the EA (see 4.2) that '*further downstream, where the Brook enters Sanders Park under Whitford Road, it suffers from low flow. As a result, there is an EA bore hole and pump by the Whitford Road Bridge to assist the flow if necessary*.' It is proposed that a headwall will be installed just downstream of where the brook passes under Whitford Road. The connection will require consent from the EA as the Battlefield Brook is designated as a main river.

Surface water storage is provided within two attenuation basins located in the north east corner of the site. A swale will covey surface water through the site and into Pond 1, the feature may also provide a limited amount of attenuation during larger rainfall events. MicroDrainage calculations are provided in Appendix J, demonstrating that sufficient surface water storage has been provided up to the 1 in 100 year +40% climate change (cc) storm event.

No existing surface water drainage has been identified within the boundary of the site. Should any drainage features be located serving off site areas, it may be necessary that these are diverted or incorporated within the on-site drainage proposals.

Where existing levels fall towards the site boundary it may be necessary to provide a cut off drain or similar to protect the site from any overland flows generated off site

It should be noted that both the Illustrative Drainage Strategy indicated within Appendix I, and supporting calculations within Appendix J, are preliminary, and as such, subject to further detailed design and approval by the relevant authorities. However, the designs illustrate that surface water arising from the development may be sustainably managed such that it does not pose a flood risk, either to proposed or existing development, to the 1 in 100 year +40% climate change storm event.

The proposed SuDS features provide an easily managed landscape structure for temporary storage of water and to trap and treat pollutants prior to discharge. Furthermore, the design of the swale will provide a preliminary stage of surface water treatment through sedimentation and filtration, prior to water passing through into the attenuation basins. The location and design also create opportunities for ecological and amenity benefits in the context of the development, subject to detailed landscape proposals. Further details of the proposed SuDS features are provided within Section 7.5.

7.5 Site Specific SuDS Benefits

Sustainable drainage is a departure from the traditional approach to draining sites. There are some key principles that influence the planning and design process enabling SuDS to mimic natural drainage by:

- storing run-off and releasing it slowly (attenuation);
- allowing water to soak into the ground (infiltration);
- slowly transporting (conveying) water on the surface;
- filtering out pollutants;
- allowing sediments to settle out by controlling the flow of water.

CIRIA has produced several guidance documents covering a range of water management scenarios. A summary of the publications used as reference when the site drainage strategy was produced are listed below.

- Planning for SUDS – making it happen (C687)
- Site handbook for the construction of SUDS (C698)
- The SUDS Manual 2015 (C753)
- Sustainable Drainage Systems – Hydraulic, structural and water quality advice.

7.5.1 Attenuation Basins

The attenuation basins will take the form of depressions, with 1 in 4 banks where achievable. They will allow peak flow rates to be reduced and enable flows to be limited to significantly below the existing run-off rate during storm events. These SuDS features are also useful in providing water treatment predominantly through the settlement of silts and suspended sediments. In addition, the basins could take the form of a multi stage treatment lagoon. Surface water entering the basins would initially enter a stilling area, facilitating the sedimentation of suspended solids. From here it could enter an area planted with reed beds to facilitate further sedimentation and facilitate the biological breakdown of oils and hydrocarbons which could enter the surface water drainage system, prior to discharge to the watercourse. A third ‘biopool’ area would be incorporated within the basin design, comprising a permanent level of standing water, to promote ecological value within the basin and provide a wet area at times when the basin may otherwise be dry. The basins can be landscaped to provide aesthetic and amenity value. Planting can be used to improve biodiversity and attract wildlife.

To demonstrate that surface water arising from the development will be appropriately treated prior to discharge, the Simple Index Approach, as outlined within the SuDS Manual (CIRIA C753) has been followed.

The most significant pollutant load within the site will arise from individual property driveways, residential car parks, low traffic roads and non-residential car parking with infrequent change. These

have an identified pollutant hazard level of 'Low as per the SuDS Manual (CIRIA C753) Table 26.2, with identified pollutant hazard indices of 0.5 for Total Suspended Solids (TSS), 0.4 for Metals, and 0.4 for Liquid Hydrocarbons.

The proposed attenuation basin has identified mitigation indices (The SuDS Manual, CIRIA C753, Table 26.3), of 0.5 for TSS, 0.5 for Metals and 0.6 for Liquid Hydrocarbons. Mitigation indices therefore exceed maximum anticipated pollutant hazard indices. This confirms that surface water arising from the development will receive an appropriate level of treatment in advance of discharge from site. Landscaping may also provide additional surface water treatment in advance of discharge.

7.5.2 Swale

Swales are designed to convey, treat and often attenuate surface water runoff. When incorporated into site designs, they can enhance the natural landscape and provide aesthetic and biodiversity benefits. A swale is proposed as part of the drainage system, which will provide an additional stage of surface water treatment through sedimentation and filtration, prior to water entering Pond 1. Due to site levels not all surface water will pass through the swale but where possible surface water should first be conveyed to the swale prior to out falling to the basin.

The proposed swale has identified mitigation indices (The SuDS Manual, CIRIA C753, Table 26.3), of 0.5 for TSS, 0.6 for Metals and 0.6 for Liquid Hydrocarbons.

7.5.3 Permeable Paving

Subject to detailed designs and consideration of the impact on adoptable drainage, permeable paving may be provided, for instance within private parking areas. Permeable paving provides 'at source' treatment of surface water, as well as limited surface water attenuation capacity, as long as such areas are appropriately maintained.

7.5.4 Water Butts

Water butts may be provided, and whilst they do not provide an attenuation role, especially when full, they do assist in minimising utility of water, and as such, can provide an important sustainable drainage role.

The utility of the above identified surface water management systems will be considered as part of detailed site engineering designs. Implementing a variety of SuDS techniques ensures that surface water quality is not compromised which meets the requirements of CIRIA Publication 'The SUDS Manual' C753 (2015).

7.6 Proposed Foul Water Drainage

As shown within the Illustrative Drainage Strategy provided in Appendix I, it is proposed that foul water will be conveyed by a gravity sewer system towards the north east corner of the site. A sewer will then be run offsite towards the 300mm diameter foul water sewer located to the east.

It is proposed to connect into the 300mm diameter public foul water sewer at manhole reference 0504, which is located approximately 300m to the east of the site. A Developer Enquiry and Sewer Capacity Assessment were completed in August 2013 for the site, which confirmed that capacity improvements were not required to accommodate flows from the proposed development. A new Developer Enquiry has been submitted to STW in order to confirm whether this capacity is still available, the response will be provided once received. STW correspondence is provided in Appendix F for reference.

7.7 Maintenance and Adoption

A foul water connection into the existing network will be subject to the successful submission of a Section 106 agreement under the Water Industry Act and approval from STW.

Subject to detailed engineering designs, it is likely that both foul and surface water drainage systems within the development will be adopted by STW. A specialist management company will be identified at the detailed design stage and appointed to maintain the SuDS features for the lifetime of the development.

Tables 7.3 to 7.6, below, indicate the envisaged maintenance activities associated with the proposed attenuation basins, swale, associated surface water headwalls, and the flow control manhole (i.e. Hydrobrake), along with the approximate frequency within which they should be completed.

Table 7.3: Attenuation Basin Suggested Maintenance Schedule

Maintenance Schedule	Required Actions	Typical Frequency
Regular Maintenance	Remove litter and debris	As required potentially monthly
	Cut grass – public areas	Monthly (during growing season)
	Cut grass – meadow grass in and around basin	Half yearly (spring, before nesting season, and autumn)
	Inspect vegetation to pond edge and remove nuisance plants (for first 3 years)	Monthly (at start, then as required)
	Hand cut submerged and emergent aquatic plants (at minimum of 0.1m above pond base; include max 25% of pond surface)	Annually
	Remove 25% of bank vegetation from waters edge to a minimum of 1m above water level	Annually
	Tidy all dead growth before start of growing season	Annually
	Remove sediment from forebay	1 – 5 years, or as required
	Remove sediment from one quadrant of the main body of ponds without sediment forebays	2 – 10 years (usually)
Occasional Maintenance	Remove sediment from the main body of big ponds, when pool volume is reduced by 20%	>25 years (usually)
Remedial Actions	Repair of erosion or other damage	As required
	Aerate pond when signs of eutrophication are detected	As required
	Realignment of rip rap or other damage	As required
	Repair/rehabilitation of inlets, outlets and overflows	As required

Table 7.4: Swale Suggested Maintenance Schedule

Maintenance schedule	Require Action	Typical Frequency
Regular Maintenance	Remove litter and debris	Monthly, or as required
	Cut grass – to retain grass height within specified design range	Monthly (during growing season), or as required
	Manage other vegetation and remove nuisance plants	Monthly at start, then as required
	Inspect inlets, outlets and overflows for blockages, and clear if required	Monthly
	Inspect infiltration surfaces for ponding, compaction, silt accumulation, record areas where water is ponding for > 48 hours	Monthly, or when required
	Inspect vegetation coverage	Monthly for 6 months, quarterly for 2 years, then half yearly
	Inspect inlets and facility surface for silt accumulation, establish appropriate silt removal frequencies	Half yearly
Occasional Maintenance	Reseed areas of poor vegetation growth; alter plant types to better suit conditions, if required	As required or if bare soil is exposed over 10% or more of the swale treatment area
Remedial Actions	Repair erosion or other damage by re-turfing or reseeding	As required
	Relevel uneven surfaces and reinstate design levels	As required
	Scarify and spike topsoil layer to improve infiltration performance, break up silt deposits and prevent compaction of the soil surface	As required
	Remove build-up of sediment on upstream gravel trench, flow spreader or at top of filter strip	As required
	Remove and dispose of oils or petrol residues using safe standard practices	As required

Table 7.5: Inlet and Outlet Headwall Suggested Maintenance Schedule

Maintenance Schedule	Required Actions	Typical Frequency
Regular Maintenance	Litter removal	As required
	Inspect vegetation above and around headwall and remove nuisance plants (for first 3 years)	Monthly (at start, then as required)
	Tidy all dead growth before start of growing season	Annually

	Remove sediment from aprons	Annually
	Flap valves and grilles: Check for and clear obstructions	Quarterly
	Litter removal	As required
	Inspect vegetation above and around headwall and remove nuisance plants (for first 3 years)	Monthly (at start, then as required)
	Tidy all dead growth before start of growing season	Annually
	Remove sediment from aprons	Annually
Remedial Actions	Repair of erosion or other damage around headwalls	As required
Monitoring	Inspect structures for evidence of poor operation	Monthly/after large storms
	Inspect structures, pipework etc. for evidence of physical damage	Monthly/after large storms
	Inspect silt accumulation rates and establish appropriate removal frequencies	Half yearly
	Check flap valves	Half yearly

Table 7.6: Flow Control Manhole Suggested Maintenance Schedule

Maintenance Schedule	Required Actions	Typical Frequency
Regular Maintenance	Inspect vegetation above and around flow control chamber and remove nuisance plants (for first 3 years)	Monthly (at start, then as required)
	Remove sediment from flow control chambers	Annually
	Flow control devices: Check for and clear obstructions	Quarterly
	Inspect vegetation above and around flow control chamber and remove nuisance plants (for first 3 years)	Monthly (at start, then as required)
	Remove sediment from flow control chambers	Annually
	Flow control devices: Check for and clear obstructions	Quarterly
	Inspect vegetation above and around flow control chamber and remove nuisance plants (for first 3 years)	Monthly (at start, then as required)
	Remove sediment from flow control chambers	Annually
	Flow control devices: Check for and clear obstructions	Quarterly
Remedial Actions	Repair of Penstock and flow control device	As required
Monitoring	Inspect structured for evidence of poor operation	Monthly/after large storm
	Inspect structures, flow control and pipework etc. for evidence of physical damage	Monthly/after large storm
	Inspect silt accumulation rates and establish appropriate removal frequencies	Half yearly
	Inspect structured for evidence of poor operation	Monthly/after large storm

8 CONCLUSION AND RECOMMENDATIONS

The proposed mixed use development at land off Whitford Road, Bromsgrove has been assessed with regards to flood risk. It is not considered that flooding poses a risk to the proposed residential development of the site subject to implementation of the recommended measures and drainage strategy.

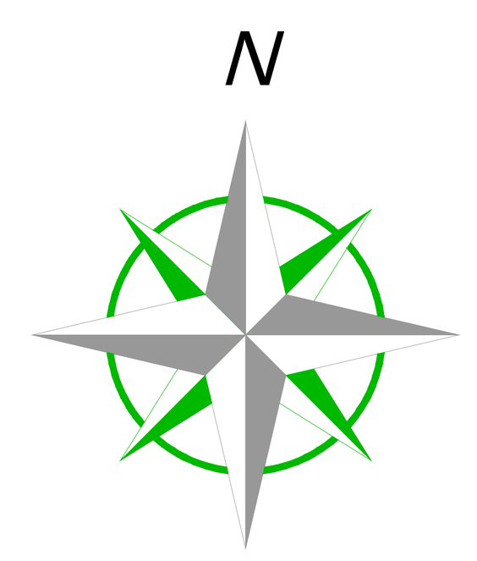
8.1 Review of NPPF Objectives

- The proposed development will not be affected by current or future flooding from any source.
- The development will not increase flood risk elsewhere.
- The measures proposed to deal with the effects and risks are appropriate.
- The exception test is not required for this assessment as the whole development site is located within Flood Zone 1 and has a vulnerability classification of “more vulnerable”.
- Other sources of flooding have also been assessed and it has been found that there will be no increase in risk of flooding from land, groundwater, canals, reservoirs or sewers as a result of this development.
- There are no anticipated negative impacts associated with the proposed development. Positive social, economic and environmental impacts will result from the proposed development provided mitigation measures outlined in Section 6 are adhered to.
- The FRA was prepared in line with the requirements of the NPPF.

8.2 Review of Drainage Strategy

- The proposed on site drainage strategy will be suitable to attenuate flows up to and including the 1 in 100+40% Climate Change rainfall event.
- Surface water discharge from the site is proposed to be limited to the greenfield runoff rate of 4.4 l/s/ha.
- Surface water for all events up to the 1 in 30 year (excluding highways) is to be disposed of via soakaways. Over and above this surface water attenuation will be provided within two attenuation basins located in the north east corner of the site.
- A swale is proposed to convey surface water flows and provide an additional stage of surface water treatment prior to discharge from the site.
- A surface water outfall is proposed to the Battlefield Brook located to the north of the site.
- The onsite sewers may be offered to Severn Trent Water for adoption under a Section 104 agreement.
- A foul water connection into the existing public sewerage network will be subject to Section 106 approval from Severn Trent Water.
- A connection into the Battlefield Brook may require consent from the Environment Agency.

Appendix A – Topographical Survey



Station Information:

Station	Easting (m)	Northing (m)	Level (m)
B1	394858.950	270012.966	109.366
B2	394836.951	270098.527	107.057
B3	394844.209	270254.503	98.712
B4	394808.822	270427.753	88.695
B5	394753.020	270552.302	86.645
B6	394691.945	270547.135	86.322
B7	394634.232	270581.217	86.894
B8	394545.527	270606.160	87.772
B9	394468.452	270675.637	88.229

Note:

Some services may have been omitted due to parked vehicles. The Ordnance Survey tile is to be used as a guide only.

OS Buildings *Surveyed Buildings*

This survey has been orientated to the Ordnance Survey (O.S) National Grid (OSGB36) via a Global Position System (GPS) and the O.S. Active Network (OS Net).

A true OSGB36 coordinate has been established near to the site centre via a transformation using the OSTN02 & OSGM02 transformation models.
The survey has been correlated to this point and a further one or more OSGB36 points established to create a true O.S. bearing for angle orientation.

No scale factor has been applied to the survey therefore the coordinates shown are arbitrary & not true O.S. Coordinates which have a scale factor applied.

Please refer to Survey Station Table to enable establishment of the on-site grid.

Legend:

Buildings / walls
Kerb line
Edge of surface
Canopy / Overhang
Line Marking
Centre Line
Barrier
H\R Hand rail
Hedge
Overhead Powerline
Chamber
Woodland
1 Station and Name
100.000 Station Level
Bush Sap Tree / Bush / Sapling
Area of Undergrowth
Gate

IC	Inspection chamber
MH	Manhole
Cvr	Cover
UTL	Unable to lift
Gy	Gully
Bg	Back Gully
TCL	Tree canopy level
G	Tree girth =
MG	Multi-girth
E:	Eaves level
R:	Ridge level
F:	Flat roof level
CPS	Concrete paving slabs
BP	Block paved
TT	Tac tile paving
Rnb	Road name board
R\wall	Retaining wall

Fence types:

I\W	Interwoven
I\R	Iron Railings
W\M	Wire Mesh
P\R	Post & Rail
P\W	Post & Wire
C\L	Chain Link
W\P	Wooden Panels
C\P	Concrete Panels
S\P	Steel Palisade

Elec	Electric
BT	British Telecom
Fh	Fire Hydrant
St	Stop tap
Sv	Stop valve
Wo	Wash Out
Wm	Water Meter
Mkr	Service Marker
Re	Rodding eye
Lp	Lamp Post
Sp	Sign Post
Ep	Electricity Post
Tp	Telegraph Post
Bo	Bollard
WL	Water level
ht	Height
IFL	Internal floor level
THL	Threshold level
Gas	Gas
Er	Earth rod

Rev	Date	Description	Drawn	Q. Ref.

greenhatch group

Topographical Surveys
Site Engineering

Measured Building Surveys
3D Laser Scanning

Rowan House
Duffield Road
Little Eaton
Derby
DE21 5DR
Tel (01332) 830044 Fax (01332) 830055
admin@greenhatch-group.co.uk

CLIENT

Catesby Property Group

PROJECT

Land off Whitford Road Bromsgrove

TITLE

Topographical Survey

SCALE	DATE	DRAWN	QUALITY REF
1: 1000	25.09.12	BG	E0740

Level datum	OS (GPS Verified)
Grid orientation	OS (GPS Verified)
Job number	17540

Drawing No.	Rev.
17540_OGL	0

Comments
This plan should only be used for its original purpose. GreenHatch Ltd accepts no responsibility for this plan if supplied to any party other than the original client.

All dimensions should be checked on site prior to design and construction.

Drainage information (where applicable) has been visually inspected from the surface and therefore should be treated as approximate only.

Notes:

DO NOT SCALE

Appendix B – Planning Layout

Notes

1. Reproduced from OS Sitemap ® by permission of Ordnance Survey® on behalf of The Controller of Her Majesty's Stationery Office. © Crown copyright 2008. All rights reserved. Licence number 100007126.

N

Denotes Location of Proposed 4m High Acoustic Fence

M5 MOTORWAY

M 5

POTENTIAL BUS GATE LOCATION

TIMBERHONGER LANE

SUNNINGDALE ROAD

WHITFORD ROAD

FOX LANE

MILLFIELD ROAD

DEANSWAY

DEANSWAY

0m 12.5m 25m 50m 75m 125m

1:1250

Revision	Desciption	Drawn	Checked	Date
B	Drawing updated to indicate proposed Acoustic Fence location.	AJS	GS	08.11.17
A	Drawing updated as per Client comments received 11.10.2017	MW	GS	24.10.17

Preliminary ■ Information ■ Tender ■ Construction ■ As Built ■

Woods Hardwick
Architects, Engineers and Development Consultants

15-17 Goldington Road
Bedford
MK40 3NH
United Kingdom
T. +44 (0)1234 268862
F. +44 (0)1234 353034
mail@woodshardwick.com
www.woodshardwick.com

Title: Land off Whitford Road: Bromsgrove

Details: Proposed Master Plan

Saved : h\projects

Scale: 1:1250@A1 Date: May '16 Drawn: MW Chk: GS

Please consider the environment before printing this drawing

16912/1012B

Appendix C – Correspondence with North Worcestershire Water Management

From:	Fiona McIntosh
To:	Josh Hughes; Dan Matthews
Subject:	FW: Flood Information Request - Land off Whitford Road, Bromsgrove, B61 7EQ (revised response)
Date:	27 May 2020 09:48:00
Attachments:	image005.png northworcestershirewatermanagementlogo65x72_a0117a5a-dd36-4d66-9229-8e0eb82b0a55.png Facebook_ba7fed51-b983-42e1-8261-ebe06d613443.png FloodsDestroyBePreparedLogo640x72_12d1a3ae-7102-45e9-b112-f1ec53101e12.png Bromsgrove SuDS DESIGN & EVALUATION.PDF

Good afternoon,

Further to your enquiry, please find within this email some information and advice which I hope is of assistance to you.

The site steeply slopes from South to North and ultimately drains into the Battlefield Brook, which flows to the North of the site. The site itself falls entirely within flood zone 1 (low risk of fluvial flooding). There is a portion of the site (a strip from South to North) which is at low risk of surface water flooding – maps indicating flood risk can be viewed here: https://flood-warning-information.service.gov.uk/long-term-flood-risk. We hold no reports of flooding on the site or in the immediate vicinity however I am aware of some instances of highway flooding nearby. While NWWM does not formally comment upon foul drainage, I would like to flag up that the additional properties may add to stress on the foul network where flooding is known to occur around the treatment works in Bromsgrove; STW will need to advise on this aspect. I would stress that our records are predominantly based upon reports of flooding from members of the public and therefore may not always be complete. If you wish to view the flood records for the area you will need to arrange this via my colleagues at Worcestershire County Council who hold the data – they are contactable via flooding@worcestershire.gov.uk.

In terms of groundwater, the site lies partially within zones II (outer protection) and III (total catchment) for a local aquifer – therefore I suggest that care is taken to ensure no contaminated runoff is discharged to the ground. On the other hand though, as the aquifer is heavily abstracted, drainage of clean roof water into the ground via SuDS would be welcomed; the FRA should provide a copy of the ground investigation report for the site to confirm the viability of infiltration drainage, and I advice the EA are contacted as experts in the groundwater field. Should a final discharge point be required into the Battlefield Brook, I would need to be sure that all sediments and pollutants have been removed, and that discharge is to an agreed attenuated volume. The watercourse at this point is classed as a Main River and I advise the EA are contacted to discuss permit requirements.

An FRA was provided as part of the planning application reference 16/1132; in general this is still fit for purpose however the climate change allowances used are not in line with the current guidance, and we would expect to see values of 40% used in a revised document. Greenfield runoff rates and volumes must not be exceeded, to ensure no increase in flood risk – the techniques for this are outlined in the attached document, and an appropriate allowance for urban creep should also be included. We would expect to see a variety of SuDS techniques used to manage not only the quality of water generated, but also to ensure good water quality leaving the site. A phasing plan for the SuDS / development would be required as part of a full planning application, although I note this may not necessarily form part of the FRA.

NWWM, along with various other local authorities, have signed up to a SuDS Design Guidance document – this gives more detail on exactly what we wish to see within an FRA / drainage strategy; I have attached a copy for reference.

I hope this helps.

Kind regards,
Fiona.

Fiona McIntosh BSc (Hons)
Senior Water Management Officer
North Worcestershire Water Management
A shared District Council service covering Bromsgrove, Redditch & Wyre Forest
01562 732 567
Wyre Forest House, Finepoint Way, Kidderminster, DY11 7WF
Fiona.McIntosh@nwwm.org.uk

Keep up to date on the latest news via NorthWorcsflooding

FLOODS DESTROY BE PREPARED

Our vision is to reduce flood risk while protecting and enhancing the water environment and encouraging sustainable water management

---

From: Josh Hughes [mailto:Josh.Hughes@rpsgroup.com]
Sent: 19 May 2020 14:55
To: North Worcestershire Water Management Enquiries
Subject: External Email : Flood Information Request - Land off Whitford Road, Bromsgrove, B61 7EQ

Good Afternoon,

We wish to enquire with you regarding a proposed development at land off Whitford Road, Bromsgrove, Worcestershire, B61 7EQ. I have attached a location plan for your reference.

Please could you provide any flood information you hold for the site, such as flood maps (fluvial, surface water, groundwater) and historic flood information.

We will be completing a Flood Risk Assessment to support a planning application for the site, therefore do you have any specific requirements for the surface water drainage strategy or Flood Risk Assessment?

If you require any further information then let me know.

Kind Regards,
Josh

Josh Hughes
Assistant Hydrologist
RPS | Consulting UK & Ireland
Salisbury House, 2a Tettenhall Road
Wolverhampton, West Midlands WV1 4SA, United Kingdom
T +44 1902 925 500
E josh.hughes@rpsgroup.com

We recognise that the months ahead will pose challenges for many of our clients and partners. We're here to help in any way we can. While COVID-19 might separate us physically in the short term, please know that we're here, we're with you and we're stronger together.

If you need support or would like to discuss your forward looking priorities, please get in touch. You can continue to contact me in the usual ways via phone and email, or we can set up a virtual meeting.

Appendix D – Correspondence with Environment Agency

From:	Josh Hughes
To:	Enquiries, Unit
Subject:	Flood Information Request - Land off Whitford Road, Bromsgrove, B61 7EQ
Date:	19 May 2020 15:16:00
Attachments:	Location Plan - Whitford Road.pdf image002.png

Good Afternoon,

We wish to enquire with you regarding flood information for a proposed development at land off Whitford Road, Bromsgrove, Worcestershire, B61 7EQ. I have attached a location plan for your reference.

Please could you provide a Product 1 information pack for the site, including flood maps (fluvial, surface water, groundwater) and historic flood information.

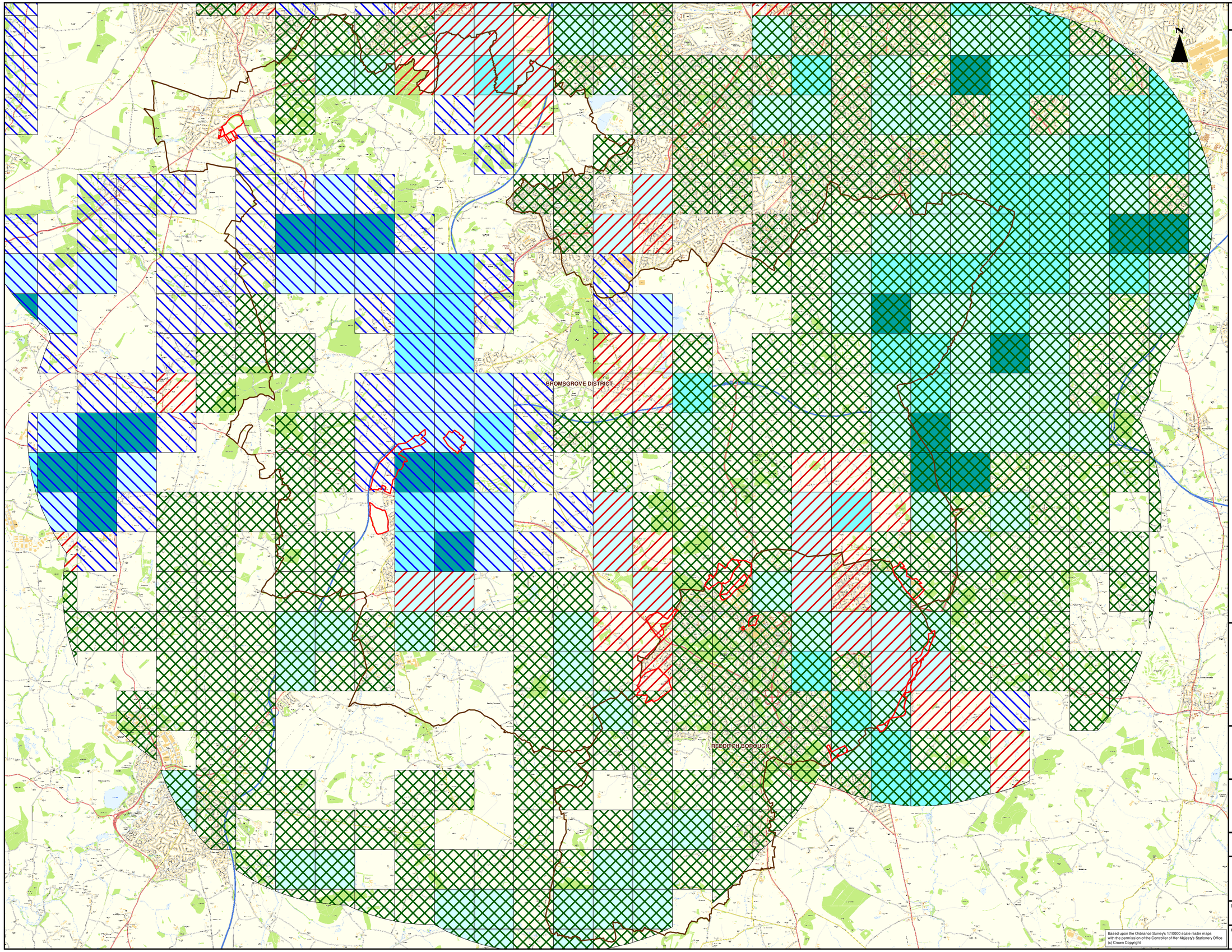
We will be completing a Flood Risk Assessment to support a planning application for the site, therefore do you have any specific requirements for the surface water drainage strategy or Flood Risk Assessment in this instance?

If you require any further information then let me know.

Kind Regards,
Josh

Josh Hughes
Assistant Hydrologist
RPS | Consulting UK & Ireland
Salisbury House, 2a Tettenhall Road
Wolverhampton, West Midlands WV1 4SA, United Kingdom
T +44 1902 925 500
E josh.hughes@rpsgroup.com

Appendix E – Groundwater Flooding Map



Development Sites Investigated For the SFRA

Council Boundaries

Ground Water Flooding by Flood Type

- Clearwater Flooding*
- Clearwater and Superficial Deposits Flooding
- Superficial Deposits Flooding**

Ground Water Flooding Coverage

Coverage per 1km square

- < 25%
- >= 25% <50%
- >= 50% <75%
- >= 75%

*Clearwater flooding results from groundwater rising and outcropping at the surface

**Superficial deposits flooding occurs when water moves through the permeable deposits from the river and floods the low-lying land either side of the river

Redditch and Bromsgrove Strategic Flood Risk Assessment

Areas at Risk of Groundwater Flooding By Type and Coverage

MWH

DRAWN BY	SCALE	DATE	Original Drawing Size
MC	1:40000	March 12	A1
CHECKED BY	DRG. NO.		
	41518000/01/004		

Appendix F – Correspondence with Severn Trent Water

- 7 AUG 2013

Severn Trent Water

Severn Trent Water Ltd
Regis Road
Wolverhampton
WV6 8RU

Tel: 01902 793871
Fax: 01902 793971

www.stwater.co.uk
net.dev.west@severntrent.co.uk

Contact: Jim Wincott

Your ref:
Our ref: WT31635 and SAP 8100

Catesby Property Group
Catsby House
5B Tournament Court
Edgehill Drive
Warwick
CV34 6LG

Ftao Graham Whitehouse

4th August 2013

Dear Graham,

Proposed Development at Land off Whitford Road/Timberhonger Lane, Bromsgrove, Worcestershire

I refer to your Development Enquiry Request last year and my reply of 29th October 2012 in respect of the above site.

You will shortly be receiving the Sewer Capacity Assessment modelling report, in which it would seem you proposed a pumped flow to the sewer network at manhole 9401 in Deansway.

You may remember in my letter of October that I stated that it was considered the whole site was capable of gravitating and this is still the case. The foul water branch sewer in Deansway has very good gradients of 1 in 21 to 1in 60 for the 225mm dia pipe and 1 in 124 for the 300mm pipe. A connection could be made to this branch sewer at any appropriate point to the suit the outfall sewer from the development site. The invert levels of the next three foul manholes downstream of the preferred connection point (MH 9401) are approximately 87m (MH9501), 85.5m (MH0505) and 82m (MH0504) AOD respectively.

The Water Company's first option for a connection to the sewerage system is by gravity where a development site can achieve this and where it cannot a pumped connection is then considered, but all other gravity options are explored for their viability, as a pumped flow is treated as a last resort, because of the on-going maintenance and running costs.

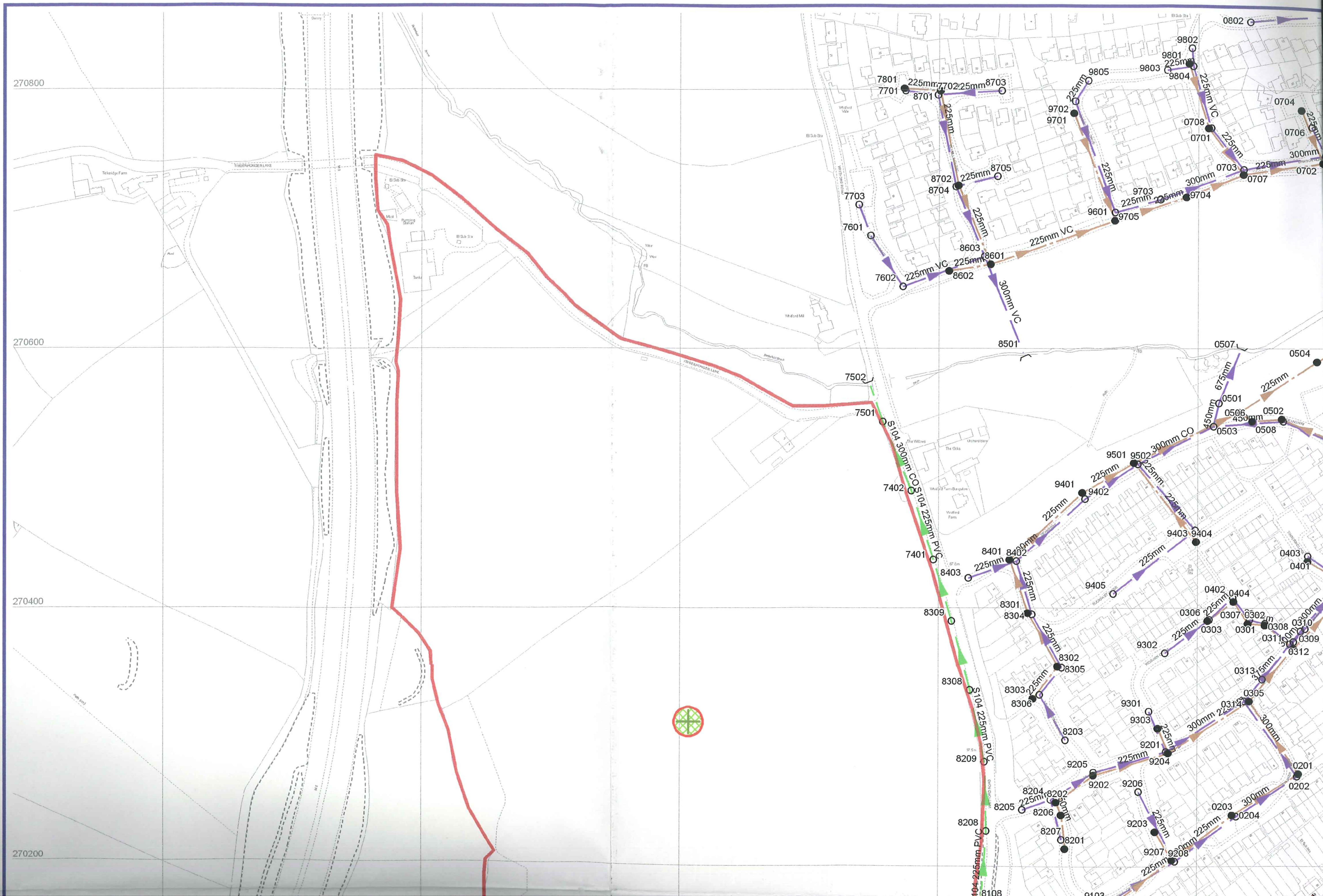
Please investigate thoroughly the potential gravity sewer option to the appropriate point to serve the whole development.

Severn Trent Water

Please quote WT31635 in any future correspondence (including e-mails) with STW Limited.

Yours sincerely,

Jim Wincott
Waste Water Services - Asset Protection (West)



270800
270600
270400
270200
0802
9802
9801
225mm
9803
9804
9805
7801
7701
225mm
7702
225mm
8703
8701
225mm
225mm VC
9702
9701
0704
0708
0701
0706
225mm
300mm
8702
8705
225mm
8704
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9703
225mm
225mm
9704
300mm
0703
0707
0702
7703
7601
9601
9705
225mm VC
8603
8601
225mm
225mm VC
7602
8602
300mm VC
8501
0507
0504
675mm
225mm
7502
7501
0501
450mm
0506
450mm
0503
0502
0508
300mm CO
S104 300mm CO
S104 225mm PVC
9501
9502
225mm
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9401
9402
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7402
8401
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9403
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9302
0311
0309
0312
225mm
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8305
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315mm
8303
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8306
8308
S104 225mm PVC
0305
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9303
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8203
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9203
8207
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225mm
8208
9207
9208
S104 225mm PVC
225mm
8108

- Abandoned Sewer
- Private Combined Gravity Sewer
- Private Foul Gravity Sewer
- Private Surface Water Gravity Sewer
- Public Combined Gravity Sewer
- Public Foul Gravity Sewer
- Public Surface Water Gravity Sewer
- Trunk Combined Gravity Sewer
- Trunk Foul Use Gravity Sewer
- Trunk Surface Water Gravity Sewer
- Combined Use Pressurised Sewer
- Foul Use Pressurised Sewer
- Surface Water Pressurised Sewer
- Highway Drain
- Combined Lateral Drain (SS)
- Foul Lateral Drain (SS)
- Surface Water Lateral Drain (SS)

- Cable, Earthing
- Cable Junction
- Cable, Optical Fibre/Instrumentation
- Cable, Low Voltage
- Cable, High Voltage
- Cable, Other
- Housing, Building (B)
- Housing, Kiosk (K)
- Disposal Site (DS)
- Sewage Treatment Works (STW)
- Housing, Other
- Pipe Support Structure
- Sewage Pumping Facility
- Sewer Facility Connection Inlet / Outlet

- Blind Shaft
- Combined Use Manhole
- Flushing Chamber
- Foul Use Manhole
- Grease Trap
- Head Node
- Hydrobrake
- Lamphole
- Outfall
- Overflow
- Penstock
- Petrol Interceptor

- Sewer Chemical Injection Point
- Sewer Junction
- Sewerage Air Valve
- Sewerage Hatch Box Point
- Sewerage Isolation Valve
- Soakaway
- Surface Water Manhole
- Vent Column
- Waste Water Storage
- Culverted Watercourse
- Pre-1937 Properties

MATER

AC - ASB
BR - BRI
CC - CON
CI - CAS
CO - CON
CSB - CON
CSU - CON
DI - DUC
GRC - GLA
MAC - MAS
MAR - MAS
PE - POL
PF - PITC
PP - POL
PSC - PLA
PVC - POL
RPM - REI
SI - SPU
XXX - OTH

All Private Sew
All section 104
All Sewers tha
Trent Water are

Sewer Node		Sewer Pipe Data								
REFERENCE	COVER LEVEL	INV LEVEL UPSTR	INV LEVEL DOWNSTR	PURP	MATL	SHAPE	MAX SIZE	MIN SIZE	GRADIENT	YEAR LAID
SO94696801	114.51	112.93	111.51	S	VC	C	150	nil	12.93	nill
SO94696805	113.44	111.49	111.22	S	VC	C	225	nil	123.00	nill
SO94696902	117.31	115.83	114.13	S	VC	C	225	nil	18.02	nill
SO94697801	113.88	112.71	109.84	S	VC	C	150	nil	11.62	nill
SO94697803	111.48	109.78	108.19	S	VC	C	225	nil	20.27	nill
SO94697804	112.21	110.73	109.84	S	VC	C	150	nil	36.68	nill
SO94697809	109.82	107.64	107.43	S	VC	C	225	nil	124.24	nill
SO94697902	114.16	112.20	111.37	S	PVC	C	225	nil	21.69	nill
SO94697903	115.22	113.66	112.24	S	VC	C	225	nil	38.84	nill
SO94697906	115.61	114.10	113.68	S	VC	C	225	nil	62.64	nill
SO94697907	114.77	113.42	112.75	S	VC	C	150	nil	39.22	nill
SO94698803	109.36	107.37	107.15	S	CO	C	300	nil	163.09	nill
SO94698905	111.40	109.01	108.84	S	PVC	C	225	nil	211.29	nill
SO94698906	110.88	108.21	107.29	S	PVC	C	225	nil	23.68	nill
SO94698907	110.95	108.39	108.39	S	PVC	C	225	nil	0.00	nill
SO94698908	112.78	108.63	108.40	S	CC	R	2010	1250	112.91	nill
SO94698909	111.30	109.12	109.03	S	VC	C	225	nil	267.20	nill
SO94698910	110.42	109.26	109.14	S	VC	C	225	nil	218.67	nill
SO94698912	108.92	106.11	105.56	S	PVC	C	150	nil	79.09	nill
SO94699802	100.37	99.25	97.88	F	nil	C	150	nil	31.72	nill
SO94699803	100.40	99.38	97.88	S	nil	C	150	nil	29.75	nill
SO94699902	106.15	104.88	96.56	S	nil	C	150	nil	15.72	nill
SO94699905	106.41	105.55	105.51	S	VC	C	150	nil	230.50	nill
SO94707401	88.18	86.94	86.02	S	PVC	C	225	nil	60.43	nill
SO94707402	87.10	85.90	85.50	S	CO	C	300	nil	143.88	nill
SO94707501	86.82	85.50	85.03	S	CO	C	300	nil	63.46	nill
SO94707601	87.64	85.85	85.12	S	VC	C	225	nil	62.59	1944
SO94707602	86.57	85.06	84.71	S	VC	C	225	nil	191.63	1944
SO94707701	92.50	90.78	90.00	S	nil	C	225	nil	32.28	nill
SO94707702	92.17	90.03	87.04	S	nil	C	225	nil	24.20	nill
SO94707703	88.60	86.82	85.89	S	VC	C	225	nil	27.56	1914
SO94707801	92.55	91.20	90.40	F	nil	C	225	nil	35.53	nill
SO94708003	108.29	106.80	103.43	S	VC	C	150	nil	19.09	nill
SO94708006	109.72	107.29	106.66	S	PVC	C	225	nil	25.10	nill
SO94708007	109.08	106.69	106.10	S	PVC	C	225	nil	79.97	nill
SO94708008	108.05	106.09	105.98	S	PVC	C	225	nil	183.10	nill
SO94708009	107.70	105.97	104.70	S	PVC	C	225	nil	26.73	nill
SO94708106	105.86	104.69	102.75	S	PVC	C	225	nil	14.40	nill
SO94708107	103.85	102.75	100.83	S	PVC	C	225	nil	13.86	nill
SO94708108	101.87	100.84	98.22	S	PVC	C	225	nil	20.95	nill
SO94708201	101.61	99.58	97.48	F	nil	C	225	nil	12.46	nill
SO94708202	99.20	nil	96.70	F	nil	C	225	nil	0.00	nill
SO94708203	98.89	97.29	96.83	S	nil	C	225	nil	87.63	nill
SO94708204	99.20	nil	97.08	S	nil	C	300	nil	0.00	nill
SO94708205	99.06	97.56	nil	S	nil	C	225	nil	0.00	nill
SO94708206	99.78	97.46	nil	F	nil	C	150	nil	0.00	nill
SO94708207	101.17	98.94	nil	S	nil	C	225	nil	0.00	nill
SO94708208	99.44	98.20	96.94	S	PVC	C	225	nil	42.56	nill
SO94708209	98.14	96.94	93.36	S	PVC	C	225	nil	15.83	nill
SO94708301	94.66	92.89	90.25	F	nil	C	225	nil	16.41	nill
SO94708302	98.74	96.31	92.91	F	nil	C	225	nil	13.79	nill
SO94708303	98.71	97.17	96.48	F	nil	C	225	nil	45.51	nill
SO94708304	94.82	92.63	90.00	S	nil	C	225	nil	16.18	nill
SO94708305	98.79	95.92	92.67	S	nil	C	225	nil	14.46	nill
SO94708306	98.79	96.76	96.37	S	nil	C	225	nil	69.28	nill
SO94708308	94.45	93.29	89.70	S	PVC	C	225	nil	15.33	nill
SO94708309	90.91	89.69	86.96	S	PVC	C	225	nil	18.09	nill
SO94708401	91.69	90.24	88.76	F	nil	C	225	nil	51.64	nill
SO94708402	91.73	88.23	87.98	S	nil	C	300	nil	297.96	nill
SO94708403	90.03	88.59	88.37	S	nil	C	225	nil	178.27	nill
SO94708601	87.00	84.75	83.93	F	VC	C	225	nil	124.20	1944
SO94708602	86.88	85.56	84.76	F	nil	C	225	nil	40.49	nill
SO94708603	87.17	84.54	83.46	S	VC	C	300	nil	73.94	1944

Sewer Node		Sewer Pipe Data								
REFERENCE	COVER LEVEL	INV LEVEL UPSTR	INV LEVEL DOWNSTR	PURP	MATL	SHAPE	MAX SIZE	MIN SIZE	GRADIENT	YEAR LAID
SO94709702	92.33	90.18	85.08	S	nil	C	225	nil	17.93	nill
SO94709703	87.20	84.91	85.45	S	nil	C	300	nil	0.00	nill
SO94709704	86.89	83.45	83.14	F	nil	C	225	nil	152.16	nill
SO94709705	86.88	85.05	84.91	S	nil	C	225	nil	260.00	nill
SO94709801	93.41	90.48	87.33	F	VC	C	225	nil	16.52	nill
SO94709802	94.72	92.74	91.81	S	nil	C	225	nil	15.26	nill
SO94709803	93.42	92.22	91.75	S	nil	C	225	nil	43.96	nill
SO94709804	93.21	90.68	87.78	S	VC	C	225	nil	17.18	nill
SO94709805	93.32	91.76	90.95	S	nil	C	225	nil	23.30	nill
SO95690801	96.96	96.18	nil	F	nil	C	150	nil	0.00	nill
SO95690802	97.65	96.53	nil	S	nil	C	150	nil	0.00	nill
SO95690804	96.98	96.10	nil	S	nil	C	150	nil	0.00	nill
SO95690805	98.54	97.84	96.14	S	nil	C	150	nil	14.16	nill
SO95690806	98.55	97.86	96.18	F	nil	C	150	nil	13.21	nill
SO95690901	88.81	86.95	83.59	F	U	C	225	nil	20.07	nill
SO95690903	88.87	87.22	83.99	S	U	C	225	nil	20.57	nill
SO95690904	89.40	87.56	87.26	S	U	C	225	nil	174.43	nill
SO95700101	88.15	86.62	81.41	F	U	C	225	nil	41.42	nill
SO95700103	87.14	85.44	84.46	S	U	C	225	nil	60.74	nill
SO95700104	91.05	89.76	85.48	S	nil	C	150	nil	10.98	nill
SO95700201	92.92	90.86	90.58	F	nil	C	225	nil	241.71	nill
SO95700202	92.86	91.42	nil	S	nil	C	300	nil	0.00	nill
SO95700203	93.25	91.27	90.88	F	nil	C	225	nil	154.38	nill
SO95700204	93.12	91.77	91.42	S	nil	C	300	nil	160.86	nill
SO95700301	96.33	94.06	94.01	S	nil	C	225	nil	247.40	nill
SO95700302	96.19	94.00	93.75	S	nil	C	225	nil	96.27	nill
SO95700303	96.50	94.72	94.25	S	nil	C	225	nil	52.68	nill
SO95700304	96.17	90.24	89.78	F	nil	C	225	nil	138.45	nill
SO95700305	96.86	91.08	90.70	S	nil	C	375	nil	157.03	nill
SO95700306	96.51	94.99	94.59	F	nil	C	225	nil	62.50	nill
SO95700307	96.31	94.34	94.31	F	nil	C	225	nil	434.67	nill
SO95700308	96.18	94.30	94.01	F	nil	C	225	nil	101.54	nill
SO95700309	95.97	90.54	90.22	S	nil	C	375	nil	131.88	nill
SO95700310	95.98	93.29	93.10	S	nil	C	300	nil	270.53	nill
SO95700311	96.16	93.50	93.30	S	nil	C	300	nil	64.05	nill
SO95700312	96.13	90.69	90.55	S	nil	C	375	nil	96.07	nill
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SO95700314	96.81	90.54	90.26	F	nil	C	225	nil	190.21	nill
SO95700401	95.23	93.65	93.20	S	nil	C	225	nil	75.13	nill
SO95700402	96.01	94.24	94.07	S	nil	C	225	nil	133.75	nill
SO95700403	95.24	93.83	93.53	F	nil	C	225	nil	131.50	nill
SO95700404	95.98	94.51	94.35	F	nil	C	225	nil	126.56	nill
SO95700501	87.28	84.18	82.37	S	nil	C	675	nil	23.29	nill
SO95700502	90.65	88.51	87.56	F	nil	C	225	nil	23.96	nill
SO95700503	89.48	86.84	nil	S	nil	C	450	nil	0.00	nill
SO95700504	84.75	82.06	81.40	F	nil	C	300	nil	124.03	nill
SO95700505	89.54	85.55	82.08	F	nil	C	225	nil	20.62	nill
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SO95700508	90.68	89.03	87.06	S	nil	C	450	nil	27.49	nill
SO95700701	89.25	87.31	84.80	F	nil	C	225	nil	17.93	nill
SO95700702	87.73	82.84	81.77	F	nil	C	225	nil	83.19	nill
SO95700703	87.53	83.12	82.86	F	nil	C	225	nil	241.54	nill
SO95700704	89.28	87.46	85.10	F	nil	C	225	nil	18.81	nill
SO95700705	87.61	84.11	83.22	S	nil	C	375	nil	108.15	nill
SO95700706	88.44	86.87	85.32	S	nil	C	225	nil	15.97	nill
SO95700707	87.60	84.44	84.13	S	nil	C	300	nil	210.06	nill
SO95700708	89.35	87.76	85.50	S	nil	C	225	nil	17.97	nill
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nil	nil	111.07	110.85	F	VC	C	150	nil	133.62	nill
nil	nil	115.56	113.84	F	VC	C	150	nil	19.44	nill
nil	nil	109.08	107.65	F	VC	C	150	nil	20.55	nill
nil	nil	106.39	106.18	F	VC	C	150	nil	142.18	nill

SO94708603	87.17	84.54	83.46	S	VC	C	300	nil	73.94	1944
SO94708701	92.24	90.38	86.73	F	nil	C	225	nil	20.31	nill
SO94708702	88.77	86.71	84.77	F	nil	C	225	nil	33.98	nill
SO94708703	93.41	91.89	90.05	S	nil	C	225	nil	26.68	nill
SO94708704	88.69	87.01	84.72	S	VC	C	225	nil	25.46	1944
SO94708705	88.89	87.38	87.06	S	nil	C	225	nil	103.06	nill
SO94709001	102.87	100.71	93.52	F	nil	C	150	nil	6.97	nill
SO94709002	97.42	95.61	89.80	S	VC	C	150	nil	7.73	nill
SO94709003	104.95	103.41	95.61	S	VC	C	150	nil	7.54	nill
SO94709102	100.89	97.58	92.19	S	nil	C	225	nil	10.91	nill
SO94709103	101.00	97.51	93.82	F	nil	C	225	nil	15.50	nill
SO94709104	103.49	100.73	98.88	S	nil	C	225	nil	13.84	nill
SO94709105	94.94	93.46	86.88	F	nil	C	150	nil	8.80	nill
SO94709201	97.54	95.44	94.68	F	nil	C	225	nil	95.82	nill
SO94709202	99.09	96.69	95.46	F	nil	C	225	nil	49.54	nill
SO94709203	96.42	93.99	91.89	F	nil	C	225	nil	12.11	nill
SO94709204	97.56	95.87	91.12	S	nil	C	300	nil	15.07	nill
SO94709205	99.06	97.06	95.89	S	nil	C	300	nil	49.78	nill
SO94709206	97.49	96.24	92.20	S	nil	C	225	nil	15.06	nill
SO94709207	95.73	91.83	91.28	F	nil	C	225	nil	105.09	nill
SO94709208	95.44	92.17	91.78	S	nil	C	300	nil	154.21	nill
SO94709301	97.74	96.65	95.99	S	nil	C	225	nil	50.94	nill
SO94709302	97.51	95.54	94.73	S	nil	C	225	nil	52.20	nill
SO94709303	97.62	95.70	95.46	F	nil	C	225	nil	85.92	nill
SO94709401	90.43	88.75	87.10	F	nil	C	225	nil	27.96	nill
SO94709402	90.44	87.96	87.81	S	nil	C	300	nil	327.27	nill
SO94709403	95.84	93.41	87.62	S	nil	C	225	nil	11.63	nill
SO94709404	95.91	94.07	87.09	F	nil	C	225	nil	11.10	nill
SO94709405	97.08	95.92	93.43	S	nil	C	225	nil	32.05	nill
SO94709501	89.27	87.07	85.57	F	VC	C	225	nil	59.93	nill
SO94709502	89.25	87.61	86.98	S	CO	C	300	nil	101.33	nill
SO94709601	87.00	83.92	83.46	F	nil	C	225	nil	125.80	nill
SO94709701	91.58	89.07	83.95	F	nil	C	225	nil	17.38	nill

nil	nil	106.13	105.80	F	VC	C	150	nil	173.93	nill
nil	nil	113.79	113.38	F	VC	C	150	nil	65.61	nill
nil	nil	113.56	111.90	F	VC	C	150	nil	32.97	nill
nil	nil	111.83	108.39	F	VC	C	150	nil	26.14	nill
nil	nil	106.62	106.41	F	VC	C	150	nil	142.27	nill
nil	nil	105.77	105.57	F	PVC	C	150	nil	183.57	nill
nil	nil	105.54	104.97	F	PVC	C	150	nil	72.45	nill
nil	nil	nil	nil	F	nil	nil	nil	nil	0.00	nill

IALS

ESTOS CEMENT
K
CRETE BOX CULVERT
T IRON
CRETE
CRETE SEGMENTS (BOLTED)
CRETE SEGMENTS (UNBOLTED)
TILE IRON
SS REINFORCED CONCRETE
ONRY IN REGULAR COURSES
ONRY RANDOMLY COURSED
ETHLENE
H
PROPYLENE
TIC STEEL COMPOSITE
VINYL CHLORIDE
FORCED PLASTIC MATRIX
(GREY) IRON
R

ers are shown in magenta
sewers are shown in green
have been transferred to Severn Trent Water after the 1st October 2011, but have not been surveyed and confirmed by Severn
shown in orange

CATEGORIES

W	- WEIR
C	- CASCADE
DB	- DAMBOARD
SE	- SIDE ENTRY
FV	- FLAP VALVE
BD	- BACK DROP
S	- SIPHON
HD	- HIGHWAY DRAIN
S104	- SECTION 104

SHAPE

C	- CIRCULAR
E	- EGG SHAPED
O	- OTHER
R	- RECTANGLE
S	- SQUARE
T	- TRAPEZOIDAL
U	- UNKNOWN

PURPOSE

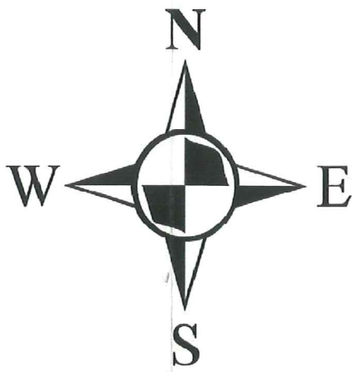
C	- COMBINED
E	- FINAL EFFLUENT
F	- FOUL
L	- SLUDGE
S	- SURFACE WATER

TABULAR KEY

A. Sewer pipe data refers to downstream sewer pipe.

B. Where the node bifurcates (splits) X and Y indicates downstream sewer pipe.

C. Gradient is stated a 1 in...



SEVERN TRENT WATER

Severn Trent Water Limited
Asset Data Management
PO Box 5344
Coventry
CV3 9FT
Telephone: 0845 601 6616

SEWER RECORD (TABULAR)

O/S Map scale: 1:2500

Date of issue: 25.10.12

Sheet No. 1 of 1

This map is centred upon:
O / S Grid reference:

x : 394591

y : 270338

Sewer Capacity Assessment

Whitford Road, Bromsgrove

Severn Trent Project Reference DE-1211-081

Version 1

Date: Aug 2013

Pell Frischmann
Burrator House
Peninsula Park
Rydon Lane
EXETER
EX2 7NT

Pell Frischmann
CONSULTANTS LTD

Sewer Capacity Assessment Summary

Sewer Capacity Assessment prepared for	Halcrow Group Ltd, Redhill House, 227 London Road, Worcester, WR5 2JG	
Development location and existing use	Site is located on farmland at the western edge of Bromsgrove at OS Grid ref SO494607,70312, Whitford Rd and Timberhanger Lane form it's eastern and northern boundaries.	
Development proposals	Foul flows from 525 residential units, 225 terraced and 300 semi detached houses, are proposed to connect via a newly constructed pump station into the public sewer system. Construction is programmed to start on 01/06/13 with the first property occupied on 01/08/13. No phasing information has been provided and there is no record of the site on Bromsgrove DC's Planning Portal at the time of reporting.	
Study aim	The aim of the study is to identify the potential impact of foul flows from the proposed development on the sewerage system.	
Impact of proposed development on public sewer network	Sewer flooding	Low
	Combined Sewer Overflows	Low
	Sewage Pumping Stations	Low
Requirement for Capacity Improvements	Capacity improvements are not required to accommodate flows from the proposed development.	
Sewage Treatment Works capacity	The site drains to Bromsgrove sewage treatment work. There is sufficient capacity at the STW to accommodate flows from this development. Whilst comparison of the measured DWF against the consented DWF indicates spare headroom equivalent, analysis of secondary treatment process indicates ZERO oxidation headroom.	

Important Information:

This Sewer Capacity Assessment has been prepared by Pell Frischmann on behalf of Severn Trent Water Ltd for Catesby Property Group. This report is based on the best available information at the time of undertaking, including Severn Trent Water hydraulic models and development proposals submitted by Catesby Property Group. If there are any changes to the development proposals after the date of submission that may affect waste water, Severn Trent Water must be informed as there may be a requirement to revisit the assessment. If there is a delay in submitting the planning application or commencing construction on site from the

anticipated dates provided, the information in this report may have become out of date and Severn Trent Water must be informed as there may be a requirement to revisit the assessment based on new information.

Table of Contents

1 Introduction

1.1 Site Location

The site is located on greenfield, currently farmed, land on the western outskirts of Bromsgrove at OS Grid Reference SO 94607 70312, with the M5 Motorway, Timberhanger Lane and Whitford road forming its Western, Northern and Eastern boundaries respectively. As such it isn't connected to the existing sewerage network

The site location is shown in Figure A-1, Appendix A.

1.2 Local Sewerage Network

The area downstream and in the vicinity of the proposed development is predominantly medium density residential housing, consisting of separately drained properties built in the 1960s

There are no known reported local capacity issues in the network.

The local sewerage network and the location of critical sewer assets are shown in Figure A-2, Appendix A.

1.3 Proposed Development

The proposed development consists of 525 residential units in total and their associated roads, a small park/play area and landscaping. The developer proposes to connect foul flows from the site into the existing public sewer system via rising main at manhole (MH) SO94709401 which is on Deansway, to the east of the site. The developer states the onsite surface water drainage system will not connect into the existing public sewer and therefore it has not been considered in this report.

The proposed development is summarised in Table 1-1. Development plans are included in Appendix A.

Table 1-1: Summary of proposed development

Development Type	Units
Housing	*225 terraced* *300 semi-detached*

1.4 Study Aims and Objectives

The aim of the study is to identify the potential impact of flows from the proposed development on the public sewer network. This will be achieved through undertaking hydraulic computer modelling of the proposed development and assessing the impact at key points on the sewer network. Where capacity improvements are likely to be required to accommodate flows from the development, the preferred notional solution is provided.

2 Sewer Capacity Assessment

2.1 Methodology

Hydraulic modelling has been used to assess the impacts of the proposed development. The methodology is summarised below:

- The best available model for the area was used as the 'baseline model'. A review of the model was undertaken to ensure that it is suitable to inform the assessment.
- The model of the sewer network draining to Bromsgrove STW was last verified in 2009. Since then details of six S104 developments and one sewer diversion (Perryfields Road) have been added to it. To date no Model Investment Confidence Assessment Score (MICAS) analysis has been performed on this catchment, as it is classed as a "non Live" Sewerage Management Plan (SMP) Catchment.
- The baseline model and proposed model were run for dry weather flow analysis and the 20 and 40 year return period events for a suite of storm durations. The results for the critical storm duration are reported throughout this report. The models were also run for the 1 year 60 minute and 5 year 90 minute storms to enable an assessment of Combined Sewer Overflow (CSO) performance.
- The model results were analysed to determine the impact of the additional flows on network performance and identify whether capacity improvements are required.

2.2 Proposed Development Flows

Foul flows arising from the proposed development have been derived using Severn Trent Water standard guidance. The developer has given two types of housing, terraced and semi detached thus the population for the site has been derived using occupancy rates of 2.2 and 2.6 respectively. During the 2009 model verification, the consumption rate of 147 l/hd/day was derived for the area surrounding the development, so this value has been used for the proposed development.

The site has been modelled to connect in at the developer's preferred manhole, reference SO94709401, and the flows are modelled to connect to the network.

No analysis of surface water flows has been undertaken as this is beyond the scope of this report.

2.3 Impact of Proposed Development on Sewer Capacity

The impact of the proposed development on sewer flooding is summarised in Table 2-1. The impact at each location is assigned an 'Impact Risk Level', which considers whether a change in performance as a result of the development is acceptable based on the risk of sewer flooding.

Table 2-1: Predicted impact on sewer flooding for modelled scenarios (baseline and post-development)

Location	Baseline performance			Post-development impact			Impact Risk Level
Road	DWF	20 year event	40 year event	DWF	20 year event	40 year event	
Worcester Road	No surcharge	No flooding	<25m3 flooding	No surcharge	Minor external flooding(<10m^3) no historical reports	Minor flooding increase (<10m^3)	Low
Stoke Road	No surcharge	780 m^3 external flooding	933 m^3 external flooding	No surcharge	Minor flooding increase (<10m^3)	Minor flooding increase (<30m^3)	Low

2.4 Capacity Improvement Requirements

No capacity improvements are judged to be required to accommodate the development.

2.5 Option Details

None required

2.6 Impact on Network Performance

No pipes surcharge under dry weather conditions as a result of the construction of the development.

The development is predicted to cause one minor new flooding location, SO95693904 in the highway on Worcester Road (<5m^3 volume). During 20 year storm events and in the baseline scenario this MH currently surcharges to ground level. There are no historical records of flooding in the vicinity of this MH and thus this can be judged as low risk. Other than this, a minor increase in existing flooding is predicted to occur at one other manhole, SO95698001, on Stoke Road. There are two historical reports of highway flooding within 300m upstream and downstream of this manhole, but this Impact can be judged to be low risk due to the small size (3m^3) of this increase.

Therefore the overall impact of the development on the existing network's performance should be judged to be low and as such capacity improvements are not likely to be required to accommodate flows from the development.

2.7 Delivery of Capacity Improvements

Under the Water Industry Act (1991), developers have a right to connect foul and surface water flows from new developments to public sewers. The Act places a general duty on sewerage undertakers, including Severn Trent Water, to provide the additional capacity that may be required to accommodate additional flows and loads arising from new domestic development. This relates to both sewerage infrastructure (including sewers and pumping stations) and sewage treatment works. In situations where there is insufficient capacity in the receiving sewerage network, Severn Trent Water may request that planning is reasonably delayed to allow sufficient time for capacity to be provided.

As a business, Severn Trent Water is specifically funded to discharge these legal obligations through our charging mechanism, overseen by Ofwat. Whilst capacity improvements will be funded by Severn Trent Water, there is a duty to minimise the impact on customers' bills by avoiding potential abortive expenditure associated with speculative development enquiries. Through working with Local Authorities and developers, Severn Trent Water aims to provide capacity within a reasonable timeframe.

At the time of writing this report the site does not have planning permission.

3 Conclusions and Recommendations

3.1 Conclusions

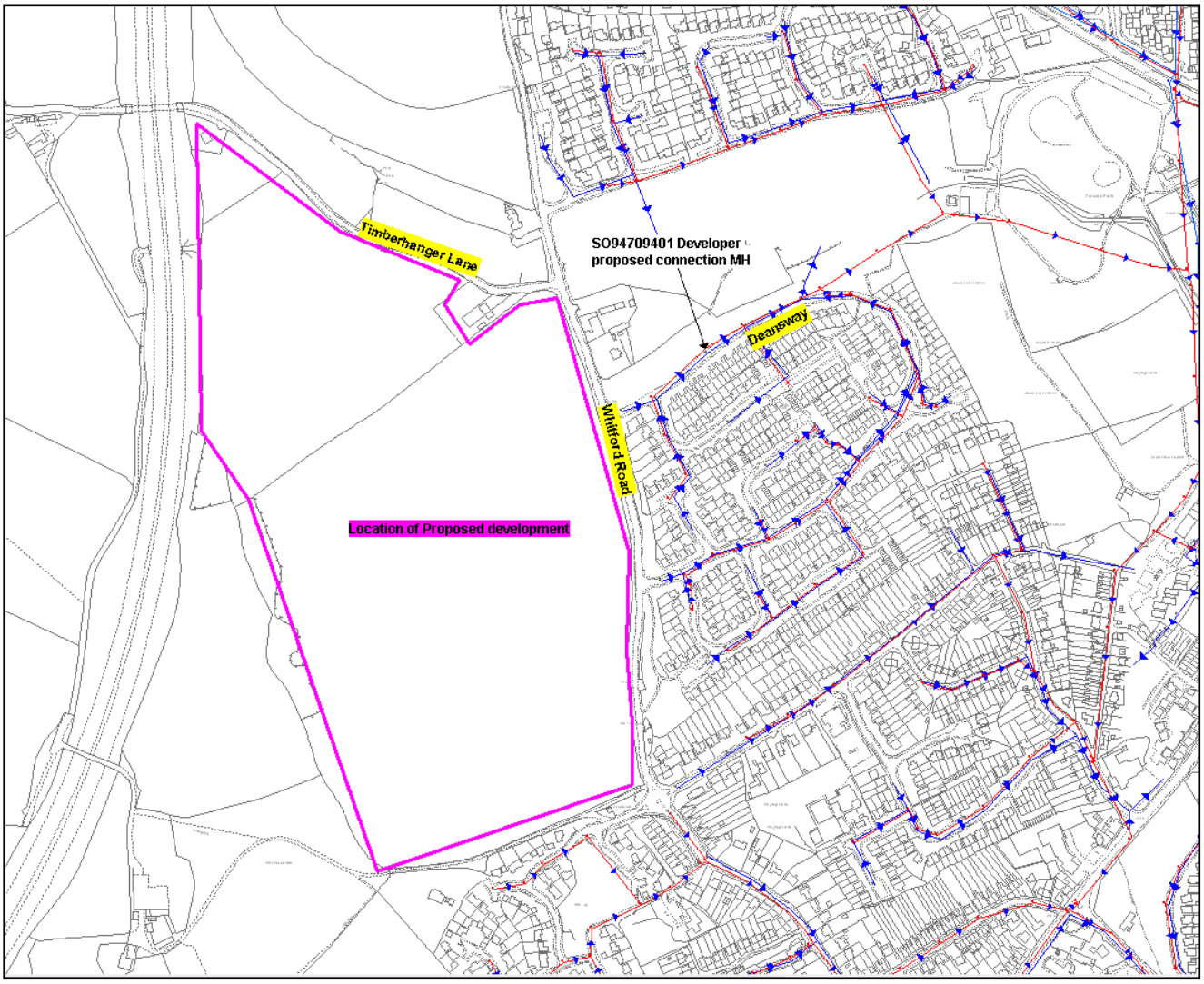
- The impact of foul flows arising from the proposed development at Whitford Road on the sewer network have been assessed using hydraulic modelling.
- The proposed development is predicted to have the following impacts:
    - Sewer Flooding: Low
    - Combined Sewer Overflows: Low
    - Sewage Pumping Stations: Low
- It is envisaged that capacity improvements are not likely to be required to accommodate foul flows from the entire proposed development.

3.2 Recommendations

It is recommended that with the current connection location and development information no remedial works will be required.

Appendix A: Site and Development Information

- Figure A-1: Site location plan



Appendix B: Model Review Proforma

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Information contained within this appendix must **not** be referred to elsewhere within this report

Appendix C: Notional Solution Options

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Appendix D: Supplementary Information

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Appendix G – QBAR Greenfield Runoff Rate

ICP SUDS Mean Annual Flood

Input

Return Period (years) 100 SAAR (mm) 700 Urban 0.000
Area (ha) 1.000 Soil 0.450 Region Number Region 4

Results l/s

QBAR Rural 4.4
QBAR Urban 4.4

Q100 years 11.3

Q1 year 3.6
Q30 years 8.6
Q100 years 11.3

Appendix H – Soakaway Investigation Report

Abbey Park
Humber Road
Coventry
CV3 4AQ
UK

Telephone: +44 (0)2476 505600
Fax: +44 (0) 2476 501417
www.rsk.co.uk

15th November 2013

Our ref. 312557-01 (00)

Miller Homes
2 Centro Place
Pride Park
Derby
DE24 8RF

C/o Catesby Estates Limited

For the Attention of Mr Jonathon Babb

RE: Supplementary soakaway investigation at Whitford Road, Bromsgrove

Dear Jonathon,

1. INTRODUCTION

On the instructions of Catesby Estates Limited, on behalf of Miller Homes (the Client), RSK Environment Limited (RSK) have undertaken a supplementary soakaway investigation at Whitford Lane, Bromsgrove.

The investigation was carried out in order to obtain information relating to the infiltration characteristics of the shallow soils beneath the site, and included the following tasks:

- A study of the local geology of the site;
- Excavation of six trial pits, to depths of between 1.36m and 2.70m below current ground level; and
- In-situ soakage testing at each of the exploratory locations.

This report is subject to the RSK service constraints given in Appendix A.

2. SITE DESCRIPTION AND GEOGRAPHIC SETTING

The site is located off Whitford Road and Timberhonger Lane, Bromsgrove; at National Grid Reference (NGR) 394530, 271260. A location plan for the site is presented as Figure 1.

The general arrangement of the site comprises open pastoral farmland occupying an area of approximately 23 hectares. Based on the information provided by the Client, it is understood that the site is under consideration for development with new residential housing and associated private gardens and infrastructure.

A Preliminary Risk Assessment and Site Investigation have previously been undertaken for the site by RSK (ref. 312220-R1 (00), dated December 2012); which should be considered in conjunction with this supplementary report.

3. GEOLOGY

The British Geological Survey (BGS) online OpenGeoscience resource (accessed November 2013) indicates that the site is directly underlain by the Bromsgrove Sandstone Formation, with no superficial cover. It should be noted that although superficial deposits are not shown to be present at the site, the geological maps indicate the presence of Alluvium adjacent north, associated with the nearby Battlefield Brook. The Mercia Mudstone Group is also noted to be present within close proximity to the site, beyond the site's northern boundary.

4. INVESTIGATION WORKS

The intrusive investigation was undertaken between the 6th and 8th November 2013, and comprised the excavation of six trial pits (SA1 to SA6) and the subsequent completion of soakaway testing within each pit using water supplied by a towed water bowser. The layout of the investigation was designed by the Client prior to commencing works on site, and locations were identified by their proximity to local features.

In accordance with the guidance outlined within BRE Digest 365: Soakaway Design, the pits were filled with stone to support the walls and prevent slumping / collapse. The tests were undertaken three times at each location, with the exception of SA4, where the nominal rate of infiltration over a period of three days precluding repeated filling.

Upon completion, the stone fill was excavated from each of the pits and the trial pits were reinstated. The stone fill was stockpiled adjacent to the site entrance on Whitford Road, as requested by the Client.

5. FINDINGS

Ground conditions

The ground conditions encountered across the site generally comprised a shallow layer of topsoil underlain by weathered Bromsgrove Sandstone Formation (BSF) (Grades C, D and E); with the exception of SA1 where a superficial cover of Alluvium, associated with the nearby Battlefield Brook, was found to overlay the BSF.

The weathered BSF encountered typically comprised of slightly silty fine to medium sand with fine to coarse fragments of weak sandstone and occasional weak sandstone cobbles; with the upper weathering horizon (Grade E) noted to contain a significant proportion of fines, particularly within SA4.

The trial pits were generally terminated upon competent sandstone bedrock, recovered as tabular and / or angular fine to coarse fragments of weak sandstone and weak sandstone cobbles.

Groundwater was not encountered during the intrusive investigation.

Infiltration characteristics

The results of the in-situ soakage testing indicate that the infiltration rate of the shallow soils exhibits considerable variability across the site. The testing undertaken at SA2 and SA6 indicates that these locations would be most suitable for the adoption of shallow pit soakaways to discharge surface run-off; and that an infiltration rate in the order of 10^{-4} m/s would be appropriate for design purposes.

The testing undertaken at SA1, SA3 and SA5 indicates that these locations may be suitable for the adoption of shallow pit soakaways to discharge surface run-off; however a lower rate of infiltration, in the order to 10^{-6} m/s, is recommended for design purposes.

In contrast, the testing undertaken at SA4 indicates that this location is unlikely to be suitable for the adoption of shallow pit soakaways, as the rate of infiltration recorded was negligible.

The full trial pit records and results of the in-situ soakage testing are presented as Appendix B.

Prepared by:	Reviewed by:
Rowan Brown Geotechnical Engineer	Marc Dixon Principal Engineer

Enclosed:

Figure 1	Site Location Plan
Figure 2	Exploratory Location Plan
Appendix A	RSK Service Constraints
Appendix B	Fieldwork Records

FIGURES

Site Location

Scale = 1:100,000 @ A3

Scale = 1:6,000 @ A3

0 200 metres

Rev	Date	Description	Drn	Chk	App
00	11.11.13	Geo	RG	SP	RB

Whitford Road, Bromsgrove

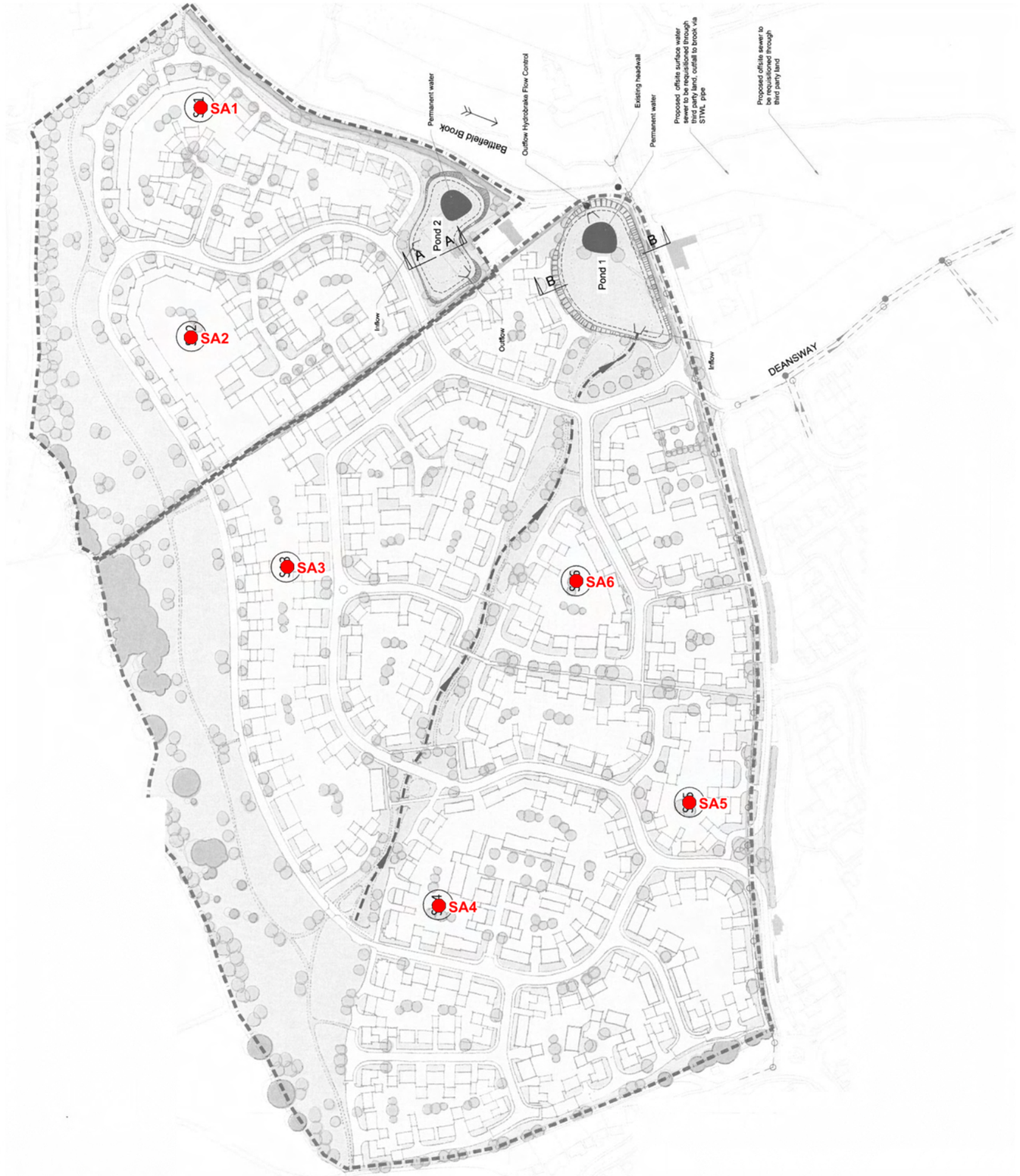
RSK

Figure 1

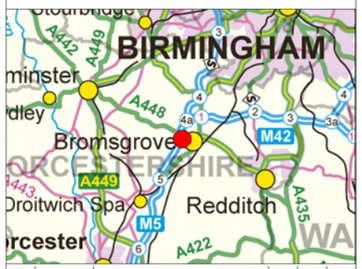
Site Location Plan

REV 00

File Name : X:\Cov Ground and Environment\Jobs\312000 ONWARDS\312500 - 312599\312557 - Whitford Road, Bromsgrove - soakaways\10 Drawings\GIS\10 - Workspaces



Soakaway Test



Rev	Date	Description	Drn	Chk	App
00	11.11.13	Geo	RG	SP	RB

Whitford Road, Bromsgrove

RSK

Figure 2

Exploratory Location Plan

0 100 metres

Scale = 1:3,000 @ A3

N W E S

REV 00

File Name : X:\Cov Ground and Environment\Jobs\312000 ONWARDS\312500 - 312599\312557 - Whitford Road, Bromsgrove - soakaways\10 Drawings\GIS\10 - Workspaces

APPENDIX A
SERVICE CONSTRAINTS

1. This report and the site investigation carried out in connection with the report (together the "Services") were compiled and carried out by RSK Environment Limited (RSK) for Catesby Estates Limited, on behalf of Miller Homes (the "client"), in accordance with the terms of a contract between RSK and the "client", dated 1st November 2013. The Services were performed by RSK with the skill and care ordinarily exercised by a reasonable environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the client.

2. Other than that expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.

3. Unless otherwise agreed the Services were performed by RSK exclusively for the purposes of the client. RSK is not aware of any interest of or reliance by any party other than the client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. **Any such party would be** well advised to seek independent advice from a competent environmental consultant and/or lawyer.

4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK 's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date hereof, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.

5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.

6. The observations and conclusions described in this report are based solely upon the Services which were provided pursuant to the agreement between the client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials.

7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a walk-over survey of the site together with RSK's interpretation of information including documentation, obtained from third parties and from the client on the history and usage of the site. The Services are also based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely. The Services clearly are limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the walk-over survey. Further RSK was not authorised and did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services. RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the client and RSK.

8. The phase II or intrusive environmental site investigation aspects of the Services is a limited sampling of the site at pre-determined borehole and soil vapour locations based on the operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the soil and groundwater conditions, together with the position of any current structures and underground facilities and natural and other activities on site. In addition chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and RSK] [based on an understanding of the available operational and historical information,] and it should not be inferred that other chemical species are not present.

9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan, but is (are) used to present the general relative locations of features on, and surrounding, the site.

APPENDIX B
FIELDWORK RECORDS

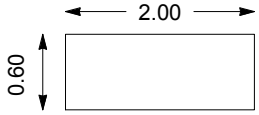
TRIAL PIT LOG

Contract:	Client:	Trial Pit:
Whitford Road, Bromsgrove	**Catesby Estates Limited**	**SA1**

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
312557	**06.11.13**	**---**	**---**	**1** of **1**
	End: **06.11.13**			

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
						Grass over brown slightly silty SAND with frequent rootlets and occasional rounded fine to coarse quartzite gravel. (TOPSOIL)	(0.35) 0.35	
						Orange brown slightly silty gravelly fine to coarse SAND. Gravel is subrounded to rounded fine to coarse quartzite. (ALLUVIUM)	(0.55) 0.90	
						Reddish brown slightly silty SAND with frequent tabular and subangular fragments of weak laminated sandstone. (BROMSGROVE SANDSTONE FORMATION (Grade D))	(1.10) 2.00	
						Trial pit terminated at 2.00m bgl and soakage testing undertaken.		

Plan (Not to Scale)



General Remarks

1. Weather: overcast, with rain.
2. Location was scanned with a cable avoidance tool and a signal generator prior to breaking ground. No services were detected.
3. Trial pit was excavated to a depth of 2.00m bgl and terminated upon hard strata.
4. Trial pit remained stable during excavation, shoring was not utilised.
5. Groundwater was not encountered, therefore dewatering was not required.
6. Upon completion of soakage testing, trial pit backfilled with compacted arisings.

All dimensions in metres | Scale: **1:25**

Method Used:	Plant Used:	Logged By:	Checked By:
Machine dug	**JCB-3CX**	**RBrown + RBrown**	

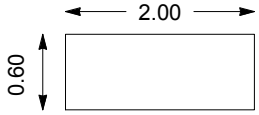
TRIAL PIT LOG

Contract:	Client:	Trial Pit:
Whitford Road, Bromsgrove	**Catesby Estates Limited**	**SA2**

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
312557	**06.11.13**	**---**	**---**	**1** of **1**
	End: **06.11.13**			

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
						Grass over dark brown slightly silty SAND with frequent rootlets. (TOPSOIL)	0.25	
						Reddish brown slightly silty very clayey SAND with occasional tabular and angular fine to coarse fragments of weak sandstone. (BROMSGROVE SANDSTONE FORMATION (Grade E))	(0.65) 0.90	
						Reddish brown slightly silty SAND with frequent tabular and angular fine to coarse fragments of weak sandstone and frequent weak sandstone cobbles. (BROMSGROVE SANDSTONE FORMATION (Grade D))	(0.50) 1.40	
						Light orange and light grey fine SAND with frequent tabular and angular fine to coarse fragments of weak sandstone and frquent weak sandstone cobbles. (BROMSGROVE SANDSTONE FORMATION (Grade D))	(0.60) 2.00	
						Light orange and light grey fine grained SANDSTONE recovered as tabular and angular medium to coarse fragments of weak sandstone and weak sandstone cobbles. (BROMSGROVE SANDSTONE FORMATION (Grade C))	(0.40) 2.40	
						Trial pit terminated at 2.40m bgl and soakage testing undertaken.		

Plan (Not to Scale)



General Remarks

1. Weather: overcast, with rain.
2. Location was scanned with a cable avoidance tool and a signal generator prior to breaking ground. No services were detected.
3. Trial pit was excavated to a depth of 2.40m bgl and terminated upon hard strata.
4. Trial pit remained stable during excavation, shoring was not utilised.
5. Groundwater was not encountered, therefore dewatering was not required.
6. Upon completion of soakage testing, trial pit backfilled with compacted arisings.

All dimensions in metres | Scale: **1:25**

Method Used:	Plant Used:	Logged By:	Checked By:
Machine dug	**JCB-3CX**	**RBrown + RBrown**	

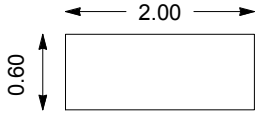
TRIAL PIT LOG

Contract:	Client:	Trial Pit:
Whitford Road, Bromsgrove	**Catesby Estates Limited**	**SA3**

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
312557	End: **06.11.13**	**---**	**---**	**1** of **1**

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
						Grass over dark brown slightly clayey SAND with frequent rootlets. (TOPSOIL)	(0.30) 0.30	
						Dark reddish brown and light greenish grey silty very clayey SAND with frequent tabular and subangular fine to coarse fragments of weak sandstone. (BROMSGROVE SANDSTONE FORMATION (Grade E))	(0.50) 0.80	
						Dark reddish brown and light greenish grey slightly silty SAND with frequent tabular and subangular fine to coarse fragments of weak sandstone and frequent weak sandstone cobbles. (BROMSGROVE SANDSTONE FORMATION (Grade D))	(0.40) 1.20	
						Dark reddish brown and occasionally light greenish grey fine grained SANDSTONE recovered as tabular and angular fine to coarse fragments of weak sandstone and weak sandstone cobbles. (BROMSGROVE SANDSTONE FORMATION (Grade C))	1.36	
						Trial pit terminated at 1.36m bgl and soakage testing undertaken.		

Plan (Not to Scale)



General Remarks

1. Weather: overcast, with rain.
2. Location was scanned with a cable avoidance tool and a signal generator prior to breaking ground. No services were detected.
3. Trial pit was excavated to a depth of 1.36m bgl and terminated upon hard strata.
4. Trial pit remained stable during excavation, shoring was not utilised.
5. Groundwater was not encountered, therefore dewatering was not required.
6. Upon completion of soakage testing, trial pit backfilled with compacted arisings.

All dimensions in metres | Scale: **1:25**

Method Used:	Plant Used:	Logged By:	Checked By:
Machine dug	**JCB-3CX**	**RBrown + RBrown**	

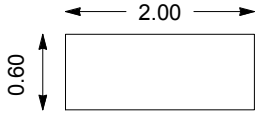
TRIAL PIT LOG

Contract:	Client:	Trial Pit:
Whitford Road, Bromsgrove	**Catesby Estates Limited**	**SA4**

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
312557	End: **06.11.13**	**---**	**---**	**1** of **1**

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
						Grass over dark brown slightly clayey SAND with frequent rootlets. (TOPSOIL)	(0.30) 0.30	
						Light orange brown mottled light grey slightly silty very clayey SAND with occasional subangular and tabular fine to medium fragments of weak sandstone. (BROMSGROVE SANDSTONE FORMATION (Grade E))	(1.20) 1.50	
						Orange brown and occasionally light grey silty fine SAND with frequent angular to subangular fine to coarse fragments of weak sandstone and frequent weak sandstone cobbles. (BROMSGROVE SANDSTONE FORMATION (Grade E))	(1.00) 2.50	
						Dark orange brown fine to medium grained SANDSTONE recovered as angular and tabular fragments of weak laminated sandstone and weak laminated sandstone cobbles. (BROMSGROVE SANDSTNE FORMATION (Grade C))	2.70	
						Trial pit terminated at 2.70m bgl and soakage testing undertaken.		

Plan (Not to Scale)



General Remarks

1. Weather: overcast, with rain.
2. Location was scanned with a cable avoidance tool and a signal generator prior to breaking ground. No services were detected.
3. Trial pit was excavated to a depth of 2.70m bgl and terminated upon hard strata.
4. Trial pit remained stable during excavation, shoring was not utilised.
5. Groundwater was not encountered, therefore dewatering was not required.
6. Upon completion of soakage testing, trial pit backfilled with compacted arisings.

All dimensions in metres | Scale: **1:25**

Method Used:	Plant Used:	Logged By:	Checked By:
Machine dug	**JCB-3CX**	**RBrown + RBrown**	

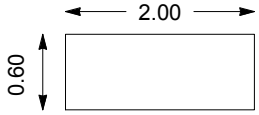
TRIAL PIT LOG

Contract:	Client:	Trial Pit:
Whitford Road, Bromsgrove	**Catesby Estates Limited**	**SA5**

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
312557	**06.11.13**	**---**	**---**	**1** of **1**
	End: **06.11.13**			

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
						Grass over dark brown slightly clayey SAND with frequent rootlets. (TOPSOIL)	(0.35) 0.35	
						Dark reddish brown and light greenish grey silty very clayey SAND with frequent subangular and tabular fine to coarse fragments of weak laminated sandstone. (BROMSGROVE SANDSTONE FORMATION (Grade E))	(0.55) 0.90	
						Dark reddish brown and light greenish grey slightly silty SAND with frequent tabular and subangular fine to coarse fragments of weak sandstone and occasional weak sandstone cobbles. (BROMSGROVE SANDSTONE FORMATION (Grade D))	(0.40) 1.30	
						Dark reddish brown and occasionally light greenish grey fine grained SANDSTONE recovered as tabular and angular to subangular fine to coarse fragments of weak sandstone and weak sandstone cobbles. (BROMSGROVE SANDSTONE FORMATION (Grade C))	(0.60) 1.90	
						Trial pit terminated at 1.90m bgl and soakage testing undertaken.		

Plan (Not to Scale)



General Remarks

1. Weather: overcast, with rain.
2. Location was scanned with a cable avoidance tool and a signal generator prior to breaking ground. No services were detected.
3. Trial pit was excavated to a depth of 1.90m bgl and terminated upon hard strata.
4. Trial pit remained stable during excavation, shoring was not utilised.
5. Groundwater was not encountered, therefore dewatering was not required.
6. Upon completion of soakage testing, trial pit backfilled with compacted arisings.

All dimensions in metres | Scale: **1:25**

Method Used:	Plant Used:	Logged By:	Checked By:
Machine dug	**JCB-3CX**	**RBrown + RBrown**	

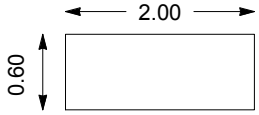
TRIAL PIT LOG

Contract:	Client:	Trial Pit:
Whitford Road, Bromsgrove	**Catesby Estates Limited**	**SA6**

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
312557	End: **06.11.13**	**---**	**---**	**1** of **1**

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
						Grass over dark brown slightly clayey SAND with frequent rootlets. (TOPSOIL)	(0.30) 0.30	
						Reddish brown slightly silty fine to coarse SAND with occasional tabular and subangular fine to coarse fragments of weak sandstone and occasional weak sandstone cobbles. (BROMSGROVE SANDSTONE FORMATION (Grade E))	(0.60) 0.90	
						Reddish brown slightly silty CLAY with occasional tabular and angular fine to medium fragments of weak laminated sandstone. (BROMSGROVE SANDSTONE FORMATION (Grade E))	(0.30) 1.20	
						Light orange brown slightly silty fine to medium SAND with frequent tabular weak sandstone cobbles. (BROMSGROVE SANDSTONE FORMATION (Grade D))	(1.00) 2.20	
						Light orange brown fine to medium grained SANDSTONE recovered as tabular fine to medium fragments of weak sandstone and weak sandstone cobbles. (BROMSGROVE SANDSTONE FORMATION (Grade C))	2.30	
						Trial pit terminated at 2.30m bgl and soakage testing undertaken.		

Plan (Not to Scale)



General Remarks

1. Weather: overcast, with rain.
2. Location was scanned with a cable avoidance tool and a signal generator prior to breaking ground. No services were detected.
3. Trial pit was excavated to a depth of 2.30m bgl and terminated upon hard strata.
4. Trial pit remained stable during excavation, shoring was not utilised.
5. Groundwater was not encountered, therefore dewatering was not required.
6. Upon completion of soakage testing, trial pit backfilled with compacted arisings.

All dimensions in metres | Scale: **1:25**

Method Used:	Plant Used:	Logged By:	Checked By:
Machine dug	**JCB-3CX**	**RBrown + RBrown**	

FULL SCALE SOAKAWAY TEST

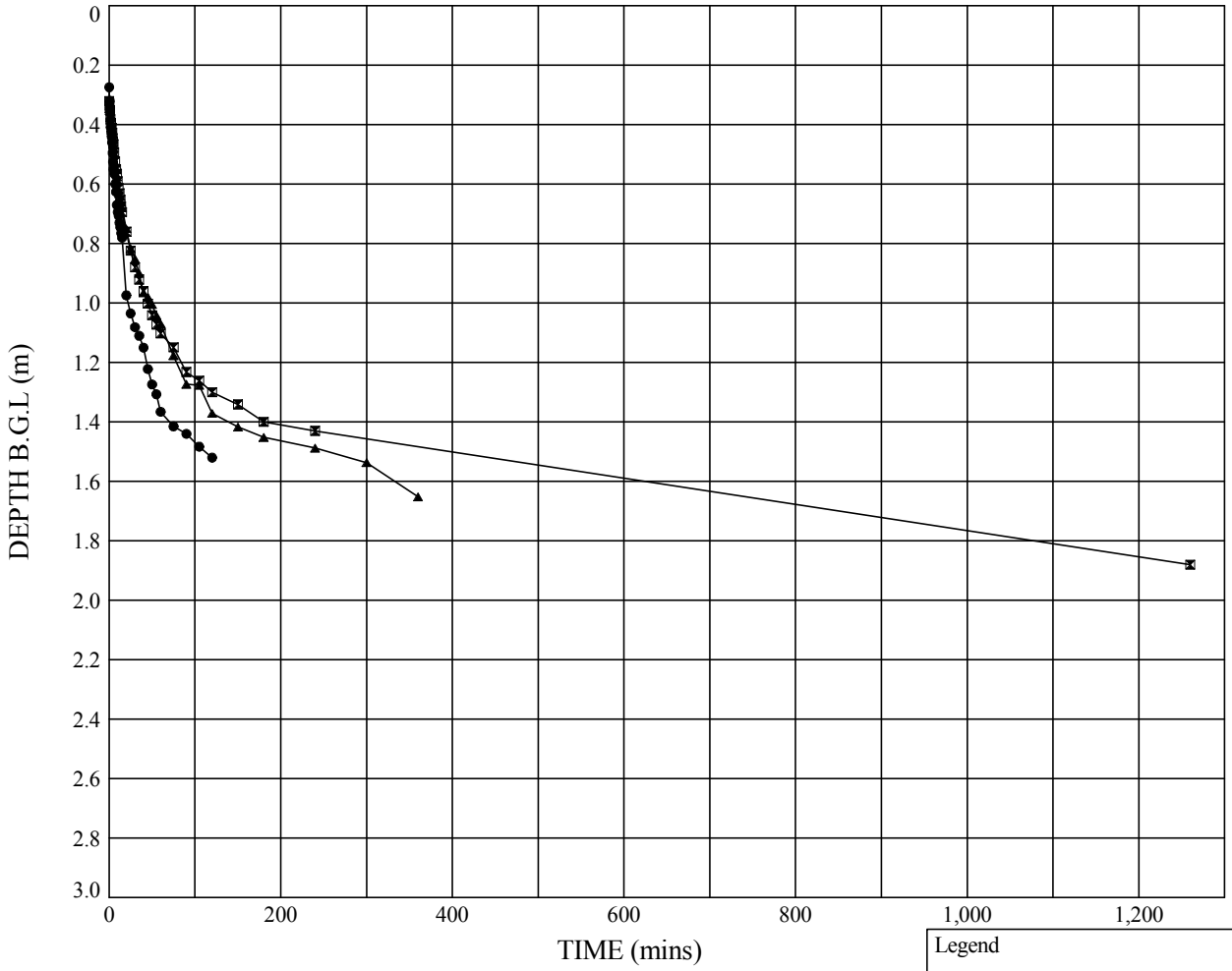
In accordance with BRE Digest 365

Soakaway Test - Position ID : **SA1**

Test Supervisor : **RBrown**

Ground Level: **---** Co-ordinates: **---**

PLOT OF DEPTH OF WATER BELOW GROUND LEVEL AGAINST TIME

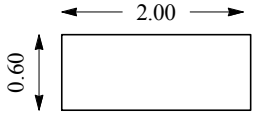


		Test 1	Test 2	Test 3	
Pit start depth:	=	*1.99*	*2.00*	**2.03**	m
Pit final depth:	=	*1.99*	*2.00*	**2.03**	m
Effective depth, De	=	*1.72*	*1.68*	**1.71**	m
Effective storage volume, V_{p75-25}	=	*1.0320*	*1.0080*	**1.0260**	m^3
Surface area, a_{p50}	=	*5.6720*	*5.5680*	**5.5450**	m^2
Time, t_{p75-25}	=	*9214*	*33691*	**18913**	secs
Infiltration rate, f	=	$1.97x10^{-5}$	$5.37x10^{-6}$	$\mathbf{9.61x10^{-6}}$	m/s

Legend

- Test 1 (7.11.13)
- Test 2 (7.11.13)
- Test 3 (8.11.13)

Plan (Not to scale)



No Bearing Taken

RSK Environment Ltd
Abbey Park
Humber Road
Coventry
CV3 4AQ

Compiled By	Date	Checked By	Date
K. Foster	**15/11/13**		

Contract: **Whitford Road, Bromsgrove**

Contract Ref: **312557**

FULL SCALE SOAKAWAY TEST

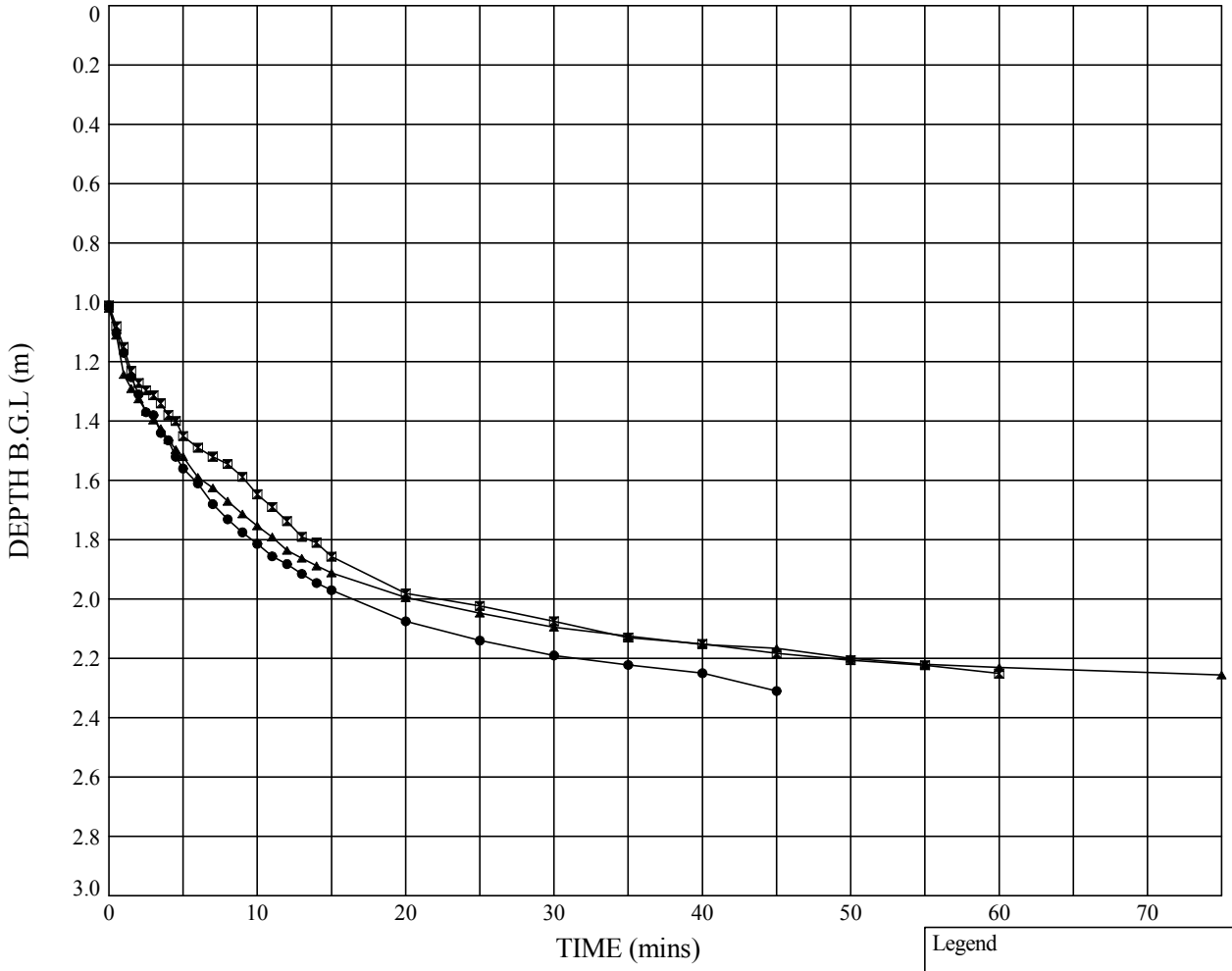
In accordance with BRE Digest 365

Soakaway Test - Position ID : **SA2**

Ground Level: ---

Co-ordinates: ---

PLOT OF DEPTH OF WATER BELOW GROUND LEVEL AGAINST TIME

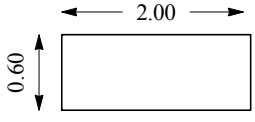


		Test 1	Test 2	Test 3	
Pit start depth:	=	*2.40*	*2.40*	**2.40**	m
Pit final depth:	=	*2.40*	*2.40*	**2.40**	m
Effective depth, De	=	*1.39*	*1.39*	**1.38**	m
Effective storage volume, V_{p75-25}	=	*0.8340*	*0.8340*	**0.8292**	m^3
Surface area, a_{p50}	=	*4.8140*	*4.8140*	**4.7932**	m^2
Time, t_{p75-25}	=	*992*	*1447*	**1410**	secs
Infiltration rate, f	=	*$1.75x10^{-4}$*	*$1.20x10^{-4}$*	**$1.23x10^{-4}$**	m/s

Legend

- Test 1 (7.11.13)
- Test 2 (7.11.13)
- Test 3 (7.11.13)

Plan (Not to scale)



No Bearing Taken

RSK Environment Ltd Abbey Park Humber Road Coventry CV3 4AQ	Compiled By	Date	Checked By	Date
	K. Foster	**15/11/13**		
	Contract: **Whitford Road, Bromsgrove**		Contract Ref: **312557**	

FULL SCALE SOAKAWAY TEST

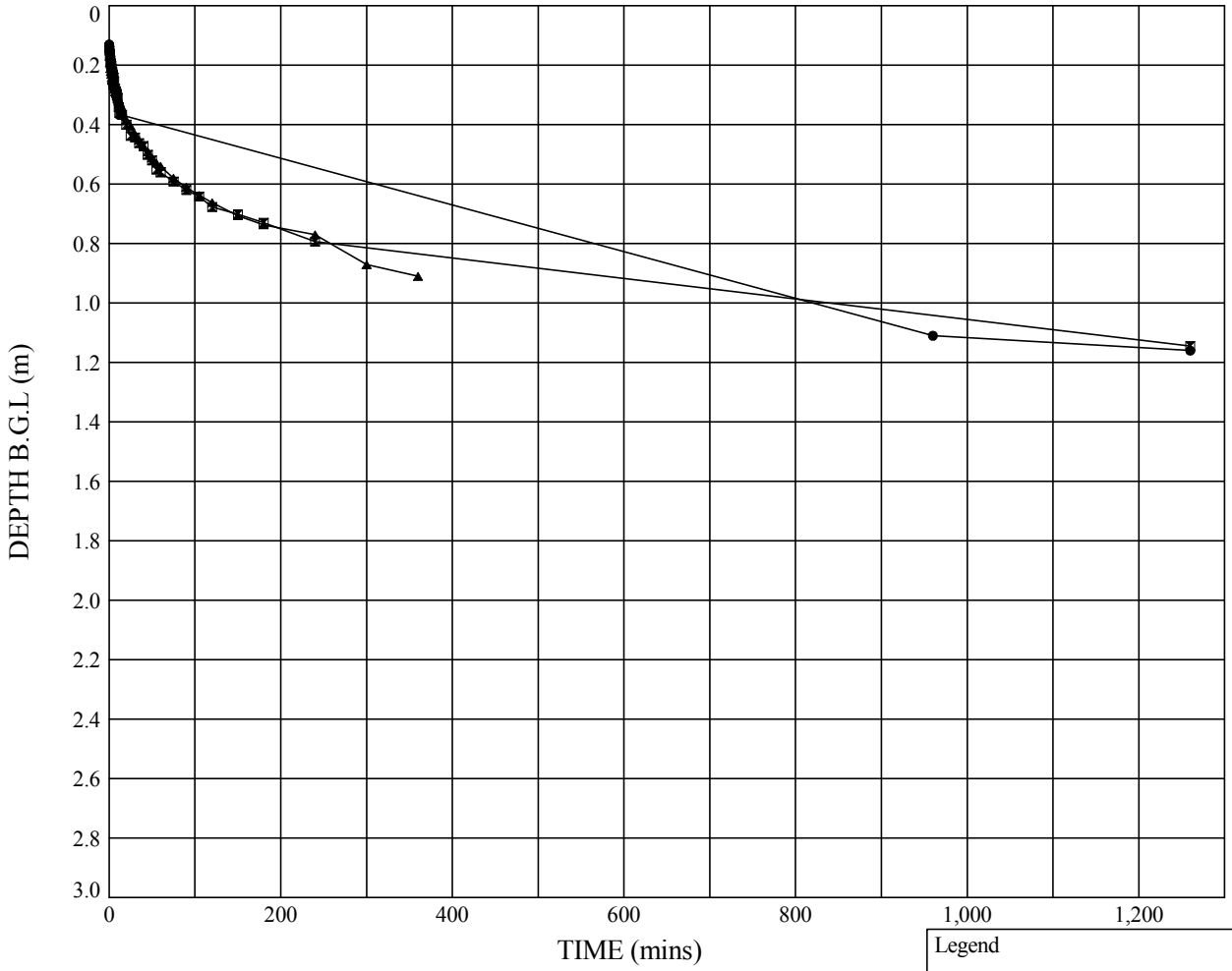
In accordance with BRE Digest 365

Soakaway Test - Position ID : **SA3**

Ground Level: ---

Co-ordinates: ---

PLOT OF DEPTH OF WATER BELOW GROUND LEVEL AGAINST TIME

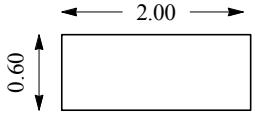


		Test 1	Test 2	Test 3	
Pit start depth:	=	*1.36*	*1.36*	*1.36*	m
Pit final depth:	=	*1.36*	*1.36*	*1.36*	m
Effective depth, De	=	*1.23*	*1.22*	*1.22*	m
Effective storage volume, V_{p75-25}	=	*0.7380*	*0.7326*	*0.7296*	m^3
Surface area, a_{p50}	=	*4.3980*	*4.3746*	*4.3616*	m^2
Time, t_{p75-25}	=	*46995*	*58247*	*33116*	secs
Infiltration rate, f	=	$3.57x10^{-6}$	$2.88x10^{-6}$	$5.05x10^{-6}$	m/s

Legend

- Test 1 (7.11.13)
- Test 2 (7.11.13)
- Test 3 (7.11.13)

Plan (Not to scale)



No Bearing Taken

RSK Environment Ltd
Abbey Park
Humber Road
Coventry
CV3 4AQ

Compiled By	Date	Checked By	Date
K. Foster	**15/11/13**		

Contract: **Whitford Road, Bromsgrove**

Contract Ref: **312557**

FULL SCALE SOAKAWAY TEST

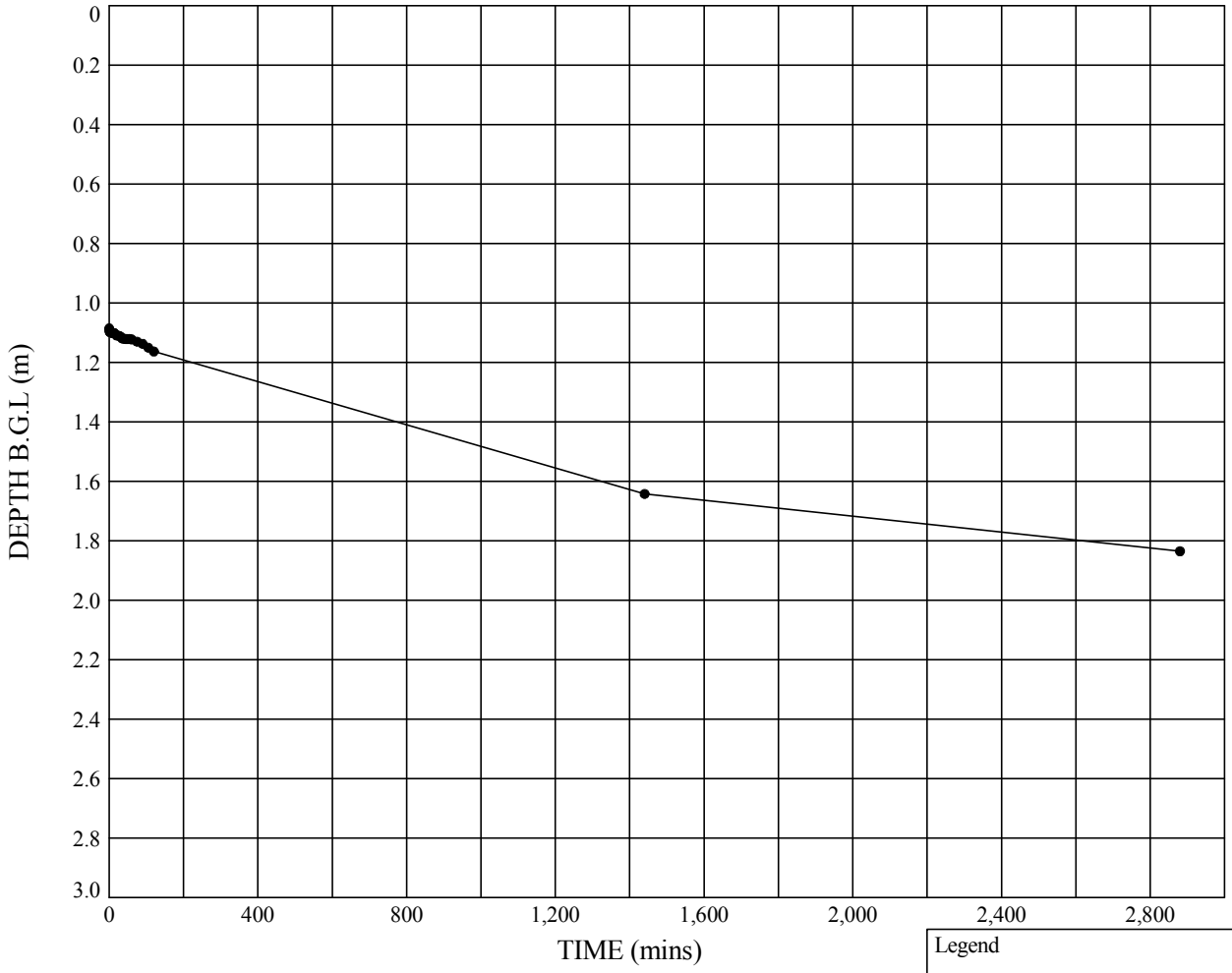
In accordance with BRE Digest 365

Soakaway Test - Position ID : **SA4**

Ground Level: ---

Co-ordinates: ---

PLOT OF DEPTH OF WATER BELOW GROUND LEVEL AGAINST TIME

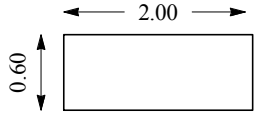


Legend

● Test 1 (7.11.13)

Pit start depth:	=	*2.74*	m
Pit final depth:	=	*2.74*	m
Effective depth, De	=	*1.66*	m
Effective storage volume, V_{p75-25}	=	*0.9930*	m^3
Surface area, a_{p50}	=	*5.6503*	m^2
Time, t_{p75-25}	=	*330003*	secs
Infiltration rate, f	=	$5.47x10^{-7}$	m/s

Plan (Not to scale)



No Bearing Taken

RSK Environment Ltd Abbey Park Humber Road Coventry CV3 4AQ	Compiled By	Date	Checked By	Date
	K. Foster	**15/11/13**		
	Contract: **Whitford Road, Bromsgrove**		Contract Ref: **312557**	

FULL SCALE SOAKAWAY TEST

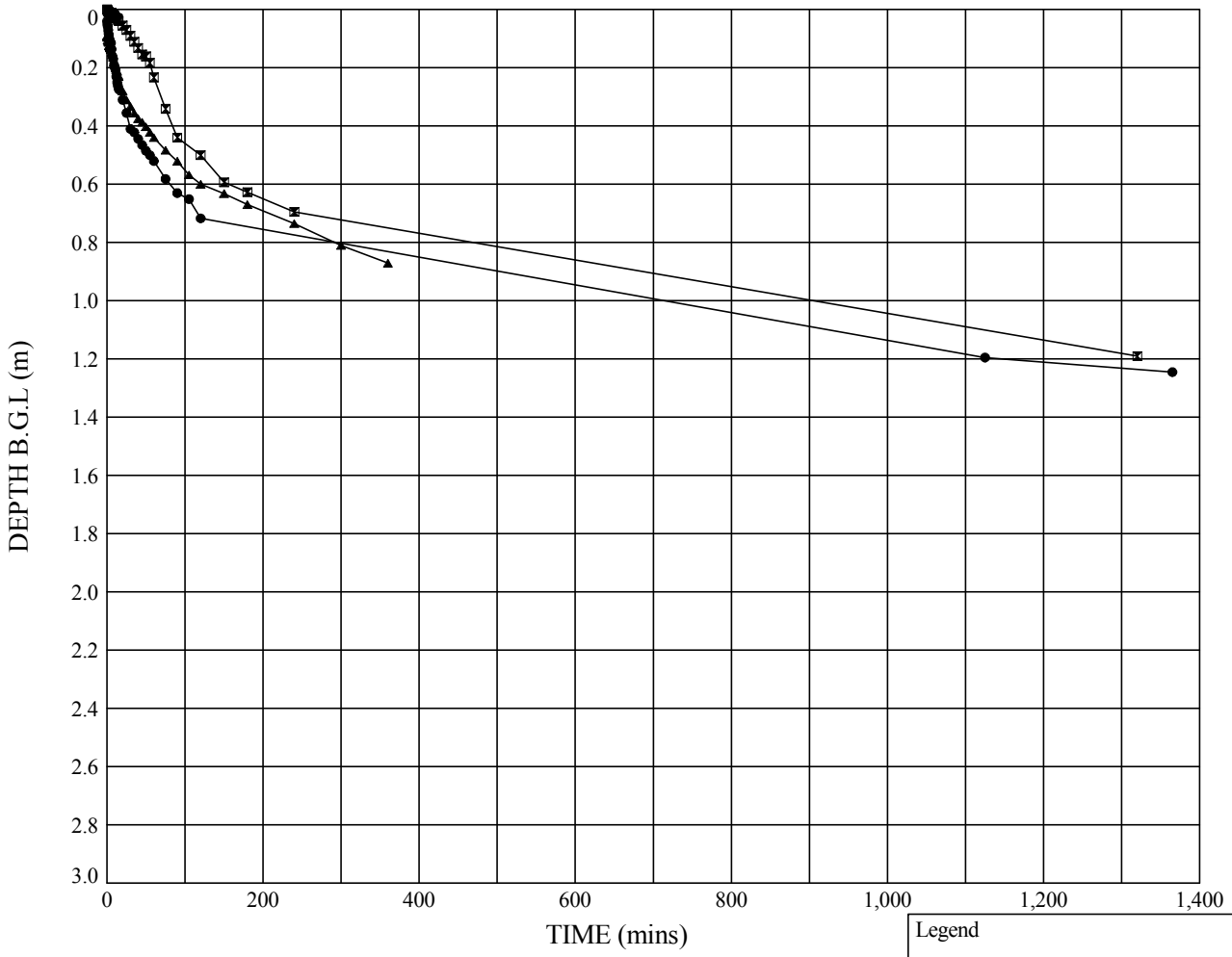
In accordance with BRE Digest 365

Soakaway Test - Position ID : **SA5**

Ground Level: ---

Co-ordinates: ---

PLOT OF DEPTH OF WATER BELOW GROUND LEVEL AGAINST TIME

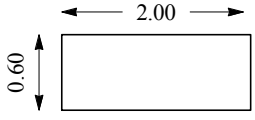


		Test 1	Test 2	Test 3	
Pit start depth:	=	*1.35*	*1.35*	*1.35*	m
Pit final depth:	=	*1.35*	*1.35*	*1.36*	m
Effective depth, De	=	*1.31*	*1.35*	*1.27*	m
Effective storage volume, V_{p75-25}	=	*0.7830*	*0.8100*	*0.7620*	m^3
Surface area, a_{p50}	=	*4.5930*	*4.7100*	*4.5020*	m^2
Time, t_{p75-25}	=	*43705*	*51493*	*28650*	secs
Infiltration rate, f	=	$3.90x10^{-6}$	$3.34x10^{-6}$	$5.91x10^{-6}$	m/s

Legend

- Test 1 (7.11.13)
- Test 2 (7.11.13)
- Test 3 (7.11.13)

Plan (Not to scale)



No Bearing Taken

RSK Environment Ltd
Abbey Park
Humber Road
Coventry
CV3 4AQ

Compiled By	Date	Checked By	Date
K. Foster	**15/11/13**		

Contract: **Whitford Road, Bromsgrove**

Contract Ref: **312557**

FULL SCALE SOAKAWAY TEST

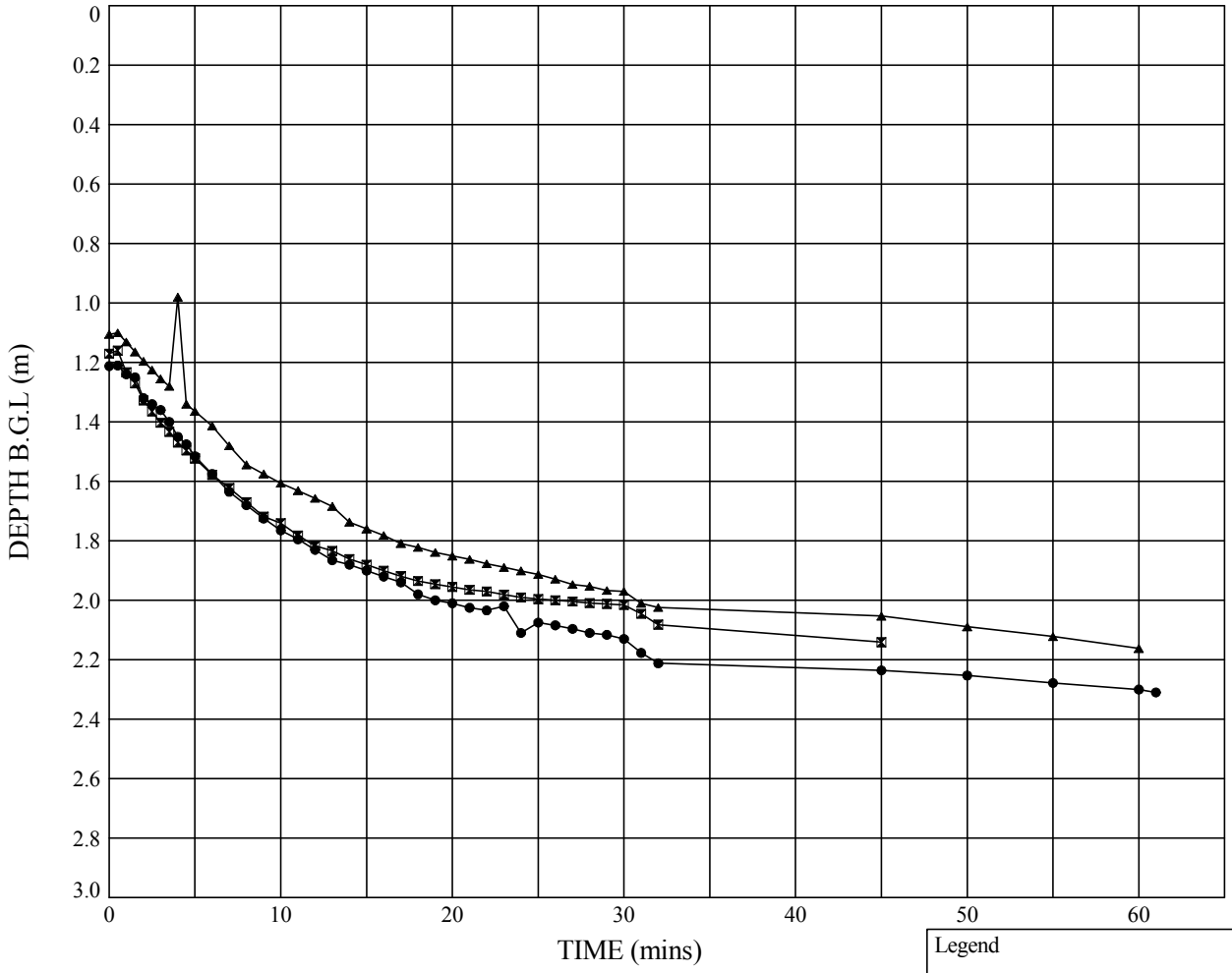
In accordance with BRE Digest 365

Soakaway Test - Position ID : **SA6**

Ground Level: ---

Co-ordinates: ---

PLOT OF DEPTH OF WATER BELOW GROUND LEVEL AGAINST TIME

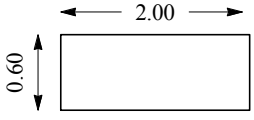


		Test 1	Test 2	Test 3	
Pit start depth:	=	**2.31**	*2.32*	*2.32*	m
Pit final depth:	=	**2.31**	*2.32*	*2.32*	m
Effective depth, De	=	**1.10**	*1.15*	*1.22*	m
Effective storage volume, V_{p75-25}	=	**0.6588**	*0.6900*	*0.7290*	m^3
Surface area, a_{p50}	=	**4.0548**	*4.1900*	*4.3590*	m^2
Time, t_{p75-25}	=	**1048**	*1604*	*1532*	secs
Infiltration rate, f	=	**$1.55x10^{-4}$**	*$1.03x10^{-4}$*	*$1.09x10^{-4}$*	m/s

Legend

- Test 1 (7.11.13)
- Test 2 (7.11.13)
- Test 3 (7.11.13)

Plan (Not to scale)



No Bearing Taken

RSK Environment Ltd Abbey Park Humber Road Coventry CV3 4AQ	Compiled By	Date	Checked By	Date
	K. Foster	**15/11/13**		
	Contract: **Whitford Road, Bromsgrove**		Contract Ref: **312557**	

Appendix I – Illustrative Drainage Strategy

Notes

1. This drawing has been prepared in accordance with the scope of RPS's appointment with its client and is subject to the terms and conditions of that appointment. RPS accepts no liability for any use of this document other than by its client and only for the purposes for which it was prepared and provided.
2. If received electronically it is the recipients responsibility to print to correct scale. Only written dimensions should be used.
3. This drawing should be read in conjunction with all other relevant drawings and specifications.

For guidance only. Do not scale off this drawing

1:20 - 0	200mm	400mm	600mm	800mm	1000	1200	1400	1600	1800	2000
1:100 - 0	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m
1:50 - 0	1m	2m	3m	4m	5m	6m	7m	8m	9m
1:5 - 0	100mm	200mm	300mm	400mm	500mm

Safety, Health & Environment Information		
In addition to the hazards / risks normally associated with the types of work detailed on this drawing take note below. 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.		
Construction risks	Maintenance/Cleaning risks	Demolition/Adaption risks

M5 MOTORWAY

Denotes Location of Proposed Acoustic Fence

Land / cut off drain may be required adjacent to highway to intercept surface water run-off from steeply sloping POS

Land / cut off drain may be required adjacent to highway to intercept surface water run-off from steeply sloping POS

Land / cut off drain may be required along site boundary and / or adjacent to highway to intercept surface water run-off from steeply sloping POS / adjacent field

Land / cut off drain may be required along site boundary and / or adjacent to highway to intercept surface water run-off from steeply sloping POS / adjacent field

Start of swale due to ground levels

Due to steep contours swale not technically feasible at top of site. Will require investigation at the detailed design stage. A cascading feature could be considered.

POTENTIAL BUS GATE LOCATION

Inflow

Pond 2
TOB 88.0m
Bed Level 86.4m
Storage Volume 1294m³

Depending upon final layout basins ideally should be linked.
If not feasible each basin will need its own flow control device.

Outflow Flow Control
Hydro-brake or similar

Pond 1
TOB 88.0m
Bed Level 85.9m
Storage Volume 3925m³

Inflow

Existing headwall SW outfall to Battlefield Brook

Proposed surface water outfall into Battlefield Brook

Potential foul water outfall to existing FWS in Deansway subject to levels

Proposed foul water connection to MH0504

MH0504
CL 84.75
IL 82.06

Proposed offsite sewer to be requisitioned through third party land. As shown on Halcrow drainage strategy

Battlefield Brook

HIGHER RONGHEATH LANE

SUNNINGDALE ROAD

WHITFORD ROAD

FOX LANE

WILLFIELD

DEANSWAY

0m 12.5m 25m 50m 75m 125m

Revision	Description	Drawn	Checked
B	Drawing updated to indicate proposed Acoustic Fence location.	AJS	GS
A	Drawing updated as per Client comments received 11.10.2017	MW	GS

Preliminary ■ Information ■ Tender ■ Construction ■ As

Woods Hardwick
Architects, Engineers and Development Consultants

Title: Land off Whitford Road: Bromsgrove

Details: Proposed Master Plan

Saved : \\rpi\projects

Scale: 1:1250@A1 Date: May '16 Drawn: MW Chk: GS

16912

Please consider the environment before printing this drawing

PRELIMINARY
SUBJECT TO DETAILED DESIGN

This drawing illustrates a sketch proposal only and as such is subject to detailed site investigation including ground conditions/contaminants, drainage, design and planning/density negotiations. The layout maybe based upon an enlargement of an OS sheet or other small scale plans and its accuracy will need to be verified by Survey. Full risk analysis under the CDM Regulations has not been undertaken.

Developable Area 16.220 ha
QBAR Greenfield Rate 4.4l/s/ha

Carriageways
Impermeable Area (100% impermeable) 1.492 ha
Restriction Rate 9.9 l/s
Required storage for a 1:100+40% CC event **1505m³**

Residential Area
Impermeable Area (60% impermeable) 8.382 ha
Impermeable area including 8% Urban Creep 9.053 ha
Restriction Rate 39.8 l/s
Required storage for a 1:30 event **2780m³**
Required storage for a 1:100+40% CC event **5905m³**

Surface water from plots up to the 1:30 year event is disposed of via infiltration, therefore the total attenuation requirement is **4630m³** (5905m³+1505m³-2780m³)

Pond 1
Approximate Volume = 3,925m³
Pond 2
Approximate Volume = 1,294m³

Ultimate discharge rate from the site will depend upon final impermeable area. A rate of 4.4 litres/sec/ha should be applied to the final site layout.

KEY

- Illustrative Foul Water Manhole
- Illustrative Foul Water Pipe Line
- Illustrative Surface Water Manhole
- Illustrative Surface Water Pipe Line
- Illustrative Headwall
- Exiting Surface Water Sewer
- Existing Foul Water Sewer
- Pond 1 Catchment
- Pond 2 Catchment

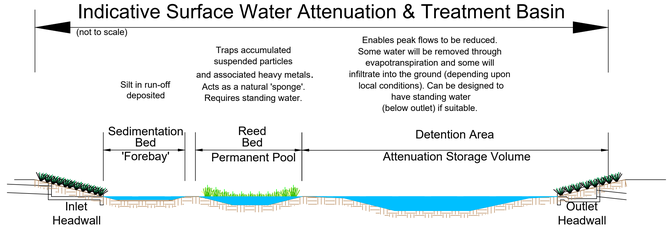
Indicative Surface Water Attenuation & Treatment Basin

(not to scale)

Silt in run-off deposited

Traps accumulated suspended particles and associated heavy metals. Acts as a natural 'sponge'. Requires standing water.

Enables peak flows to be reduced. Some water will be removed through evapotranspiration and some will infiltrate into the ground (depending upon local conditions). Can be designed to have standing water (below outlet) if suitable.



Notes:
Client's ground specialists to confirm if lining of basin is required to prevent groundwater ingress.
Planting subject to discussion with landscape architects.
Bank gradient will depend upon site levels and discussions with the adopting authority.
Outfall to an Ordinary Watercourse will require consent from the Lead Local Flood Authority
Outfall to a Main River will require consent from the Environment Agency
Outfall to a public sewer will require consent from the Sewerage Undertaker

Rev	Description	By	Ckd	Date
P01	First Issue	JH	DM	26.05.20

MAKING COMPLEX EASY
Salisbury House, 2A Tettenhall Road, Wolverhampton, West Midlands, WV1 4SA
T: 01902 925500 E: rpswlv@rpsgroup.com

Client: Catesby Strategic Land Limited

Project: Land off Whitford Road Bromsgrove

Title: Illustrative Drainage Strategy

Status	Scale	Date Created
Preliminary	1:1000 @A0	26.05.20

Task Team Manager	Information Author	Task Information Manager
DM	JH	DM

Document Number: AAA5285-RPS-xx-xx-DR-C-600-01
Project Code - Originator - Zone - Level - Type - Role - Drawing Number

RPS Project Number: AAA5285 Suitability: Revision: P01

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Appendix J – MicroDrainage Calculations

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	86.278	0.378	9.9	548.9	O K
30 min Summer	86.395	0.495	9.9	718.5	O K
60 min Summer	86.513	0.613	9.9	891.2	O K
120 min Summer	86.629	0.729	9.9	1059.2	O K
180 min Summer	86.689	0.789	9.9	1146.8	O K
240 min Summer	86.726	0.826	9.9	1200.1	O K
360 min Summer	86.766	0.866	9.9	1258.9	O K
480 min Summer	86.788	0.888	9.9	1290.6	O K
600 min Summer	86.798	0.898	9.9	1305.3	O K
720 min Summer	86.801	0.901	9.9	1309.0	O K
960 min Summer	86.792	0.892	9.9	1296.2	O K
1440 min Summer	86.758	0.858	9.9	1246.0	O K
2160 min Summer	86.707	0.807	9.9	1172.2	O K
2880 min Summer	86.658	0.758	9.9	1101.6	O K
4320 min Summer	86.562	0.662	9.9	961.9	O K
5760 min Summer	86.460	0.560	9.9	813.4	O K
7200 min Summer	86.373	0.473	9.9	687.5	O K
8640 min Summer	86.297	0.397	9.9	577.3	O K
10080 min Summer	86.233	0.333	9.9	483.2	O K
15 min Winter	86.324	0.424	9.9	616.1	O K
30 min Winter	86.455	0.555	9.9	807.0	O K
60 min Winter	86.590	0.690	9.9	1002.5	O K
120 min Winter	86.721	0.821	9.9	1192.3	O K
180 min Winter	86.790	0.890	9.9	1293.4	O K
240 min Winter	86.833	0.933	9.9	1356.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	132.861	0.0	559.8	26
30 min Summer	87.290	0.0	715.4	41
60 min Summer	54.663	0.0	921.7	70
120 min Summer	33.095	0.0	1116.2	130
180 min Summer	24.358	0.0	1232.3	190
240 min Summer	19.485	0.0	1314.6	248
360 min Summer	14.144	0.0	1423.0	366
480 min Summer	11.275	0.0	1486.5	486
600 min Summer	9.449	0.0	1523.6	604
720 min Summer	8.176	0.0	1537.2	722
960 min Summer	6.502	0.0	1520.0	960
1440 min Summer	4.700	0.0	1456.9	1210
2160 min Summer	3.392	0.0	2059.9	1584
2880 min Summer	2.689	0.0	2177.2	1996
4320 min Summer	1.935	0.0	2350.3	2848
5760 min Summer	1.531	0.0	2479.2	3584
7200 min Summer	1.276	0.0	2582.9	4328
8640 min Summer	1.099	0.0	2669.3	5032
10080 min Summer	0.968	0.0	2744.3	5752
15 min Winter	132.861	0.0	627.0	26
30 min Winter	87.290	0.0	773.6	41
60 min Winter	54.663	0.0	1032.5	70
120 min Winter	33.095	0.0	1250.3	128
180 min Winter	24.358	0.0	1380.5	186
240 min Winter	19.485	0.0	1457.9	244

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
360 min Winter	86.883	0.983	9.9	1427.7	O K
480 min Winter	86.911	1.011	9.9	1469.0	O K
600 min Winter	86.926	1.026	10.0	1491.0	O K
720 min Winter	86.933	1.033	10.0	1500.8	O K
960 min Winter	86.931	1.031	10.0	1497.6	O K
1440 min Winter	86.895	0.995	9.9	1445.4	O K
2160 min Winter	86.830	0.930	9.9	1350.8	O K
2880 min Winter	86.765	0.865	9.9	1256.7	O K
4320 min Winter	86.631	0.731	9.9	1062.6	O K
5760 min Winter	86.478	0.578	9.9	840.5	O K
7200 min Winter	86.345	0.445	9.9	645.9	O K
8640 min Winter	86.235	0.335	9.9	486.5	O K
10080 min Winter	86.149	0.249	9.9	361.4	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
360 min Winter	14.144	0.0	1542.3	360
480 min Winter	11.275	0.0	1572.5	476
600 min Winter	9.449	0.0	1569.3	592
720 min Winter	8.176	0.0	1560.2	706
960 min Winter	6.502	0.0	1537.4	928
1440 min Winter	4.700	0.0	1486.4	1346
2160 min Winter	3.392	0.0	2307.2	1676
2880 min Winter	2.689	0.0	2438.5	2140
4320 min Winter	1.935	0.0	2605.5	3072
5760 min Winter	1.531	0.0	2777.0	3880
7200 min Winter	1.276	0.0	2892.6	4616
8640 min Winter	1.099	0.0	2989.8	5280
10080 min Winter	0.968	0.0	3073.6	5952

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.300	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 2.250

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.750	4	8	0.750	8	12	0.750

Model Details

Storage is Online Cover Level (m) 88.000

Tank or Pond Structure

Invert Level (m) 85.900

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1453.0	0.300	1453.0	0.600	1453.0	0.900	1453.0
0.100	1453.0	0.400	1453.0	0.700	1453.0	1.000	1453.0
0.200	1453.0	0.500	1453.0	0.800	1453.0		

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0144-9900-1050-9900
Design Head (m)	1.050
Design Flow (l/s)	9.9
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	144
Invert Level (m)	85.850
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.050	9.9	Kick-Flo®	0.698	8.2
Flush-Flo™	0.315	9.9	Mean Flow over Head Range	-	8.5

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	5.2	0.800	8.7	2.000	13.4	4.000	18.7	7.000	24.4
0.200	9.5	1.000	9.7	2.200	14.0	4.500	19.8	7.500	25.3
0.300	9.9	1.200	10.5	2.400	14.6	5.000	20.8	8.000	26.1
0.400	9.8	1.400	11.3	2.600	15.2	5.500	21.8	8.500	26.8
0.500	9.6	1.600	12.1	3.000	16.3	6.000	22.7	9.000	27.6
0.600	9.2	1.800	12.8	3.500	17.5	6.500	23.6	9.500	28.3

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	100.395	0.395	39.7	1186.0	O K
30 min Summer	100.510	0.510	39.7	1530.9	O K
60 min Summer	100.622	0.622	39.7	1867.0	O K
120 min Summer	100.723	0.723	39.7	2168.8	Flood Risk
180 min Summer	100.768	0.768	39.7	2303.4	Flood Risk
240 min Summer	100.789	0.789	39.7	2366.8	Flood Risk
360 min Summer	100.798	0.798	39.7	2395.0	Flood Risk
480 min Summer	100.788	0.788	39.7	2365.0	Flood Risk
600 min Summer	100.769	0.769	39.7	2308.5	Flood Risk
720 min Summer	100.751	0.751	39.7	2252.2	Flood Risk
960 min Summer	100.716	0.716	39.7	2147.1	Flood Risk
1440 min Summer	100.651	0.651	39.7	1953.2	O K
2160 min Summer	100.561	0.561	39.7	1684.3	O K
2880 min Summer	100.479	0.479	39.7	1436.3	O K
4320 min Summer	100.335	0.335	39.7	1005.0	O K
5760 min Summer	100.224	0.224	39.7	673.0	O K
7200 min Summer	100.145	0.145	39.3	435.3	O K
8640 min Summer	100.091	0.091	38.6	273.5	O K
10080 min Summer	100.059	0.059	37.4	177.9	O K
15 min Winter	100.445	0.445	39.7	1335.5	O K
30 min Winter	100.576	0.576	39.7	1726.9	O K
60 min Winter	100.705	0.705	39.7	2114.1	Flood Risk
120 min Winter	100.822	0.822	39.7	2465.1	Flood Risk
180 min Winter	100.877	0.877	39.7	2630.9	Flood Risk
240 min Winter	100.906	0.906	39.7	2716.8	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	73.219	0.0	1240.7	26
30 min Summer	47.686	0.0	1617.7	40
60 min Summer	29.711	0.0	2016.9	70
120 min Summer	17.979	0.0	2440.2	128
180 min Summer	13.265	0.0	2699.9	186
240 min Summer	10.647	0.0	2891.2	246
360 min Summer	7.777	0.0	3165.4	362
480 min Summer	6.223	0.0	3379.1	480
600 min Summer	5.232	0.0	3550.5	554
720 min Summer	4.539	0.0	3696.3	610
960 min Summer	3.626	0.0	3937.2	740
1440 min Summer	2.638	0.0	4298.8	996
2160 min Summer	1.918	0.0	4686.2	1388
2880 min Summer	1.528	0.0	4978.0	1788
4320 min Summer	1.109	0.0	5419.5	2520
5760 min Summer	0.883	0.0	5752.2	3232
7200 min Summer	0.739	0.0	6019.5	3896
8640 min Summer	0.639	0.0	6248.1	4584
10080 min Summer	0.565	0.0	6446.1	5240
15 min Winter	73.219	0.0	1390.1	26
30 min Winter	47.686	0.0	1811.1	40
60 min Winter	29.711	0.0	2258.1	68
120 min Winter	17.979	0.0	2733.4	126
180 min Winter	13.265	0.0	3024.7	184
240 min Winter	10.647	0.0	3236.9	240

Summary of Results for 30 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
360 min Winter	100.925	0.925	39.7	2776.3	Flood Risk
480 min Winter	100.923	0.923	39.7	2769.1	Flood Risk
600 min Winter	100.908	0.908	39.7	2725.4	Flood Risk
720 min Winter	100.887	0.887	39.7	2661.6	Flood Risk
960 min Winter	100.842	0.842	39.7	2525.1	Flood Risk
1440 min Winter	100.758	0.758	39.7	2275.5	Flood Risk
2160 min Winter	100.624	0.624	39.7	1870.8	O K
2880 min Winter	100.492	0.492	39.7	1475.2	O K
4320 min Winter	100.276	0.276	39.7	827.8	O K
5760 min Winter	100.133	0.133	39.2	397.6	O K
7200 min Winter	100.059	0.059	37.4	178.4	O K
8640 min Winter	100.031	0.031	33.0	94.1	O K
10080 min Winter	100.012	0.012	29.6	36.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
360 min Winter	7.777	0.0	3546.1	356
480 min Winter	6.223	0.0	3785.3	466
600 min Winter	5.232	0.0	3977.7	576
720 min Winter	4.539	0.0	4140.8	678
960 min Winter	3.626	0.0	4411.1	770
1440 min Winter	2.638	0.0	4812.8	1082
2160 min Winter	1.918	0.0	5249.4	1524
2880 min Winter	1.528	0.0	5576.8	1932
4320 min Winter	1.109	0.0	6071.1	2644
5760 min Winter	0.883	0.0	6441.2	3288
7200 min Winter	0.739	0.0	6743.1	3832
8640 min Winter	0.639	0.0	6998.0	4576
10080 min Winter	0.565	0.0	7221.0	5248

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.300	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 9.053

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	3.018	4	8	3.018	8	12	3.018

Model Details

Storage is Online Cover Level (m) 101.000

Tank or Pond Structure

Invert Level (m) 100.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	3000.0	1.000	3000.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0265-3980-1200-3980
Design Head (m)	1.200
Design Flow (l/s)	39.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	265
Invert Level (m)	99.800
Minimum Outlet Pipe Diameter (mm)	300
Suggested Manhole Diameter (mm)	1800

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	39.7	Kick-Flo®	0.883	34.3
Flush-Flo™	0.437	39.7	Mean Flow over Head Range	-	33.1

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	8.4	0.800	36.7	2.000	50.8	4.000	71.1	7.000	93.4
0.200	27.2	1.000	36.4	2.200	53.2	4.500	75.3	7.500	96.6
0.300	38.7	1.200	39.7	2.400	55.5	5.000	79.2	8.000	99.6
0.400	39.7	1.400	42.8	2.600	57.7	5.500	83.0	8.500	102.6
0.500	39.6	1.600	45.6	3.000	61.8	6.000	86.6	9.000	105.5
0.600	39.1	1.800	48.3	3.500	66.6	6.500	90.0	9.500	108.4

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	100.366	0.366	39.7	2197.7	O K
30 min Summer	100.479	0.479	39.7	2873.8	O K
60 min Summer	100.593	0.593	39.7	3558.8	O K
120 min Summer	100.703	0.703	39.7	4216.5	Flood Risk
180 min Summer	100.759	0.759	39.7	4556.8	Flood Risk
240 min Summer	100.793	0.793	39.7	4758.7	Flood Risk
360 min Summer	100.828	0.828	39.7	4970.1	Flood Risk
480 min Summer	100.846	0.846	39.7	5074.7	Flood Risk
600 min Summer	100.852	0.852	39.7	5110.8	Flood Risk
720 min Summer	100.851	0.851	39.7	5104.0	Flood Risk
960 min Summer	100.835	0.835	39.7	5012.2	Flood Risk
1440 min Summer	100.788	0.788	39.7	4730.5	Flood Risk
2160 min Summer	100.727	0.727	39.7	4364.8	Flood Risk
2880 min Summer	100.673	0.673	39.7	4038.7	O K
4320 min Summer	100.571	0.571	39.7	3427.2	O K
5760 min Summer	100.480	0.480	39.7	2882.8	O K
7200 min Summer	100.399	0.399	39.7	2396.2	O K
8640 min Summer	100.327	0.327	39.7	1962.5	O K
10080 min Summer	100.265	0.265	39.7	1589.8	O K
15 min Winter	100.411	0.411	39.7	2468.7	O K
30 min Winter	100.539	0.539	39.7	3231.2	O K
60 min Winter	100.668	0.668	39.7	4007.8	O K
120 min Winter	100.793	0.793	39.7	4760.4	Flood Risk
180 min Winter	100.859	0.859	39.7	5155.8	Flood Risk
240 min Winter	100.900	0.900	39.7	5397.1	Flood Risk

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	132.861	0.0	2252.8	26
30 min Summer	87.290	0.0	2959.5	41
60 min Summer	54.663	0.0	3709.7	70
120 min Summer	33.095	0.0	4491.5	130
180 min Summer	24.358	0.0	4957.9	190
240 min Summer	19.485	0.0	5290.0	248
360 min Summer	14.144	0.0	5757.5	366
480 min Summer	11.275	0.0	6122.4	486
600 min Summer	9.449	0.0	6405.0	604
720 min Summer	8.176	0.0	6435.4	722
960 min Summer	6.502	0.0	6390.7	960
1440 min Summer	4.700	0.0	6216.9	1226
2160 min Summer	3.392	0.0	8291.4	1604
2880 min Summer	2.689	0.0	8760.3	2000
4320 min Summer	1.935	0.0	9459.4	2772
5760 min Summer	1.531	0.0	9978.4	3576
7200 min Summer	1.276	0.0	10390.1	4328
8640 min Summer	1.099	0.0	10743.1	5024
10080 min Summer	0.968	0.0	11043.4	5752
15 min Winter	132.861	0.0	2523.0	26
30 min Winter	87.290	0.0	3300.8	41
60 min Winter	54.663	0.0	4152.7	70
120 min Winter	33.095	0.0	5031.2	128
180 min Winter	24.358	0.0	5552.2	186
240 min Winter	19.485	0.0	5924.0	244

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
360 min Winter	100.944	0.944	39.7	5664.6	Flood Risk
480 min Winter	100.969	0.969	39.7	5811.5	Flood Risk
600 min Winter	100.980	0.980	39.7	5881.4	Flood Risk
720 min Winter	100.984	0.984	39.7	5902.5	Flood Risk
960 min Winter	100.976	0.976	39.7	5855.8	Flood Risk
1440 min Winter	100.931	0.931	39.7	5586.1	Flood Risk
2160 min Winter	100.853	0.853	39.7	5118.7	Flood Risk
2880 min Winter	100.782	0.782	39.7	4694.5	Flood Risk
4320 min Winter	100.636	0.636	39.7	3818.4	O K
5760 min Winter	100.494	0.494	39.7	2963.4	O K
7200 min Winter	100.371	0.371	39.7	2223.7	O K
8640 min Winter	100.267	0.267	39.7	1602.3	O K
10080 min Winter	100.184	0.184	39.6	1106.5	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
360 min Winter	14.144	0.0	6444.8	360
480 min Winter	11.275	0.0	6498.4	476
600 min Winter	9.449	0.0	6485.7	592
720 min Winter	8.176	0.0	6464.0	706
960 min Winter	6.502	0.0	6406.7	930
1440 min Winter	4.700	0.0	6258.7	1354
2160 min Winter	3.392	0.0	9283.6	1692
2880 min Winter	2.689	0.0	9809.9	2164
4320 min Winter	1.935	0.0	10590.7	3068
5760 min Winter	1.531	0.0	11169.2	3856
7200 min Winter	1.276	0.0	11640.4	4608
8640 min Winter	1.099	0.0	12031.4	5280
10080 min Winter	0.968	0.0	12368.3	5952

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.300	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 9.053

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	3.018	4	8	3.018	8	12	3.018

Model Details

Storage is Online Cover Level (m) 101.000

Tank or Pond Structure

Invert Level (m) 100.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	6000.0	1.000	6000.0

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0265-3980-1200-3980
Design Head (m)	1.200
Design Flow (l/s)	39.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	265
Invert Level (m)	99.800
Minimum Outlet Pipe Diameter (mm)	300
Suggested Manhole Diameter (mm)	1800

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	39.7	Kick-Flo®	0.883	34.3
Flush-Flo™	0.437	39.7	Mean Flow over Head Range	-	33.1

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Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	8.4	0.800	36.7	2.000	50.8	4.000	71.1	7.000	93.4
0.200	27.2	1.000	36.4	2.200	53.2	4.500	75.3	7.500	96.6
0.300	38.7	1.200	39.7	2.400	55.5	5.000	79.2	8.000	99.6
0.400	39.7	1.400	42.8	2.600	57.7	5.500	83.0	8.500	102.6
0.500	39.6	1.600	45.6	3.000	61.8	6.000	86.6	9.000	105.5
0.600	39.1	1.800	48.3	3.500	66.6	6.500	90.0	9.500	108.4