Resilience and Flood Risk

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# Land to the east of Hookham's Lane, Salph End, Renhold, MK41 0JX

FLOOD RISK ASSESSMENT

&

DRAINAGE STRATEGY

21/01/2020

Version 3.0

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## Revision History

| Version | Date | Amendments | Issued to |
|---|---|---|---|
| 1.0 | 27/09/2019 | | Craig Nixon |
| 2.0 | 22/10/2019 | Minor drainage amendment | Frazer Hickling |
| 3.0 | 21/01/2020 | Drainage amendment | Frazer Hickling |

## Quality Control

| Action | Signature | Date |
|---|---|---|
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| Checked | [redacted] | 21/01/2020 |
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## Disclaimer



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# Contents

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# 1.0 Introduction

RAB Consultants has prepared this Flood Risk Assessment (FRA) in support of the proposed residential development at Land to the east of Hookham's Lane, Salph End, Renhold.

The development site is located in Flood Zone 1 according to the Environment Agency's Flood Map for Planning (Rivers and Sea). The Planning Practice Guidance for the National Planning Policy Framework (NPPF) requires a site-specific FRA to be carried out for developments located in Flood Zones 2 and 3 and for those which are 1 hectare (ha) or greater in size. A site-specific FRA is required to ensure that the development is safe from flooding and will not increase the risk of flooding elsewhere.

The Secretary of State for Communities and Local Government laid a Written Ministerial Statement in the House of Commons on 18th December 2014 setting out changes to planning that will apply for major development from 6 April 2015. Therefore, from 6 April 2015 local planning policies and decisions on planning applications relating to major development are required to ensure that sustainable drainage systems (SuDS) are used for the management of surface water. As the Lead Local Flood Authority, Bedford Borough Council is required under Article 18 of the Town and Country Planning (Development Management Procedure) (England) Order 2015 (the Development Management Procedure Order) to provide consultation response on the surface water drainage provisions associated with major development.

Major development is defined within the Development Management Procedure Order as development that involves any one or more of the following:

- the winning and working of minerals or the use of land for mineral working deposits;
- waste development;
- the provision of dwelling houses where:
  - the number of dwelling houses to be provided is 10 or more; or
  - the development is to be carried out on a site having an area of 0.5 hectares or more and it is not known whether the development falls within sub-paragraph 3.1;
- the provision of a building or buildings where the floor space to be created by the development is 1,000 square metres or more; or
- development carried out on a site having an area of 1 hectare or more.

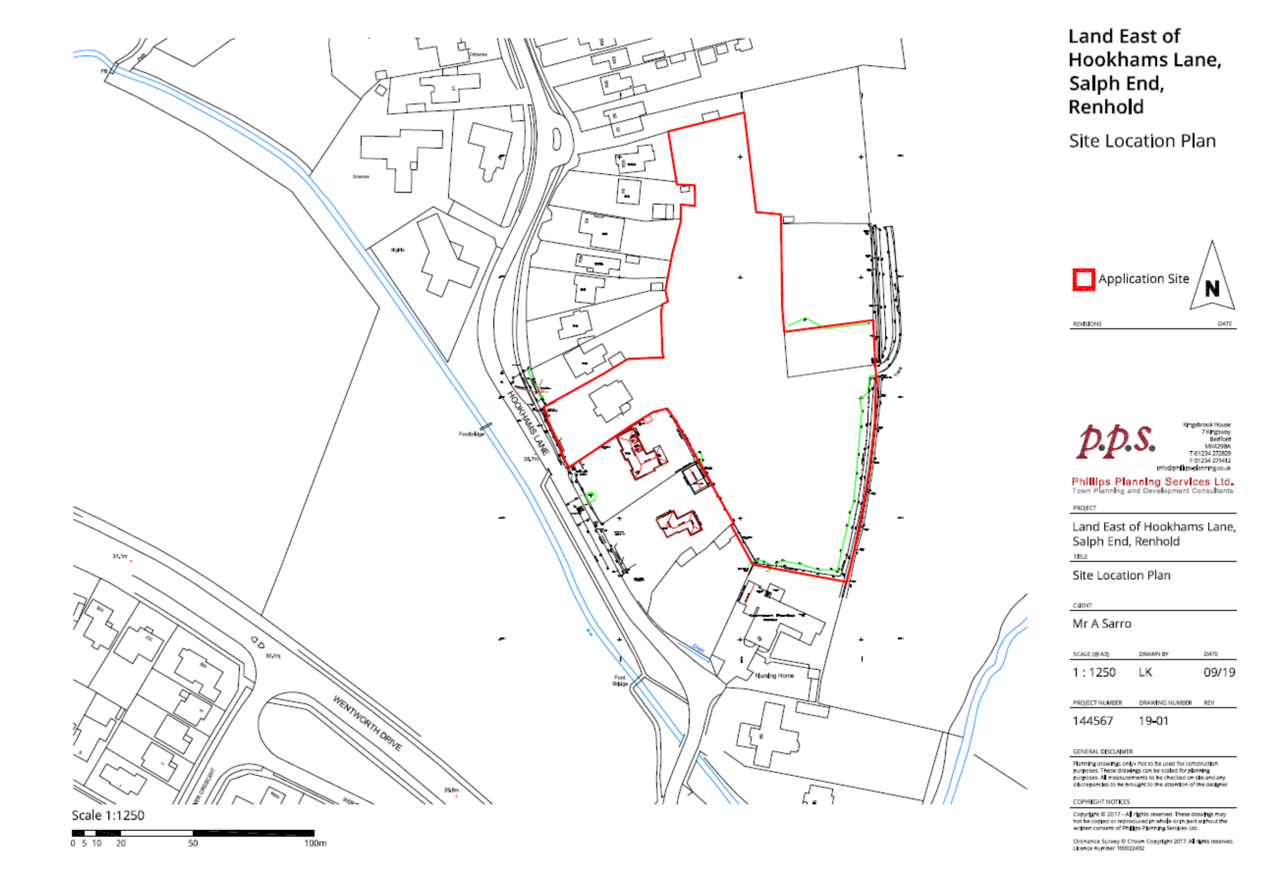
As such, a drainage strategy is required to identify measures for the management of surface water runoff, also in line with the 2018 Bedford Borough Council Supplementary Planning Document for Sustainable Drainage Systems (SPD).

# 2.0 Site details

## 2.1 Site location

**TABLE 1: SITE LOCATION**

| | |
|---|---|
| Site address: | Land to the east of Hookham's Lane, Salph End, Renhold, MK41 0JX |
| Site area: | 1.18 ha |
| Existing land use: | Greenfield |
| OS NGR: | TL 07747 52394 |
| Local Planning Authority: | Bedford Borough Council |




## 2.2 Site description

The site visit was undertaken by RAB Consultants on the 17th of September 2019. A photographic survey and a visual assessment of the existing site, including the surrounding areas, were undertaken on the day.

Access to the site is via a dirt road with a gated entrance just off Hookhams Lane in an eastern direction. The dirt road leads back to the site's open space which is located directly behind neighbouring houses on Hookhams Lane (Figure 1). The site is currently occupied by agricultural land with vegetation running around the perimeter.

A ditch is located on the western boundary (Figure 2), approximately 500 mm – 1m deep and discharges into a drain (Figure 3); the ditch runs under the dirt road via pipes. On the eastern boundary another ditch, approximately 1.7m deep (Figure 4) flows in a southern direction towards the main river, where it joins just south of the site (Figure 5). Both the river and ditch are very overgrown, especially at the confluence.

On Hookhams Lane, road runoff is most likely discharged into the stream that is located east of Hookhams Lane road (Figure 6) via the use of gullies and the highway drain.

Surface water runoff is currently draining to the east ditch for the majority of the site. A small part of the site slopes to the west with runoff most likely running at greenfield rates towards Hookhams Lane where it is being collected and managed by road gullies.

**TABLE 2: SITE PHOTOGRAPHS**

| | |
|---|---|
|  **FIGURE 1: ACCESS ONTO THE SITE** |  **FIGURE 2: DITCH ON THE WESTERN BOUNDARY** |
|  **FIGURE 3: DRAINAGE FOR WESTERN BOUNDARY DITCH** |  **FIGURE 4: DITCH ON EASTERN BOUNDARY** |

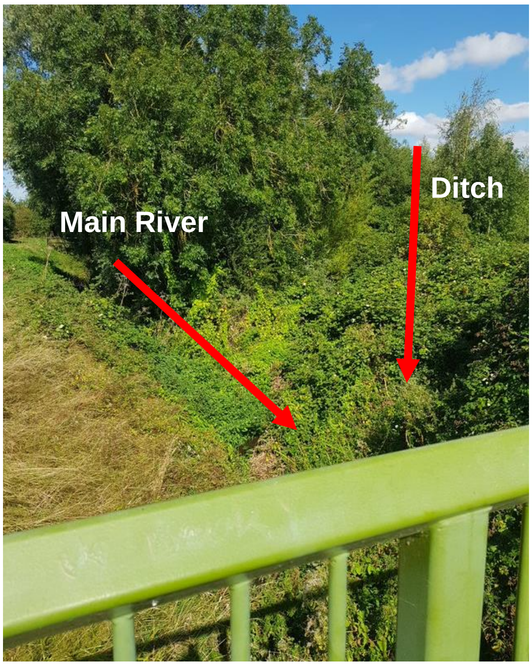



FIGURE 5: DITCH JOINING THE MAIN RIVER


FIGURE 6: HOOKHAM'S LANE AND MAIN RIVER OUTSIDE SITE

## 2.3 Development proposal

Permission is sought to construct up to 28 dwellings with associated parking and amenity space.

# 3.0 Flood risk

## 3.1 Sequential test

According to the Environment Agency's Flood Map for Planning the site lies in Flood Zone 1; which is described in the NPPF as land having a less than 1 in 1,000 annual probability of river or sea flooding (less than 0.1% AEP).

The NPPF follows a sequential risk-based approach in determining the suitability of land for development in flood risk areas, with the intention of steering all new development to the lowest flood risk areas. NPPF Planning Practice Guidance (PPG) Table 2 confirms the 'Flood risk vulnerability classification' of a site, depending upon the proposed usage. This classification is subsequently applied to Table 3 'Flood risk vulnerability and flood zone compatibility' to determine whether:

- The proposed development is suitable for the flood zone in which it is located; and
- Whether an Exception Test is required for the proposed development

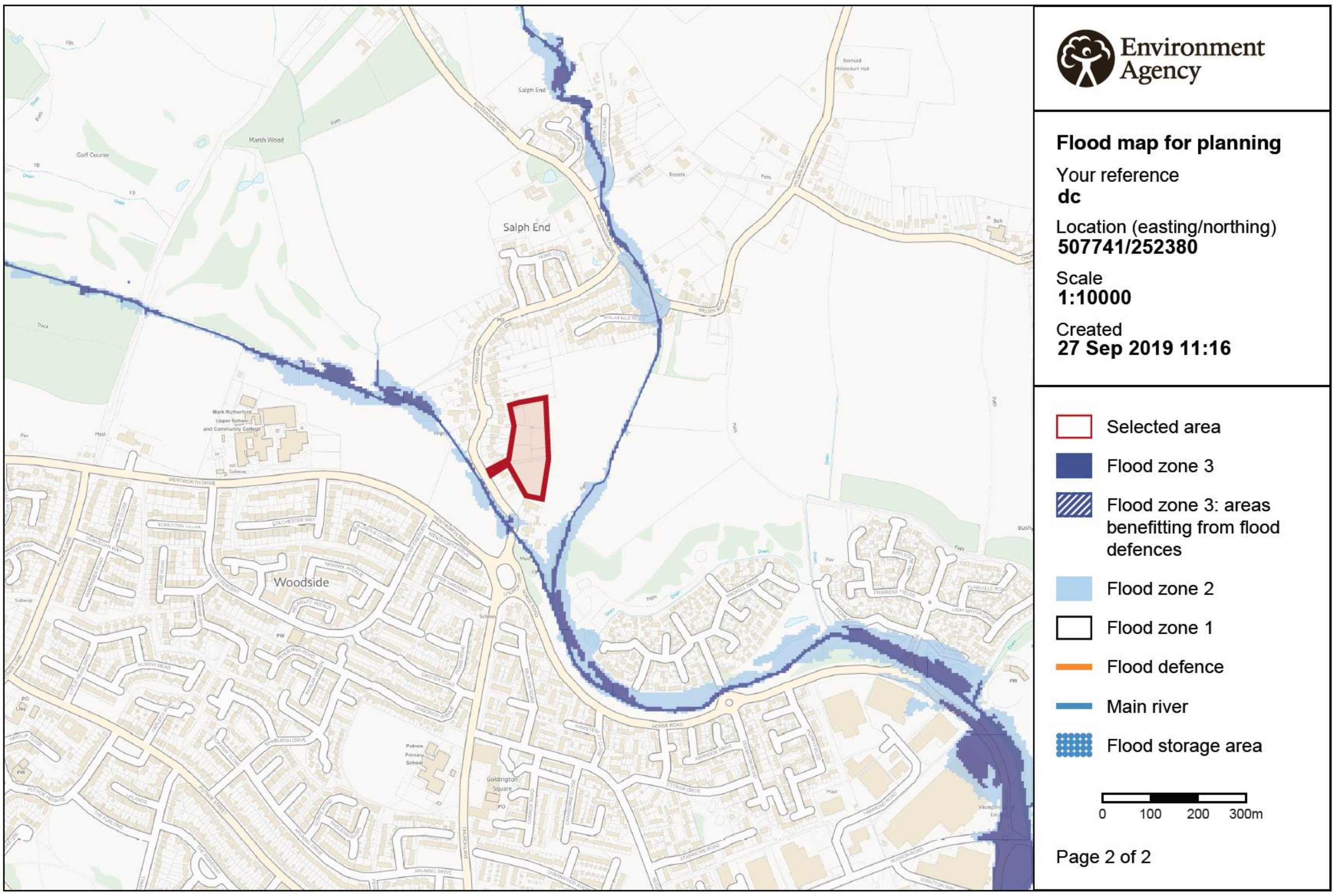





**FIGURE 7: ENVIRONMENT AGENCY FLOOD MAP**

The proposed development is classed as a 'more vulnerable' development in Flood Zone 1, in accordance with NPPF PPG. The development is therefore appropriate for the Flood Zone and passes the Sequential Test.

## 3.2 Flooding history

The 2015 Bedford Borough Council Strategic Flood Risk Assessment (SFRA) shows two IDB historic flood incidents in Salph End. One incident was in 2001 due to fluvial flooding although no more detail was given on this event.

## 3.3 Fluvial (Rivers)

According to the Environment Agency Flood Map for Planning, the site is located in Flood Zone 1 therefore has less than 0.1% AEP risk of flooding from this source.

## 3.4 Flood defence breach or overtopping

### 3.4.1. Breach risk

The site is not protected by any formal defences therefore is not at risk from a breach.

### 3.4.2. Overtopping risk

The site is not protected by any formal defences therefore is not at risk from overtopping.

## 3.5 Coastal/tidal

The site is located at a considerable distance from the sea and is not at risk of coastal or tidal flooding.

## 3.6 Pluvial (Surface water)

When the infiltration capacity of land or the drainage capacity of a local sewer network is exceeded, excess rainwater flows overland. This water will collect in topographic depressions and at obstructions, which can inundate development in low lying areas. The severity of the rainfall event, the degree of saturation of the soil before the event, the permeability of soils and geology, and the gradient of the surrounding land and it's use; all contribute to and affect the severity of overland flow.

The Environment Agency Flood Map for Surface Water (Figure 8) can be used to see the approximate areas that would experience surface water flooding from a range of AEPs, which is used to categorise the risk (Table 3).

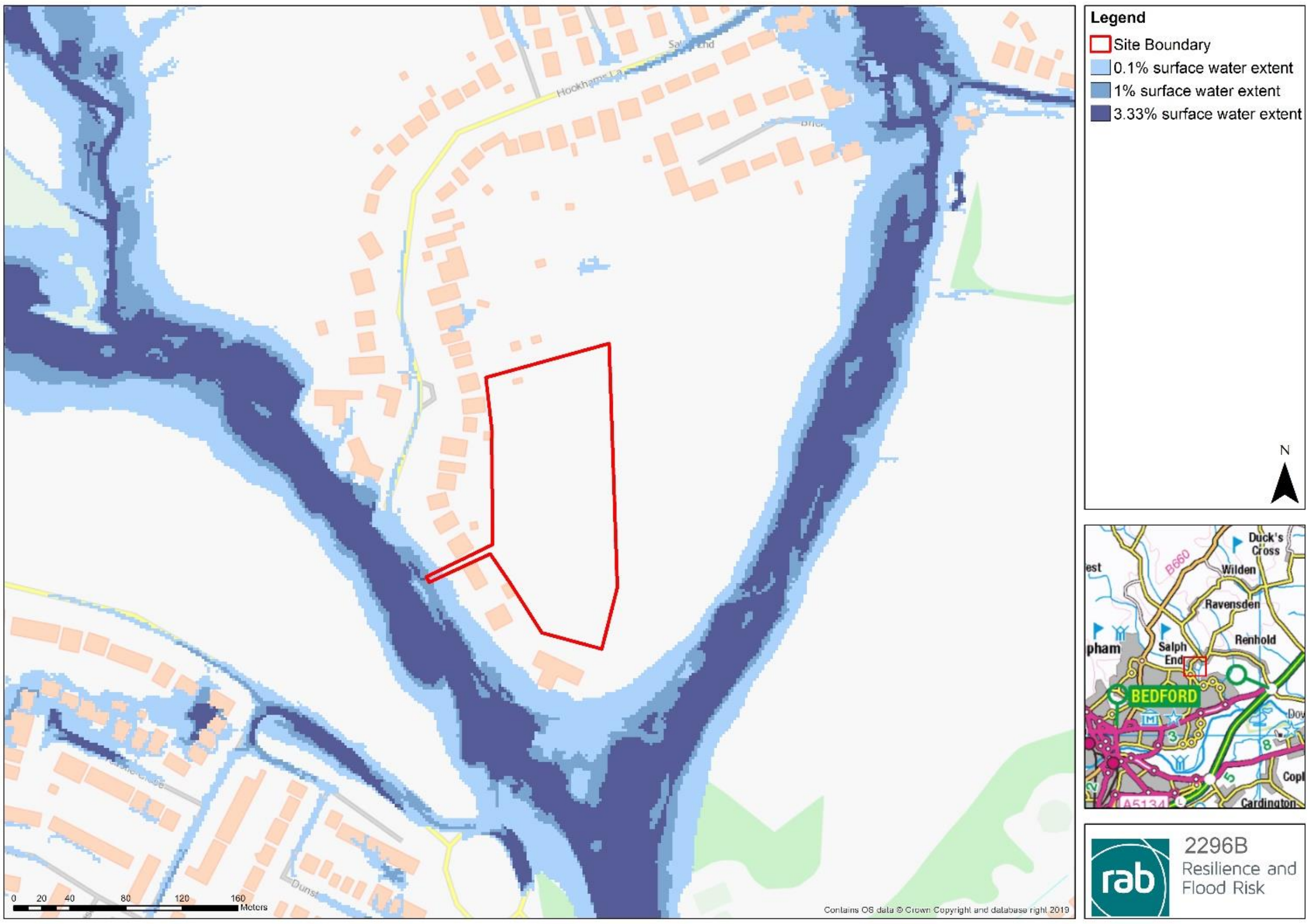



**FIGURE 8: ENVIRONMENT AGENCY FLOOD RISK FROM SURFACE WATER**

**TABLE 3: ENVIRONMENT AGENCY SURFACE WATER RISK CATEGORIES**

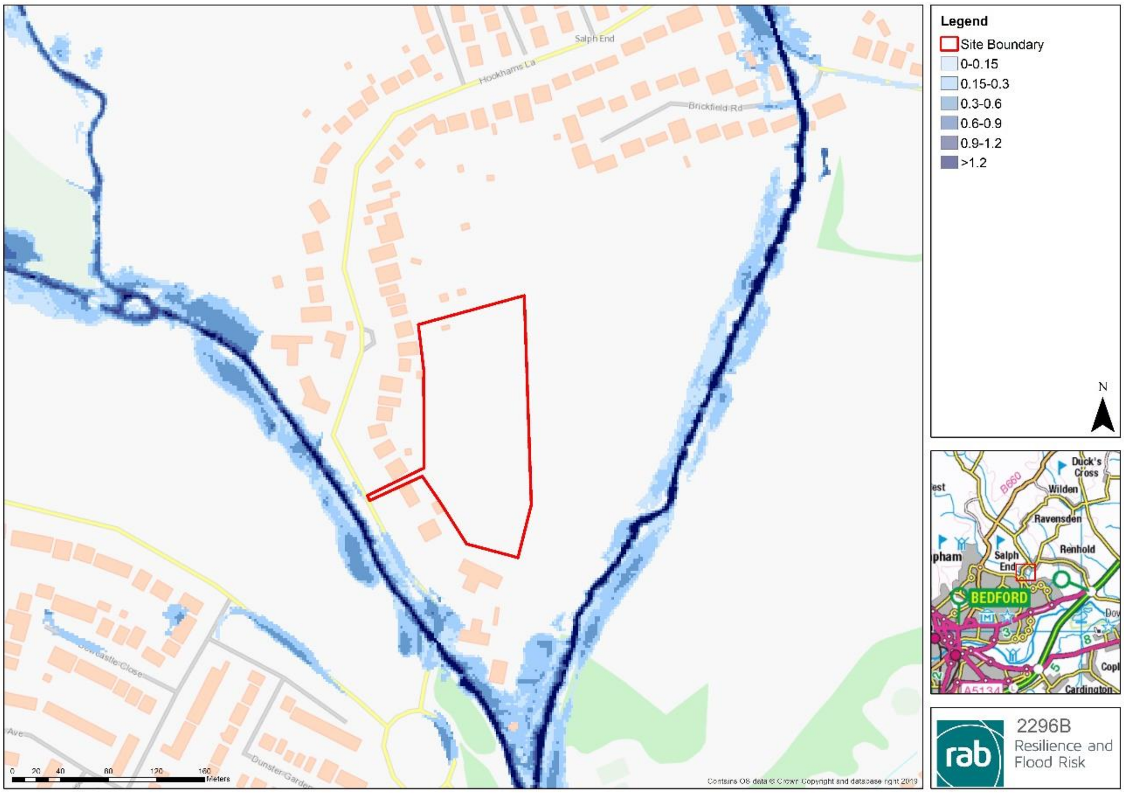
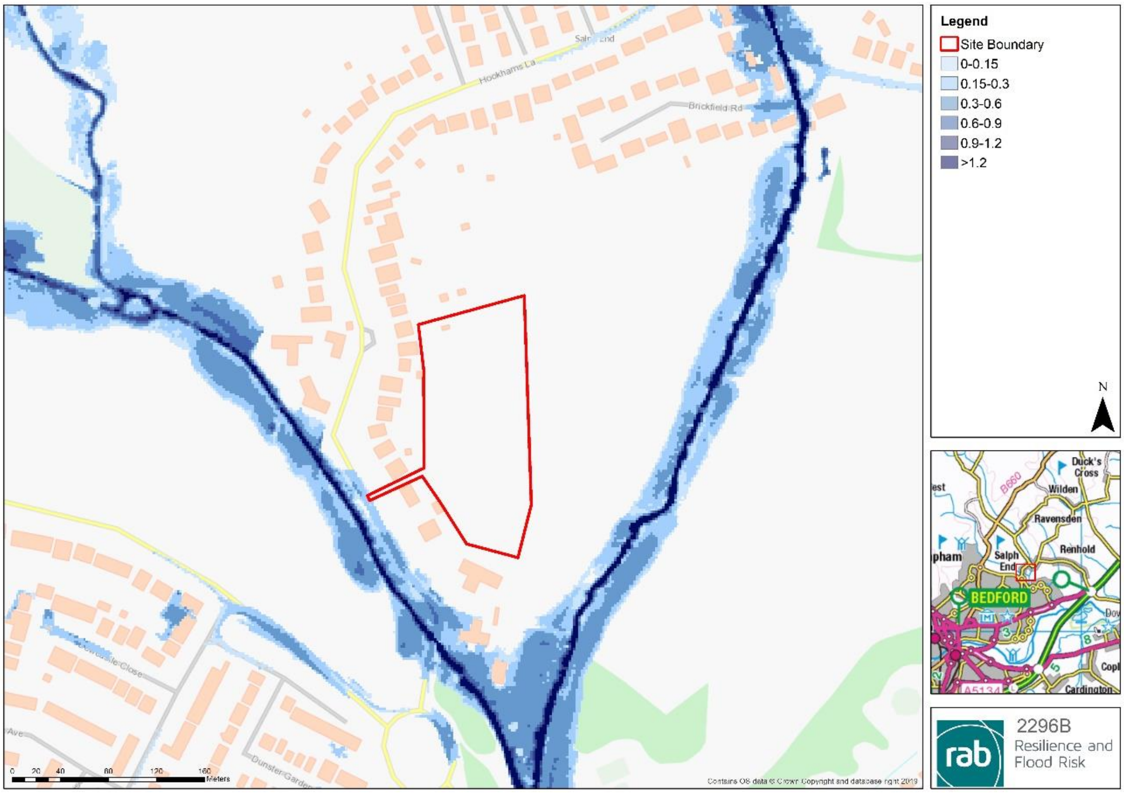
| Surface Water Risk Category | Surface water flooding Annual Exceedance Probability |
|---|---|
| Very Low | < 0.1% |
| Low | Between 1% and 0.1% (1 in 100 years and 1 in 1000 years) |
| Medium | Between 1% and 3.3% (1 in 100 years and 1 in 30 years) |
| High | > 3.3% (1 in 30 years) |

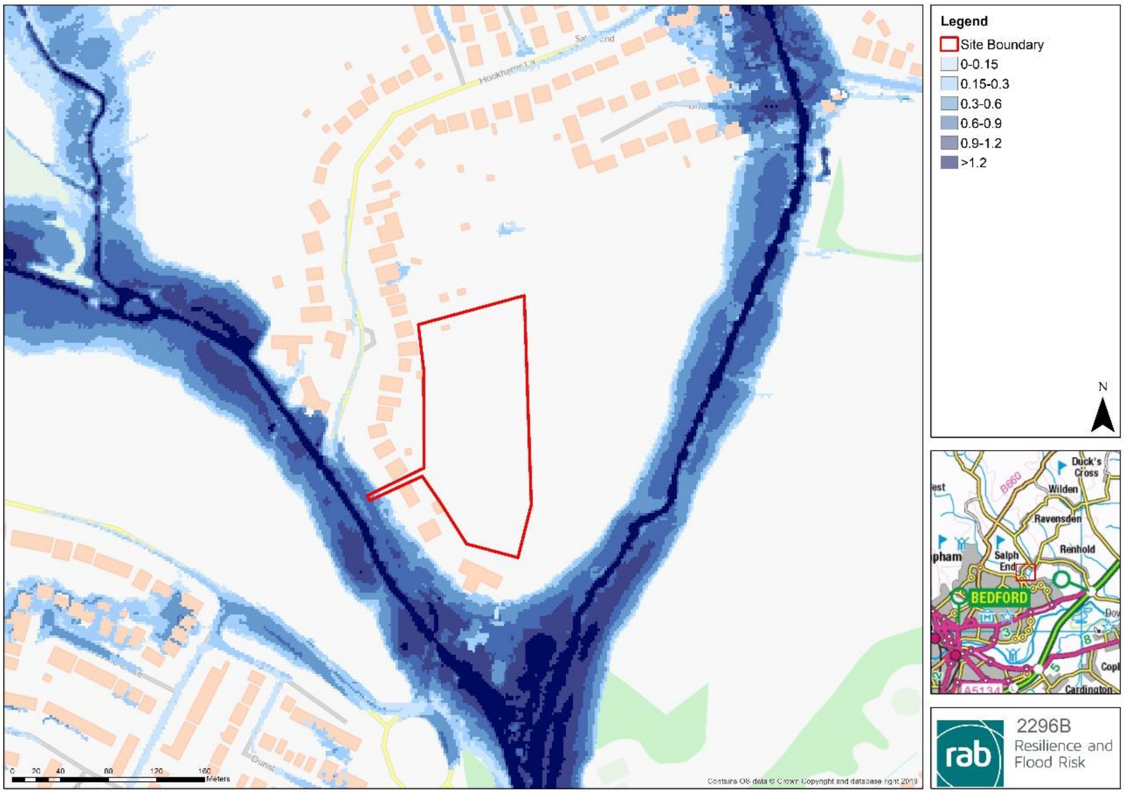
The Surface Water map identifies that the site is at very low risk from surface water flooding. Hookhams Lane is shown to be at medium/high risk from surface water flooding.

The site is shown not to flood during the 3.33% AEP, 1% AEP and 0.1% AEP surface water events.

During the 1% AEP, Hookhams Lane outside the site could flood to depths of 600 mm and during the 0.1% AEP it could flood to depths of between 600 mm and 900 mm as shown in Table 4.

**TABLE 4: SURFACE WATER FLOOD DEPTHS FOR A RANGE OF AEP'S**

<table>
<tr><th>AEP</th><th>Flood extent</th></tr>
<tr><td>3.33%</td><td>
</td></tr>
<tr><td>1%</td><td>
</td></tr>
</table>

| AEP | Flood extent |
| --- | --- |
| 0.1% |  |

## 3.7 Artificial water bodies

According to the Environment Agency Reservoir Flood Map, the site is not at risk of flooding from this source.

## 3.8 Groundwater

British Geological Survey (BGS) records indicate that the proposed development site overlies bedrock composed of Peterborough Member - mudstone. This is overlain (superficial deposits) by Oadby Member – Diamicton. Mudstone is impermeable therefore provides a barrier to rising groundwater.

There are no boreholes within close proximity to the site.

The 2015 SFRA shows the site within a 25%-50% area susceptible to groundwater flooding, suggesting low to medium risk.

As there is a high degree of variability when considering groundwater flooding, using historic flooding is not a robust measure of the risk of flooding in future years.

## 3.9 Sewers

Anglian Water is responsible for the adopted surface and foul sewer networks within the District and maintain a DG5 register of sites affected by sewer flood incidents on a post code basis.

The 2015 SFRA shows that at postcode MK41 0 there have been between 14 and 18 historical sewer flooding incidents. This potential and unpredictable risk can be mitigated by the use of non-return valves to the foul sewer system of the site.

It is important to note that previous sewer flood incidents, or the lack thereof, do not indicate the current or future risk to the site. Upgrade work could have been carried out to alleviate any issues or conversely, in areas that have not experienced sewer flooding incidents, the local drainage infrastructure could deteriorate leading to future flooding.

# 4.0 Mitigation measures

## 4.1 Risk to buildings

### 4.1.1. Finished floor levels

In accordance with BS8533:2017 *'Assessing and managing flood risk in development – code of practice'*, in order to afford a level of protection against flooding it is recommended that finished floor levels should be set at a nominal 300mm above either the 1% AEP of fluvial flooding or the 0.5% AEP of tidal flooding depending on which is greater (both including climate change).

The site is located outside of the fluvial and surface water risk. Industry best practise suggests setting ground finished floor levels 150 mm above local ground level to offer a level of protection against infrastructure failure.

### 4.1.2. Flood resistance

It is highly recommended to install a non-return valve to the last foul water manhole, prior to connecting to the Anglian Water foul sewer, in order to mitigate against any potential infrastructure failure.

### 4.1.3. Flood resilience

Flood resilience measures are not required.

## 4.2 Risk to occupiers

### 4.2.1. Safe access/egress

The site access road will remain dry during all critical events however, Hookhams Lane is shown to flood during the 1% AEP and the 0.1% AEP. Following methods within BS8533:2017, a hazard rating of between 1.45 – 1.67 has been calculated for the site access during the 0.1% AEP surface water flood event, based on a depth of 600 mm – 900 mm and a velocity of 0.25 m/s. According to FD2321_3437_TRP the hazard rating reflects a danger for some and danger for most classification. This means that emergency services will be able to access the site should it be required while the residents will not be impacted (based on the Environment Agency surface water map).

## 4.3 Risk to others

### 4.3.1. Floodplain compensation

The site is in Flood Zone 1 therefore floodplain compensation is not required.

### 4.3.2. Surface water run-off

Information surrounding potential methods to further reduce surface water run-off, such as through the incorporation of incorporate Sustainable Drainage Systems (SuDS), can be found within Chapter 5.0 below.

# 5.0 Drainage strategy

## 5.1 SuDS feasibility

The SuDS Manual (2015) discusses the SuDS approach to managing surface water runoff which is intended to mimic the natural catchment process as closely as possible. The approach sets out the design objectives in respect of SuDS:

- Use of surface water runoff as a resource;
- Manage rainwater close to where it falls (at source);
- Manage runoff on the surface (above ground);
- Allow rainwater to soak into the ground (infiltration);
- Promote evapotranspiration;
- Slow and store runoff to mimic natural runoff rates and volumes;
- Reduce contamination of runoff through pollution prevention and by controlling the runoff at source; and
- Treat runoff to reduce the risk of urban contaminants causing environmental pollution.

Depending on the characteristics of the site and local requirements, these may be used in conjunction and to varying degrees. Table 5 presents the functions of the SuDS components (from which a management train can be created) and their feasibility in respect of the site.

**TABLE 5: FEASIBILITY OF SUDS TECHNIQUES AT THE DEVELOPMENT SITE**

| Technique | Description | Feasibility<br>Y / N / M (Maybe) |
|---|---|---|
| Good building design and rainwater harvesting | Components that capture rainwater and facilitate its use within the building or local environment. | **Maybe** – rainwater harvesting tanks could be incorporated to reuse grey water. Water butts could be incorporated into each house. |
| Porous and pervious surface materials | Structural surfaces that allow water to penetrate, thus reducing the proportion of runoff that is conveyed to the drainage system (green roofs, pervious paving). | **Yes** – permeable paving could be used in the outside parking spaces. |
| Infiltration Systems | Components that facilitate the infiltration of water into the ground. These often include temporary storage zones to accommodate runoff volumes before slow release to the soil. | **No** – due to the poor infiltration results infiltration is not possible at the site. |
| Conveyance Systems | Components that convey flows to downstream storage systems (e.g. swales, watercourses). | **Maybe** – there is a lack of space on site for conveyance systems therefore this may not be an appropriate option. |

| Technique | Description | Feasibility<br>Y / N / M (Maybe) |
|---|---|---|
| Storage Systems | Components that control the flows and, where possible, volumes of runoff being discharged from the site, by storing water and releasing it slowly (attenuation). These systems may also provide further treatment of the runoff (e.g. ponds, wetlands, and detention basins). | **Yes** – storage systems such as wet ponds and cellular storage could be incorporated into the final designs. |
| Treatment Systems | Components that remove or facilitate the degradation of contaminants present in the runoff. | **Yes** – treatment systems can be incorporated into the above SuDS features. |

## 5.2 Existing surface water management

### 5.2.1. Existing drainage arrangements

The site is currently greenfield therefore has no formal drainage infrastructure. Surface water most likely drains into the adjacent open channel to the east, with the River downstream being the ultimate receptor. The small part of the site which slopes to the west most likely drains to Hookhams Lane highway drainage network via overland flow paths and following the topography.

### 5.2.2. Natural flow path

The natural flow path suggests that water will flow from the north towards the south of the site. The levels fall from 33.5 mAOD to 30.30 mAOD. In addition, the entrance to the west of the site falls from the east to the west from a level of 30.80 mAOD to 29.10 mAOD.

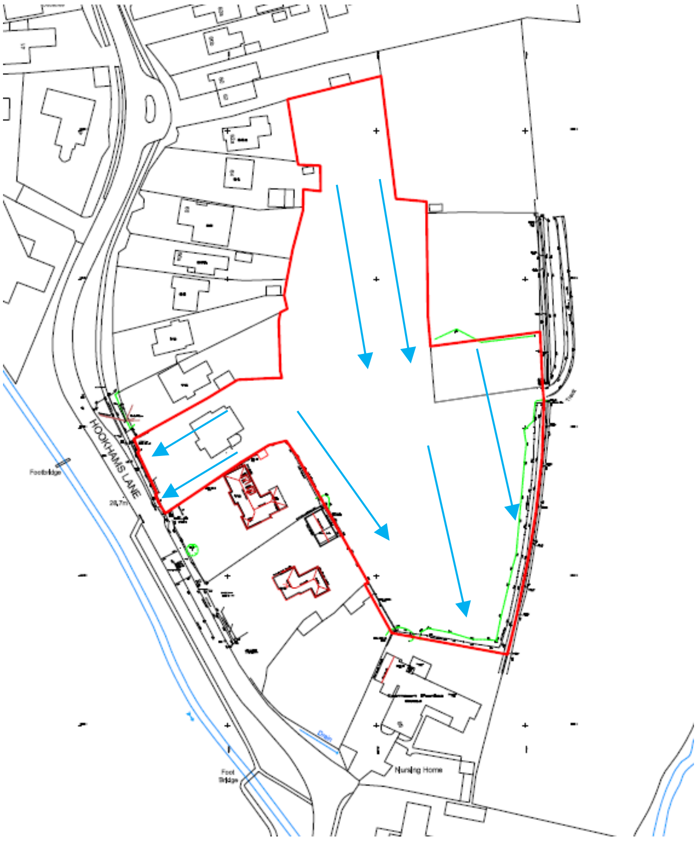


**FIGURE 9: NATURAL FLOW PATH**

### 5.2.3. Greenfield runoff

The greenfield runoff rate was calculated using the ICP SUDS method for determining Greenfield runoff rate built into Microdrainage WinDes 2013.1 (including the modification given in the Interim Code of Practice for SUDS, Chapter 6):

- SAAR (mm) = 568
- Area (ha) = 1
- Soil = 0.4

The QBAR was calculated at 2.7 l/s/ha (see Appendix D). Table 6 below shows the greenfield runoff rates relevant to the proposed hardstanding area of 0.662 ha.

**TABLE 6: GREENFIELD PEAK FLOW RUNOFF RATES**

| AEP (%) | Greenfield peak flow rate (l/s) |
|---|---|
| 100 | 1.5 |
| 50 (QBAR) | 1.8 |
| 3.33 | 4.2 |
| 1 | 6.3 |
| 1 +35% Climate Change* | 8.5 |

* Anglian river basin higher central climate change allowance

## 5.3 Proposed discharge

The 2015 SuDS Manual recommends a specific hierarchy in terms of surface water discharge destinations:

1. Discharge into the ground.
2. Discharge into a water body.
3. Discharge to a surface water sewer.
4. Discharge to a combined sewer.

Due to a very low infiltration rate (the pit water level only fell approximately 1 cm over 24 hours), infiltration is not a feasible option on site.

There is an open channel located east of the site which the site can discharge to. As such, the site will discharge to a water body at a controlled rate of 2 l/s for all events up to and including the 1% AEP + 40% CC (1 in 100 year plus 40% climate change), as recommended by Bedford Borough Council at their response (reference: E19721) dated 22/10/2019.

In addition, the small part of the site which slopes towards the west at Hookhams Lane, will have to drain to the highway drain located at the road. This is due to the fact that gravity flow will not work in this part of the site. A connection to the highway drain running under Hookhams Lane will be made under a S278 & S38 agreements; please note that this part of the site will only drain road runoff therefore the use of SuDS is not applicable in this instance. A 50 mm orifice chamber will control the rate of runoff to 5.5 l/s using a 375 mm diameter pipe to convey and attenuate the road runoff; this configuration will be confirmed during the adoption stage. Please note that the proposed building in Catchment B will drain into the Catchment A surface water network via gravity flow.

## 5.4 Proposed surface water management

The proposed drainage scheme has been modelled in Microdrainage Source Control to understand the evolving flow regime under flood conditions and the potential for flooding. The proposed scheme (see Appendix D) will integrate a range of features, in line with the SuDS Manual philosophy, taking into consideration site constraints. Figure 10 below shows the two catchments relevant to the development proposals. Catchment A will manage surface water runoff via the use of a wet pond while Catchment B will manage road runoff via the use of a piped network. The wet pond will discharge to the eastern open channel while the piped network will discharge to the highway drain.

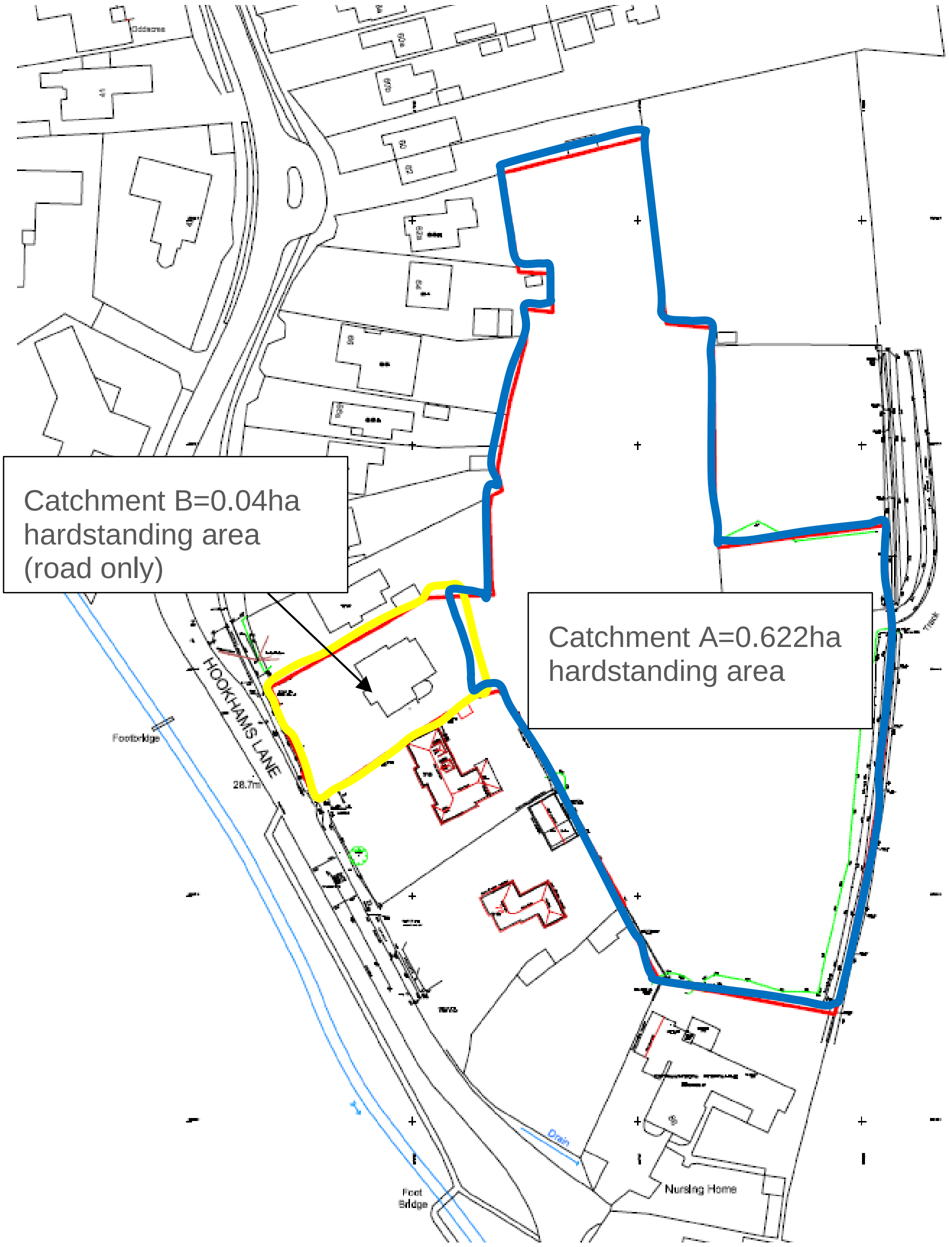



**FIGURE 10: CATCHMENT DELINEATION**

### 5.4.1. Wet pond

The wet pond should have an active depth of 1.90 m and an outer area of approximately 449 $m^2$, while the permanent pool will be an additional 300mm depth. The pond has been designed to manage runoff from catchment A.

The side slopes of the pond should be set at a minimum of 1 in 3 and planted with short grass (50 mm-75 mm) and native vegetation species in a sparse fashion along the benches. It is highly recommended to install native reed species to enhance the filtering of organic matter and promote the establishment of other species. The reeds should be planted at the central part of the pond to promote plug flow conditions.

A planting schedule should be produced at the detailed design stage to identify native species that should be used. Vegetation should not be planted near the outlet as research suggests that this decreases discharge capacity and water treatment efficiency.

Due to the requirement for the pond to be raised in order to achieve the required cover level, a Flex MSE vegetated wall system should be installed as conceptually shown in drawing 2296B_002_R2.

The SuDS pond construction must comply with the CIRIA Guidance on the construction of SuDS C768 (2017) recommendations.

### 5.4.2. Permeable pavement

A Type C (see Table 20.1 of the SuDS Manual) permeable pavement will be used to manage roof/road runoff at the site, where applicable.

It is recommended to discharge roof runoff directly onto the permeable pavement surface where possible. Alternatively, or where it is not practicable roof runoff should discharge to the sub-base on the permeable pavement via catchpits and diffusers, as described in the Interpave Guidance document (Figure 11).

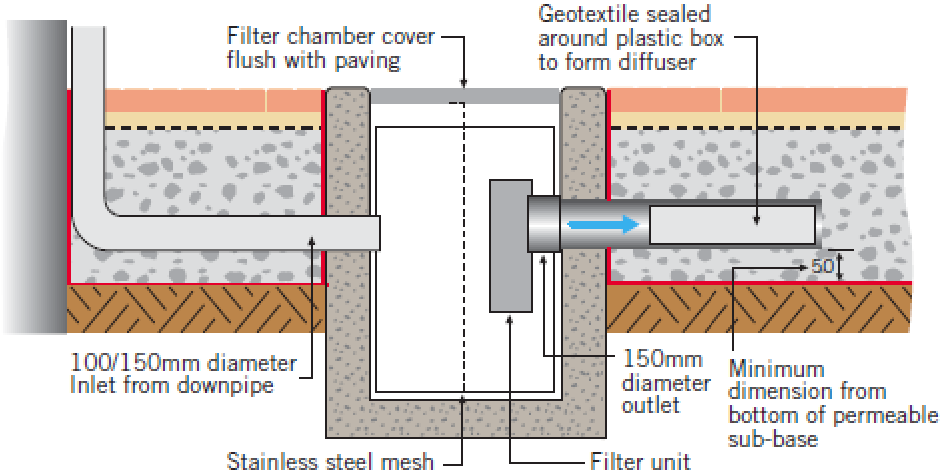



**FIGURE 11: TYPICAL ROOF DRAINAGE OUTLET (INTERPAVE GUIDANCE DOCUMENT, 2008)**

Road runoff from the access road and relevant parking areas will infiltrate to the permeable pavement and receive an appropriate level of treatment. Kerb design should be in line with local standards and at least 100 mm to encourage water to infiltrate to the permeable pavement structure efficiently.

The laying course material must be sufficiently coarse to allow the free vertical flow of water and to prevent its intrusion into the underlying coarse-graded aggregate, yet sufficiently fine to permit the accurate installation of the paving blocks. The material should comply with the requirements of a material of type

2/6.3 Gc 80/20 according to BS EN 13242:2002. The requirement for a capping material should be identified once detailed soil investigations have been undertaken at the site. All capping materials should meet the requirements of either 6F1 or 6F2 of Table 6.1 of Highways Agency's '*Specification for Highway Works – Series 600 – Earthworks*'.

### 5.4.3. Outfall

The proposed outfall to the east open channel will be an Athlon H3C (or similar) headwall equipped with Kee Klamp and a flap valve. The headwall should not encroach into the slopped bank of the ditch and not impede the flow. In addition, a drainage consent will need to be applied to the Bedford Borough Council prior to any works taking place.

### 5.4.4. Water quantity benefits

The scheme will offer significant reductions in runoff rates, compared to the corresponding greenfield runoff rates, in the order of -11.11% - 76.47%, as shown in Table 7. There will be a slight increase during the 50% AEP but the reductions in the higher intensity storms demonstrate that the development will offer significant benefits in terms of reducing the risk of flooding to others downstream.

The values below refer to Catchment A as the greenfield values for Catchment B are close to 0. Catchment B only discharges road runoff and as such the controlled rate of 5 l/s will offer water quantity benefits to the highway drainage network.

In addition, significant water quality benefits will be provided through filtration of the runoff prior to discharge to the adjacent ditch. As such, the proposed scheme provides water quantity benefits, in line with the 2015 SuDS Manual.

**TABLE 7: EXISTING AND PROPOSED PEAK FLOW RUNOFF RATES (CATCHMENT A)**

| AEP (%) | Greenfield peak flow rate (l/s) | Proposed peak flow rate (l/s) | Change (%) |
|---|---|---|---|
| 50 | 1.8 | 2 | -11.11 |
| 3.33 | 4.2 | 2 | 52.38 |
| 1 | 6.3 | 2 | 68.25 |
| 1 +40%CC** | 8.5* | 2 | 76.47 |

* Anglian river basin higher central climate change allowance ** Upper end peak rainfall intensity allowance

### 5.4.5. Water quality benefits

In line with the SuDS Manual, the water must receive a certain degree of treatment. There are no significant risks of pollution as a result of the development as it is classed a low density residential with no major risks.

According to Table 26.2 of the SuDS Manual and based on the land use, the site has a low pollution hazard level. In detail, the pollution hazard indices are:

- Total Suspended Solids= 0.5
- Heavy Metals= 0.4
- Hydrocarbons= 0.4

Consequently, the proposed SuDS feature(s) must have a higher mitigation index. Mitigation indices for various SuDS components can be found in Table 26.3 of the SuDS Manual (2015).

**Total SuDS Mitigation Index = mitigation index$_1$ + (0.5 x mitigation index$_n$)**

Where mitigation index$_n$ = mitigation index for component n.

The proposed drainage scheme utilises permeable paving (mitigation index $_1$) and a pond (mitigation index$_{2)}$.

Using Table 26.3 of the SuDS Manual (2015), the mitigation indices for each pollutant and for each feature were identified:

- TSS – SuDS mitigation index = 1.05 > 0.5.
- Heavy Metals – SuDS mitigation index = 0.95 > 0.4.
- Hydrocarbons – SuDS mitigation index = 0.95 > 0.4.

Consequently, the proposed scheme is in line with the water quality requirements of the SuDS Manual (2015).

## 5.5 Exceedance

It is inevitable that as a result of heavy or extreme rainfall, the capacities of sewers and other drainage systems will be exceeded on occasion. Drainage exceedance will occur when the rate of surface water runoff exceeds the inlet capacity of the drainage system, when the receiving water or pipe system becomes overloaded, when the outfall becomes restricted due to flood levels in the receiving water, or due to poor maintenance of the SuDS features.

### 5.5.1. Designing for exceedance

The proposed drainage scheme has been conceptually designed to safely manage an extreme rainfall event (1% AEP + 40% CC) with no flooding. In addition, an exceedance bund set at 31.70 mAOD will be installed at the periphery of the pond to protect the site users and others downstream from extreme events. Should exceedance occur, surface water will overflow to the adjacent ditch without increasing the risk of health and safety of the site users. In addition, the proposed finished floor levels will be set 150mm above local ground level to mitigate against the potential failure of the drainage infrastructure.

Finally, the effect of urban creep has been applied to the design, in line with the 2018 Bedford Borough Council SuDS SPD. Urban creep tests the ability of the drainage system to accommodate increased rates of runoff as a result of potential increases in the hardstanding areas. The system will experience some flooding during the climate change event should the hardstanding area increases by 10% across the site. An expected flood volume of 13.3 $m^3$ is expected during the 1% AEP +40% CC. This flood water will most likely flow towards the new access road and to the eastern ditch. The small flood volume and the large available area (approximately 190 $m^2$) at the access road suggests that the expected flood depth (70mm) is to be low, while the impact to others downstream is also expected to be low; this assumes that the system will be effectively maintained throughout its design life.

## 5.6 Amenity and biodiversity

Flora should be planted where possible around the proposed houses. Primary consideration should be given to locally native species, and plants that benefit wildlife through their nectar, fruit, or berries. Generally, the choice of plant species should reflect the usual design decisions relating to their location in terms of aspect, sun or shade, height, from, colour, whether evergreen or deciduous, native or ornamental, and soil factors such as pH, depth, nutrient status and organic content. However, the consideration has to be their ability to withstand the fluctuations in soil moisture that will occur; this is very important for the wet pond.

## 5.7 Maintenance schedule

Maintenance can be categorised to into three main groups:

- Regular maintenance
- Occasional maintenance
- Remedial maintenance

The level of inspection and maintenance will vary depending on the type of SuDS component and scheme, the land use, and the type of vegetation. It is vital that SuDS construction is supervised and inspected on completion if owners and the Lead Local Flood Authority (Bedford Borough Council) are to avoid taking on liabilities. This will help to ensure that the specified materials are being used and that they are being placed correctly. Incorrect materials or installation should be rejected as they will adversely affect the performance, maintenance costs and ultimately the design life of the SuDS components.

The SuDS features incorporated to this particular design have to be maintained in order to ensure efficient water treatment and water management.

It is understood that a private management company will be responsible for the management of the proposed drainage scheme and SuDS features.

### 5.7.1. Wet pond

**TABLE 8: GUIDELINE MAINTENANCE SCHEDULE FOR THE WET POND, ADAPTED FROM CIRIA RP992/23 & C753**

| Maintenance | Frequency |
|---|---|
| **Regular Cleaning**<br>Litter removal, inspect control structures to/from pond, grass cutting on slopes, remove invasive plants (first three years only) | Monthly |
| **Occasional Tasks**<br>Tidy all dead growth (scrub clearance) before the start of the growing season.<br>Remove invasive species (if spotted).<br>Inspect silt accumulation rate at the side benches (if any) and remove if appropriate.<br>Remove 25% of bank vegetation without interfering with established ecosystem (be careful of nesting, other animals, etc.).<br>Vegetation management – 30% cut.<br>Maintain a sparse vegetation cover at the banks to reduce the generation of biogenic debris (increased suspended solids).<br>Identify requirements for remedial maintenance (if applicable) and take action. | Every 12 months |
| **Remedial Work**<br>Repair erosion or other damage.<br>Replant, where necessary.<br>Aerate wet pond when signs of eutrophication are detected.<br>Repair inlets/outlets. | As required |

### 5.7.2. Permeable pavement

**Table 9: Guideline maintenance schedule for permeable pavements, adapted from CIRIA RP992/23 and C753**

| Maintenance | Frequency |
|---|---|
| **Regular Monitoring**<br>Brush regularly and remove sweepings from all hard surfaces.<br>Inspect all inflows/outflows along with manholes for blockages.<br>Check monitoring wells for any signs of siltation. | Quarterly and after the area experiences flooding |
| **Occasional Tasks**<br>Brush and vacuum surface once a year to prevent silt blockage and enhance design life.<br>Check operation of perforated pipes by inspection of flows after rain | Every six months |
| **Remedial Work**<br>Monitor effectiveness of permeable paving and if water does not infiltrate immediately a reinstatement of the top layers or specialist cleaning. The manufacturer should be contacted to provide further guidance.<br>Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance or a hazard to users, and replace lost jointing material.<br>Rehabilitation of surface and upper substructure by remedial sweeping.<br>Check monitoring wells and replace permeable layer and sand-bed layer if heavily silted. | As required and after flood events |

### 5.7.3. Flow control device and proprietary treatment device

Please note that the flow control chamber will require regular maintenance. The maintenance schedule for the chamber must be specified by the manufacturer, as different features have different requirements.

The silt-traps maintenance schedule will have to be specified by the manufacturer as again different features will have different maintenance requirements.

# 6.0 Conclusion

The proposed development at Land to the east of Hookham's Lane, Salph End, Renhold, MK41 0JX is located in Flood Zone 1, as defined in the NPPF. The proposal includes the construction of residential units along with parking and amenity space (Appendix A).

As the site is located in Flood Zone 1, the Sequential Test can be considered passed.

On the basis of the available information from the Environment Agency and Bedford Borough Council the site is at very low risk from fluvial, tidal, reservoir, flood defence breach, flood defence overtopping, and surface water flooding.

The area has seen historical sewer flooding and has a 25%-50% susceptibility to groundwater flooding.

The proposed development must incorporate SuDS as described in Chapter 5.0 of this report and in the relevant drawing in Appendix D. Both permeable paving and a wet pond along with a piped network will be incorporated into the final design.

The proposed development can be deemed appropriate, provided that the recommendations in this report are adhered to, it will not increase the flood risk to other people, and it will provide multiple benefits with respect to the sustainable management of surface water runoff.

# 7.0 Recommendations

- The ground finished floor levels should be set 150 mm above local ground level to offer a level of protection against infrastructure failure.
- It is highly recommended to install a non-return valve to the last foul water manhole, prior to connecting to the Anglian Water foul sewer, in order to mitigate against the potential for infrastructure failure.
- The site should manage surface water runoff via the combination of permeable paving and a wet pond as described in Chapter 5.0 of this report and as shown in drawing RAB2296B_001.
- The proposed permeable paving and wet pond should be maintained in line with Table 8 & Table 9 of this report. It is understood that a private management company will be responsible for the maintenance of the SuDS features.
- An ACO Q-Brake flow control chamber limiting the rate of runoff to 2 l/s, as per the request made by Bedford Borough Council.
- An orifice flow control chamber should limit the rate for runoff to 5 l/s for the Catchment B pipe.
- The outflow pipe from the wet pond should discharge to the adjacent eastern ditch through the client owned land via an Athlon H3C (or similar) headwall equipped with a Kee Klamp and flap valve. This should be located at the banks of the watercourse without encroaching into the bank and without impeding the flow.
- The outflow pipe from Catchment B should discharge to the highway drain, subject to confirmation from the Bedford Borough Council Highways team during the adoption stage.
- A Flex MSE (or similar) vegetated wall system with a crest level of 33.70 mAOD should be installed to the periphery of the pond in order to achieve the required cover level.
- A discharge consent should be obtained by the Bedford Borough Council during the detailed design stage.

# Appendix A – Development Proposals


# East of Hookman's Lane, Salph End, Renhold

## Site Layout Plan

Local Plan 2032 Representations
Proposed site for up to 20 dwellings

**Accommodation Schedule**

Affordable

| Plot | GIFA (m²) | Beds | Parking | Garages |
|---|---|---|---|---|
| 1 | 77.5 | 2 | 2 | 1 |
| 2 | 81.4 | 3 | 2 | 1 |
| 3 | 81.4 | 3 | 2 | 1 |
| 14 | 81.4 | 3 | 2 | 1 |
| 15 | 81.4 | 3 | 2 | 1 |
| 16 | 77.5 | 2 | 2 | 1 |

Open Market

| Plot | GIFA (m²) | Beds | Parking | Garages |
|---|---|---|---|---|
| 4 | 161.6 | 4 | 2 | 1 |
| 5 | 177.2 | 4 | 4 | 2 |
| 6 | 161.6 | 4 | 2 | 1 |
| 7 | 181.9 | 4 | 4 | 2 |
| 8 | 177.1 | 5 | 4 | 2 |
| 9 | 177.2 | 4 | 2 | 2 |
| 10 | 181.9 | 4 | 2 | 2 |
| 11 | 177.1 | 5 | 4 | 2 |
| 12 | 181.9 | 4 | 4 | 2 |
| 13 | 161.6 | 4 | 4 | 2 |
| 17 | 177.2 | 4 | 4 | 2 |
| 18 | 181.9 | 4 | 4 | 2 |
| 19 | 161.6 | 4 | 4 | 2 |
| 20 | 177.1 | 5 | 4 | 2 |

Kingsbrook House
7 Kingsway
Bedford
MK429BA
T 01234 272829
F 01234 271412
info@phillips-planning.co.uk

Phillips Planning Services Ltd.
Town Planning and Development Consultants

PROJECT
East of Hookman's Lane, Salph End, Renhold

TITLE
Site Layout Plan

CLIENT
Mr A Sarro

| SCALE (@ A2) | DRAWN BY | DATE |
|---|---|---|
| 1 : 100 | LS | 10/15 |

| PROJECT NUMBER | DRAWING NUMBER | REV |
|---|---|---|
| 144567 | 15-02 | |

GENERAL DISCLAIMER

Planning drawings only - not to be used for construction purposes. These drawings can be scaled for planning purposes. All measurements to be checked on site and any discrepancies to be brought to the attention of the designer

# Appendix B – Topographic Survey


## Control Station Coordinates

| Station | Desc. | Easting | Northing | Height |
|---|---|---|---|---|
| STN1 | PEG | 507726.577 | 252347.425 | 32.029 |
| STN2 | PEG | 507814.394 | 252365.037 | 32.940 |
| STN3 | PEG | 507757.595 | 252356.632 | 33.023 |
| STN4 | PEG | 507740.934 | 252365.400 | 33.101 |
| STN5 | PEG | 507764.001 | 252371.395 | 33.447 |
| STN6 | PEG | 507784.438 | 252373.304 | 33.261 |
| STN7 | PEG | 507705.632 | 252344.178 | 31.185 |
| STN8 | PEG | 507754.837 | 252318.460 | 31.536 |
| STN9 | PEG | 507729.108 | 252365.798 | 32.594 |
| STN10 | PEG | 507667.626 | 252320.552 | 28.902 |

| ISSUE | Details/Reason for issue | Date |
|---|---|---|
| A | Original Survey Issue | 27/8/2019 |

NOTES

GENERAL NOTES:

1. All underground services are surveyed at accessible points only. Routes between these points are assumed and representative. UTL = Unable to lift
2. The accuracy and content of this drawing is dependent on the original specification and KSL should be consulted before use of this data for purposes other than its original intention.
3. While every effort has been made to correctly identify individual tree species that may appear on this survey, they should be considered indicative only. If accurate identification is of great significance it is recommended that an arborist be consulted.

Multi-boled trees are denoted by

Trees annotated thus:– Ash / Ht 15.0 / 47.239 represents Species / Estimated height(m) / Level at base

**TITLE:**

# Land to R/O 60 to 80 Hookhams Lane. Renhold. Beds

Topographic Survey

HORIZONTAL CONTROL: Related to Ordnance National Grid (OSGB36(15)

VERTICAL CONTROL:
Related To Ordnance Datum via GPS Observations (OSGB36(15)

| | |
|---|---|
| DRG. I.D: Plan 200 at A0 | JOB. I.D. 7080HOOK |
| DATE: 27/8/2019 | SCALE: 1/200 |
| SURVEYED: TC | DRAWN: TC |
| SHEET: 1 of 1 | |
| ISSUE: A | CLIENT: Phillips Planning Services |


**Kempston Surveys Ltd.**
Hargrave House,
50, Bunyan Road,
Kempston.
Bedford. MK42 8HL.
Telephone : 01234 854731
Facsimile : 01234 857895
Email : admin@kempstonsurveys.co.uk
Web : www.kempstonsurveys.co.uk

# Appendix C – Infiltration Test

**Grange Geo Consulting Ltd**
43 Winchilsea Avenue Newark Notts NG24 4AD UK
+44 (0)7773 529385
[redacted]
*www.grangegeo.co.uk*

Grange Geo
Geotechnical & Environmental Specialists

6th September 2019

For the attention **of** [redacted]

Dear Dr Tsavdaris

**Re: soakaway testing at land off Hookhams Lane, Renhold, Bedford**

The following investigation was carried out at the above location in accordance with our quotation dated 16th of August 2019 and emailed instruction from RAB Consultants to conduct the work. Initial background information for the site indicated superficial deposits of the Oadby Member Diamicton (Glacial Deposits) in the northern part of the site, with the whole site underlain by the solid Geology of the Peterborough Member – Mudstone at depth.

## Site Works

The purpose of the investigation was to supply soakaway test data in general accordance with BRE document 365 (Soakaway Design) at two positions adjacent to a potential new development of housing at land to the east of Hookhams Lane, Renhold, near Bedford, to be incorporated as part of the future surface water disposal system.

The test locations were selected by RAB Consultants. The site consisted of a well kept grass field to the south, and very overgrown fields to the north comprising of rough grass bushes and small trees.

The appended drawing (R19083-DWG2) illustrates the position of the test pits, which were excavated on 02/09/2019 to depths of 1.5mbgl (metres below ground level).

Ground conditions varied slightly across the site. TP1 to the south comprised topsoil overlying stiff CLAY to the base of the trial pit at 1.5m bgl. In TP2 a thin layer of clayey, sandy gravel, was present under the topsoil to a depth of 0.60m which is likely to be Oadby Member Diamicton deposits. Underlying this was stiff clays of the Peterborough Member bedrock.

Water was added to TP1 and TP2 using a 1000litre IBC. Falling water level readings were undertaken using manual electronic dip-meter readings by a geotechnical engineer. A full record of the trial pit profiles is included in the appendix.

**Grange Geo Consulting Ltd**
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Geotechnical & Environmental Specialists

## Results

Very slow infiltration rates occurred in both trial pits. As such only one test was conducted as the water level did not reach 75% after a 24 hour period. The water levels in both pits only fell approx. 1 cm over 24 hours which is too slow to calculate an infiltration rate.

Yours sincerely,

for **Grange GeoConsulting Ltd**

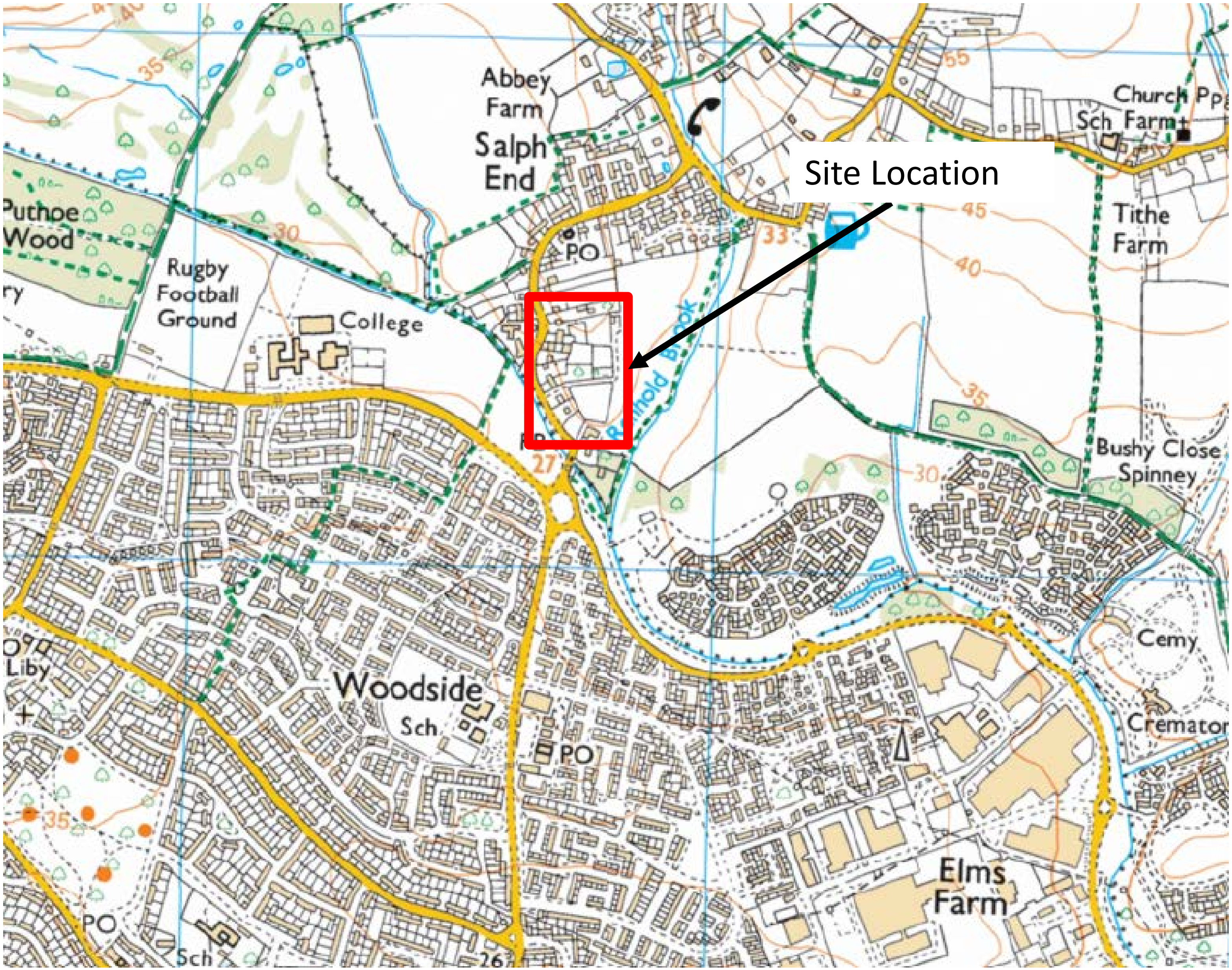
[redacted]

[redacted]
**Director**
MSc DIC FGS

# APPENDICES

# Appendix A

SITE LOCATION PLAN




| | | | | |
|---|---|---|---|---|
| Grange Geo | Site Locations, Renhold | Client- Rab Consultants<br>Date- September 2019 | North | Drawing- R19083-1 |

# Appendix B

TRIAL PIT PHOTOGRAPHS

Figure 1: TP1


Figure 2: TP1 Spoil

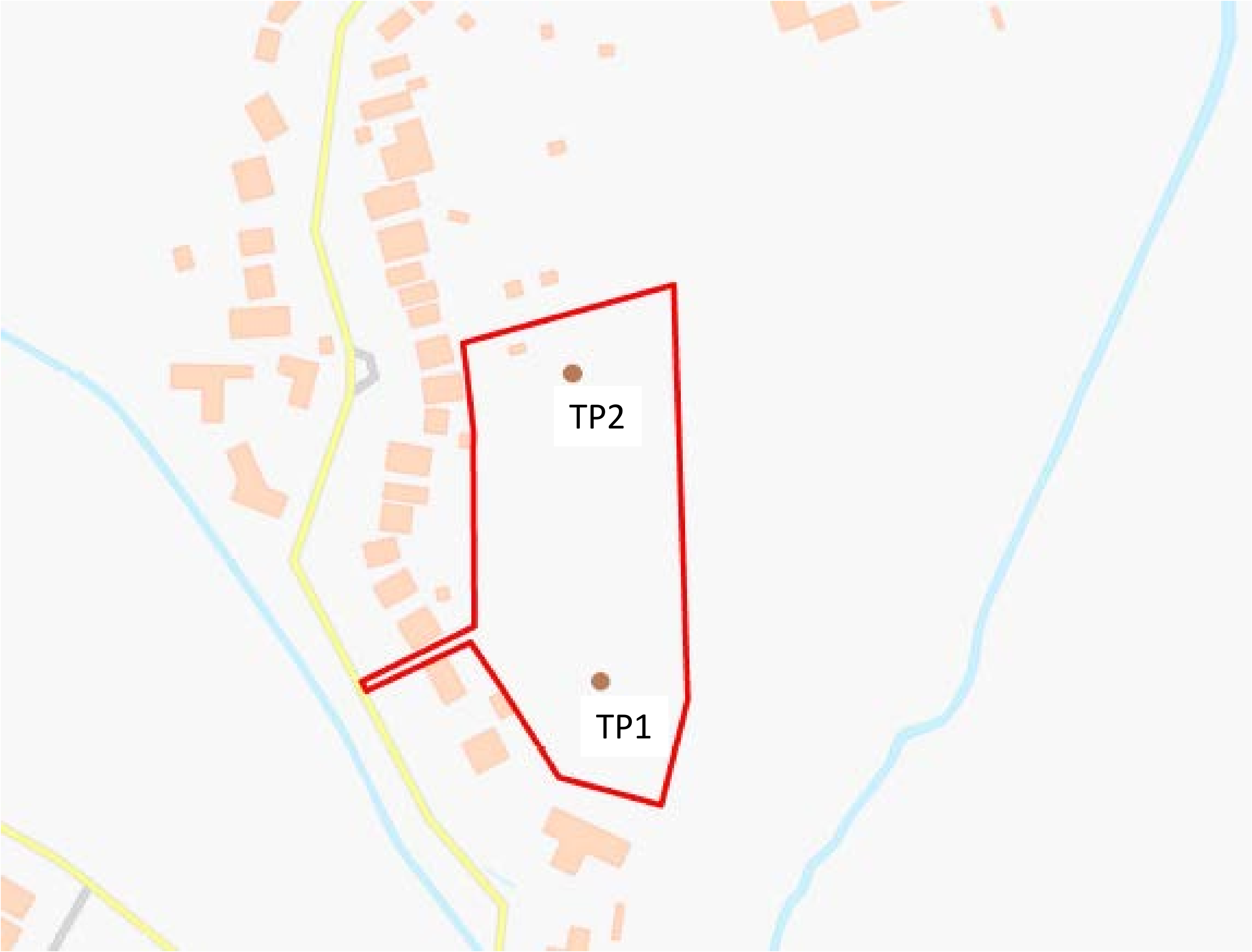
Figure 3: TP2

Figure 4: TP2 spoil

Figure 5: TP1 on completion

# Appendix C

GROUND INVESTIGATION PLAN, EXPLORATORY HOLE LOGS




| | | | | |
|---|---|---|---|---|
| Grange Geo | Soakaway Locations, Hookhams Lane, Renhold | Client- Rab Consultants<br>Date- September 2019 | North | Drawing- R19083-2 |

# Trial Pit Log

**TP No: TP1**

Client: RAB Consultants
Project: Renhold

Sheet: 1 of 1
Method: Excavation with mini digger

Grange Geo

| Sample Depth (m) | Sample Type | S. Vane kN/m² | Description | Depth mBGL | Legend |
|---|---|---|---|---|---|
| | | | Topsoil, dark brown, slightly sandy, CLAY. | 0.20 | |
| | | | Stiff, brown and olive mottled CLAY. Peterborough Member - Mudstone) | 1.30 | |
| | | | Stiff, blue grey and light grey mottled, silty CLAY. Peterborough Member - Mudstone) | 1.50 | |
| | | | End of trial pit. | | |

General Comments:

1. Pit walls stable.
2. No groundwater encountered.
3. No visible or olfactory evidence of contamination

Date: 02/09/2019
Logged by: AH
Checked: AH
Job No: R19083

Grange Geo Consulting Ltd, 43 Winchilsea Avenue, Newark, NG24 4AD
Tel: 07773529385

# Trial Pit Log

**TP No: TP2**

Client: RAB Consultants
Project: Renhold

Sheet: 1 of 1
Method: Excavation with mini digger

| Sample Depth (m) | Sample Type | S. Vane kN/m$^2$ | Description | Depth mBGL | Legend |
|---|---|---|---|---|---|
| | | | Topsoil, dark brown, slightly gravelly, CLAY. Gravels of fine to medium, sub rounded quartzite and flint. | | |
| | | | Orange brown, silty, clayey, sandy, GRAVEL. Gravels of fine to coarse, sub angular to rounded quartzite and flint. (Oadby Member- Diamicton) | 0.50 | |
| | | | Stiff, grey and brown mottled, silty, CLAY with abundant small shell fragments. (Peterborough Member - Mudstone) | 1.00 | |
| | | | | 1.50 | |
| | | | End of trial pit. | 2.00 | |
| | | | | 2.50 | |
| | | | | 3.00 | |

General Comments:

1. Pit walls slightly unstable from surface.
2. No groundwater encountered.
3. No visible or olfactory evidence of contamination

Date: 02/09/2019
Logged by: AH
Checked: AH
Job No: R19083

Grange Geo Consulting Ltd, 43 Winchilsea Avenue, Newark, NG24 4AD
Tel: 07773529385

# Appendix D

## Soakaway Testing Results

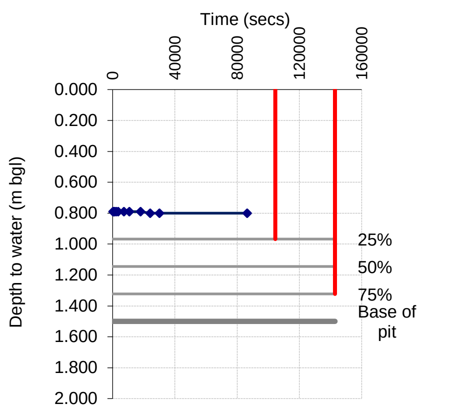
**BRE BR365 - Trial Pit Soakaway Data Sheet**

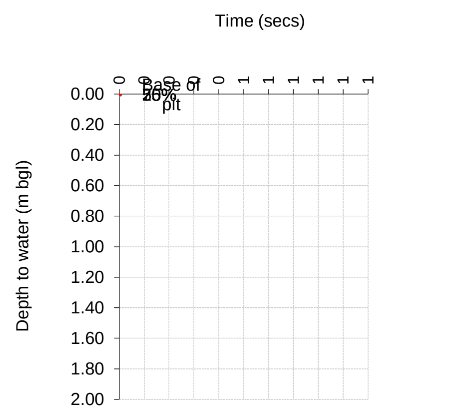
**Site:** Renhold

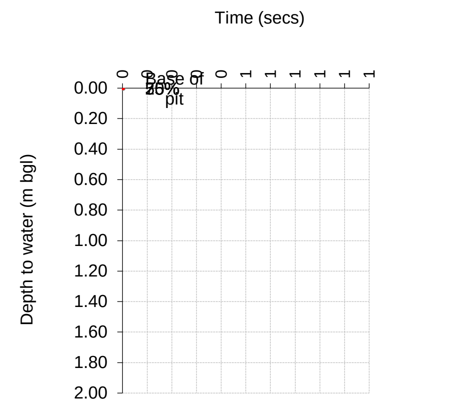
**Client:** RAB Consultants

**Test Location** TP1 **Date of start of testing** 02/09/2019 **Date at end of testing** 03/09/2019

| Test Run 1 | | | Test Run 2 | | | Test Run 3 | | |
|---|---|---|---|---|---|---|---|---|
| **Pit Dimensions (m)** | | | **Pit Dimensions (m)** | | | **Pit Dimensions (m)** | | |
| Length | | 1.400m | Length | | | Length | | |
| Width | | 0.300m | Width | | | Width | | |
| Depth | | 1.500m | Depth | | | Depth | | |
| Fill Depth | | 0.710m | Fill Depth | | 0.000m | Fill Depth | | 0.000m |
| Max Volume | | 0.298m³ | Max Volume | | 0.000m³ | Max Volume | | 0.000m³ |
| Gravel used to backfill Test Pit | | No | Gravel used to backfill Test Pit | | No | Gravel used to backfill Test Pit | | No |
| **Time to soakaway** | | | **Time to soakaway** | | | **Time to soakaway** | | |
| Time | | Depth to water | Time | | Depth to water | Time | | Depth to water |
| (secs) | (min) | (m bgl) | (secs) | (min) | (m bgl) | (secs) | (min) | (m bgl) |
| | *0* | *0.790* | | *0* | | *0* | *0* | |
| 300 | 5 | 0.790 | | | | | | |
| 600 | 10 | 0.790 | | | | | | |
| 1200 | 20 | 0.790 | | | | | | |
| 2400 | 40 | 0.790 | | | | | | |
| 3600 | 60 | 0.790 | | | | | | |
| 7200 | 120 | 0.790 | | | | | | |
| 10800 | 180 | 0.790 | | | | | | |
| 18000 | 300 | 0.790 | | | | | | |
| 24000 | 400 | 0.800 | | | | | | |
| 30000 | 500 | 0.800 | | | | | | |
| 86400 | 1440 | 0.800 | | | | | | |
| **25% water depth** | | 0.968m | **25% water depth** | | 0.000m | **25% water depth** | | 0.000m |
| **50% water depth** | | 1.145m | **50% water depth** | | 0.000m | **50% water depth** | | 0.000m |
| **75% water depth** | | 1.323m | **75% water depth** | | 0.000m | **75% water depth** | | 0.000m |
| **25% time (seconds)** | | 104490 sec | **25% time (seconds)** | | | **25% time (seconds)** | | |
| **75% time (seconds)** | | 142830 sec | **75% time (seconds)** | | | **75% time (seconds)** | | |
| $V_{p\ 75-25}$ | | 0.1491m³ | $V_{p\ 75-25}$ | | 0.0000m³ | $V_{p\ 75-25}$ | | 0.0000m³ |
| $a_{p\ 50}$ **(Actual area from test)** | | 2.8170m² | $a_{p\ 50}$ **(Actual area from test)** | | 0.0000m² | $a_{p\ 50}$ **(Actual area from test)** | | 0.0000m² |
| $t_{p\ 75-25}$ | | 38340.0 | $t_{p\ 75-25}$ | | | $t_{p\ 75-25}$ | | |
| **Soil Infiltration Rate** | | | **Soil Infiltration Rate** | | | **Soil Infiltration Rate** | | |



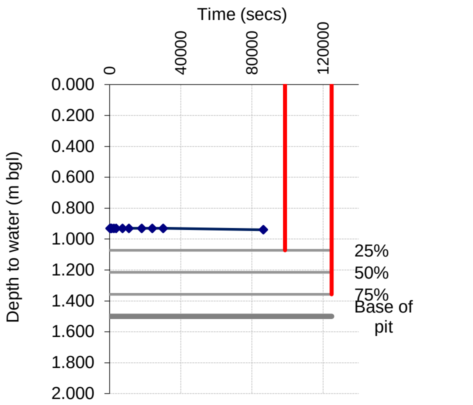



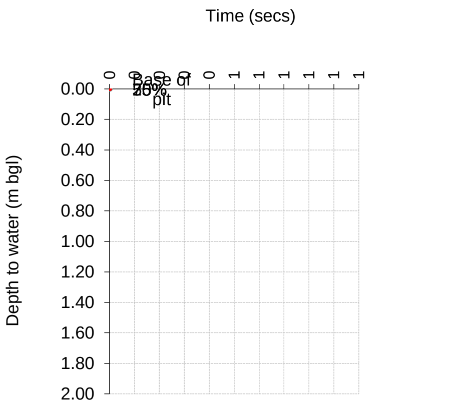

Note: Groundwater table taken as base of pit for infiltration rate calculation.

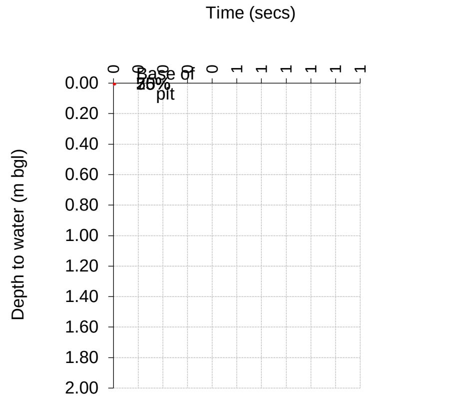
**BRE BR365 - Trial Pit Soakaway Data Sheet**

**Site:** Renhold
**Client:** RAB Consultants
**Test Location** TP2 **Date of start of testing** 02/09/2019 **Date at end of testing** 03/09/2019

| Test Run 1 | | | Test Run 2 | | | Test Run 3 | | |
|---|---|---|---|---|---|---|---|---|
| **Pit Dimensions (m)** | | | **Pit Dimensions (m)** | | | **Pit Dimensions (m)** | | |
| Length | | 1.200m | Length | | | Length | | |
| Width | | 0.300m | Width | | | Width | | |
| Depth | | 1.500m | Depth | | | Depth | | |
| Fill Depth | | 0.570m | Fill Depth | | 0.000m | Fill Depth | | 0.000m |
| Max Volume | | 0.205m³ | Max Volume | | 0.000m³ | Max Volume | | 0.000m³ |
| Gravel used to backfill Test Pit | | No | Gravel used to backfill Test Pit | | No | Gravel used to backfill Test Pit | | No |
| **Time to soakaway** | | | **Time to soakaway** | | | **Time to soakaway** | | |
| Time | | Depth to water | Time | | Depth to water | Time | | Depth to water |
| (secs) | (min) | (m bgl) | (secs) | (min) | (m bgl) | (secs) | (min) | (m bgl) |
| | *0* | *0.930* | | *0* | | *0* | *0* | |
| 300 | 5 | 0.930 | | | | | | |
| 600 | 10 | 0.930 | | | | | | |
| 1200 | 20 | 0.930 | | | | | | |
| 2400 | 40 | 0.930 | | | | | | |
| 3600 | 60 | 0.930 | | | | | | |
| 7200 | 120 | 0.930 | | | | | | |
| 10800 | 180 | 0.930 | | | | | | |
| 18000 | 300 | 0.930 | | | | | | |
| 24000 | 400 | 0.930 | | | | | | |
| 30000 | 500 | 0.930 | | | | | | |
| 86400 | 1440 | 0.940 | | | | | | |
| **25% water depth** | | 1.073m | **25% water depth** | | 0.000m | **25% water depth** | | 0.000m |
| **50% water depth** | | 1.215m | **50% water depth** | | 0.000m | **50% water depth** | | 0.000m |
| **75% water depth** | | 1.358m | **75% water depth** | | 0.000m | **75% water depth** | | 0.000m |
| **25% time (seconds)** | | 98579 sec | **25% time (seconds)** | | | **25% time (seconds)** | | |
| **75% time (seconds)** | | 124774 sec | **75% time (seconds)** | | | **75% time (seconds)** | | |
| $V_{p\ 75\text{-}25}$ | | 0.1026m³ | $V_{p\ 75\text{-}25}$ | | 0.0000m³ | $V_{p\ 75\text{-}25}$ | | 0.0000m³ |
| $a_{p\ 50}$ **(Actual area from test)** | | 2.0550m² | $a_{p\ 50}$ **(Actual area from test)** | | 0.0000m² | $a_{p\ 50}$ **(Actual area from test)** | | 0.0000m² |
| $t_{p\ 75\text{-}25}$ | | 26195.7 | $t_{p\ 75\text{-}25}$ | | | $t_{p\ 75\text{-}25}$ | | |
| **Soil Infiltration Rate** | | | **Soil Infiltration Rate** | | | **Soil Infiltration Rate** | | |




Note: Groundwater table taken as base of pit for infiltration rate calculation.

# Appendix D – Drainage


| | | | | | | |
|---|---|---|---|---|---|---|
| (c) Crown copyright and database rights 2019 Ordnance Survey 100022432 | Date: 16/08/19 | Scale: 1:1250 | Map Centre: 507747,252394 | Data updated: 31/07/19 | Our Ref: 329724 - 1 | Wastewater Plan A1 |



Foul Sewer
Surface Sewer
Combined Sewer
Final Effluent
Rising Main*
Private Sewer*
Decommissioned Sewer*

Outfall*
Inlet*
Manhole*

Sewage Treatment Works
Public Pumping Station
Decommissioned Pumping Station

*(Colour denotes effluent type)

freya.green@rbcconsultants.co.uk
2296B

love every drop
anglianwater

| Manhole Reference | Easting | Northing | Liquid Type | Cover Level | Invert Level | Depth to Invert |
|---|---|---|---|---|---|---|
| 0401 | 508003 | 252463 | F | - | - | - |
| 0501 | 508042 | 252536 | F | - | - | - |
| 0601 | 508069 | 252679 | F | - | - | - |
| 0602 | 508051 | 252681 | F | - | - | - |
| 0603 | 508031 | 252683 | F | - | - | - |
| 0604 | 508040 | 252652 | F | - | - | - |
| 0605 | 508013 | 252700 | F | - | - | - |
| 0606 | 508021 | 252653 | F | - | - | - |
| 0607 | 508041 | 252601 | F | - | - | - |
| 1001 | 508172 | 252069 | F | 29.25 | 25.272 | 3.978 |
| 1003 | 508152 | 252093 | F | 30.225 | 28.2 | 2.025 |
| 1004 | 508157 | 252099 | F | - | - | - |
| 1004 | 508159 | 252079 | F | - | - | - |
| 1004 | 508105 | 252070 | F | - | - | - |
| 1004 | 508102 | 252074 | F | - | - | - |
| 1004 | 508117 | 252080 | F | - | - | - |
| 1004 | 508113 | 252085 | F | - | - | - |
| 1004 | 508115 | 252082 | F | - | - | - |
| 1004 | 508127 | 252096 | F | - | - | - |
| 1004 | 508139 | 252082 | F | - | - | - |
| 1004 | 508149 | 252090 | F | - | - | - |
| 1100 | 508167 | 252127 | F | - | - | - |
| 1100 | 508174 | 252134 | F | - | - | - |
| 1100 | 508189 | 252123 | F | - | - | - |
| 1100 | 508190 | 252115 | F | - | - | - |
| 1100 | 508192 | 252106 | F | - | - | - |
| 1101 | 508177 | 252131 | F | - | - | - |
| 1101 | 508180 | 252119 | F | - | - | - |
| 1601 | 508166 | 252685 | F | - | - | - |
| 1602 | 508160 | 252663 | F | - | - | - |
| 1603 | 508143 | 252665 | F | - | - | - |
| 1702 | 508176 | 252716 | F | - | - | - |
| 2000 | 508228 | 252097 | F | 28.875 | 25.686 | 3.189 |
| 2001 | 508209 | 252088 | F | 29 | 25.5 | 3.5 |
| 2003 | 508204 | 252098 | F | - | - | - |
| 2003 | 508207 | 252092 | F | - | - | - |
| 2100 | 508249 | 252108 | F | 28.775 | 26.602 | 2.173 |
| 2101 | 507271 | 252101 | F | 35.26 | 33.14 | 2.12 |
| 2101 | 508259 | 252119 | F | 28.85 | 26.7 | 2.15 |
| 2102 | 507279 | 252124 | F | 34.25 | 30.875 | 3.375 |
| 2102 | 508200 | 252105 | F | - | - | - |
| 2102 | 508243 | 252125 | F | - | - | - |
| 2102 | 508238 | 252119 | F | - | - | - |
| 2102 | 508246 | 252114 | F | - | - | - |
| 2102 | 508234 | 252134 | F | - | - | - |
| 2102 | 508234 | 252125 | F | - | - | - |
| 2103 | 507288 | 252181 | F | 32 | 29.96 | 2.04 |
| 2104 | 507254 | 252128 | F | - | - | - |
| 2201 | 507278 | 252228 | F | 31.58 | 29 | 2.58 |
| 2302 | 507264 | 252311 | F | 32.15 | 28.17 | 3.98 |
| 3101 | 507322 | 252198 | F | 31.6 | 29.4 | 2.2 |
| 3102 | 507319 | 252175 | F | 32.07 | 29.62 | 2.45 |
| 3103 | 507392 | 252127 | F | 33.48 | 29.86 | 3.62 |
| 3104 | 507389 | 252169 | F | 32.05 | 29.34 | 2.71 |
| 3105 | 507395 | 252185 | F | 31.55 | 29.11 | 2.44 |
| 3201 | 507327 | 252227 | F | 31.33 | 28.85 | 2.48 |
| 3301 | 507343 | 252314 | F | 32.14 | 27.85 | 4.29 |
| 3302 | 507335 | 252307 | F | 31.93 | 28.34 | 3.59 |
| 4101 | 507455 | 252193 | F | 31.96 | 28.79 | 3.17 |
| 4102 | 507497 | 252170 | F | 31.19 | 28.27 | 2.92 |
| 4103 | 507493 | 252117 | F | 36.25 | 33.5 | 2.75 |
| 4104 | 507425 | 252104 | F | 33.83 | 30.01 | 3.82 |
| 4105 | 507404 | 252162 | F | 32.26 | 29.62 | 2.64 |
| 4201 | 507406 | 252214 | F | 31.07 | 28.9 | 2.17 |
| 4202 | 507455 | 252292 | F | 31.23 | 27.28 | 3.95 |
| 4301 | 507410 | 252307 | F | 31.59 | 27.53 | 4.06 |
| 5101 | 507506 | 252161 | F | 31.21 | 28.24 | 2.97 |
| 5102 | 507513 | 252158 | F | 31.29 | 28.12 | 3.17 |
| 5103 | 507570 | 252112 | F | 31.6 | 28.55 | 3.05 |
| 5201 | 507557 | 252233 | F | 29.94 | 26.64 | 3.3 |
| 5202 | 507510 | 252265 | F | 30.59 | 26.99 | 3.6 |
| 6001 | 507686 | 252076 | F | 31.22 | 27.95 | 3.27 |
| 6002 | 507640 | 252077 | F | 31.14 | 29.14 | 2 |
| 6101 | 507614 | 252192 | F | 29.84 | 26.38 | 3.46 |
| 6102 | 507686 | 252170 | F | 29.65 | 25.92 | 3.73 |
| 6103 | 507696 | 252184 | F | 28.74 | 23.55 | 5.19 |
| 6105 | 507603 | 252174 | F | 30.37 | 27.88 | 2.49 |
| 6201 | 507682 | 252296 | F | 28.56 | 27 | 1.56 |
| 6301 | 507645 | 252395 | F | 30.04 | 28.21 | 1.83 |
| 6302 | 507640 | 252368 | F | 29.15 | 27.54 | 1.61 |
| 6401 | 507676 | 252454 | F | 34.46 | 29.86 | 4.6 |
| 6501 | 507649 | 252511 | F | - | - | - |
| 6502 | 507650 | 252533 | F | - | - | - |
| 6503 | 507650 | 252586 | F | - | - | - |
| 6601 | 507679 | 252632 | F | - | - | - |
| 6602 | 507659 | 252603 | F | - | - | - |
| 7002 | 507780 | 252100 | F | 28.66 | 23.01 | 5.65 |
| 7102 | 507736 | 252178 | F | 27.92 | 23.83 | 4.09 |
| 7103 | 507734 | 252184 | F | 27.95 | 23.94 | 4.01 |
| 7104 | 507763 | 252154 | F | 28.5 | 24 | 4.5 |
| 7105 | 507737 | 252188 | F | 28.04 | 23.96 | 4.08 |
| 7106 | 507737 | 252168 | F | 28.28 | 23.17 | 5.11 |
| 7200 | 507723 | 252202 | F | 28.19 | 24.05 | 4.14 |
| 7201 | 507726 | 252215 | F | 28.07 | 25.69 | 2.38 |
| 7601 | 507755 | 252675 | F | - | - | - |
| 7602 | 507748 | 252664 | F | - | - | - |
| 7603 | 507702 | 252653 | F | - | - | - |
| 8101 | 507835 | 252168 | F | 27.77 | 24.95 | 2.82 |
| 8201 | 507865 | 252246 | F | - | - | - |
| 8601 | 507876 | 252622 | F | - | - | - |
| 8602 | 507817 | 252692 | F | - | - | - |
| 8702 | 507862 | 252711 | F | - | - | - |
| 9302 | 507962 | 252388 | F | - | - | - |

| Manhole Reference | Easting | Northing | Liquid Type | Cover Level | Invert Level | Depth to Invert |
|---|---|---|---|---|---|---|
| 9303 | 507929 | 252316 | F | 28.5 | 25.34 | 3.16 |
| 9601 | 507920 | 252648 | F | - | - | - |
| 9602 | 507973 | 252647 | F | - | - | - |
| 9603 | 507990 | 252677 | F | - | - | - |
| 9705 | 507951 | 252709 | F | - | - | - |
| 9709 | 507978 | 252720 | F | - | - | - |
| 1051 | 508174 | 252071 | S | 29.225 | 27.6 | 1.625 |
| 1053 | 508159 | 252078 | S | - | - | - |
| 1053 | 508163 | 252073 | S | - | - | - |
| 1053 | 508107 | 252070 | S | - | - | - |
| 1053 | 508113 | 252086 | S | - | - | - |
| 1053 | 508118 | 252079 | S | - | - | - |
| 1053 | 508127 | 252097 | S | - | - | - |
| 1150 | 508142 | 252109 | S | 30.85 | 29.225 | 1.625 |
| 1151 | 508184 | 252109 | S | - | - | - |
| 1151 | 508185 | 252101 | S | - | - | - |
| 1152 | 508174 | 252134 | S | - | - | - |
| 1152 | 508185 | 252134 | S | - | - | - |
| 1152 | 508187 | 252120 | S | - | - | - |
| 2053 | 507269 | 252099 | S | 34.75 | 31.53 | 3.22 |
| 2053 | 508257 | 252069 | S | 28.225 | 26.6 | 1.625 |
| 2054 | 508228 | 252094 | S | 28.95 | 27.219 | 1.731 |
| 2055 | 508211 | 252086 | S | 29.05 | 27.4 | 1.65 |
| 2057 | 508208 | 252091 | S | - | - | - |
| 2060 | 507260 | 252075 | S | 36 | 34 | 2 |
| 2151 | 507251 | 252135 | S | 34 | 32.15 | 1.85 |
| 2151 | 508249 | 252106 | S | 28.775 | 27.175 | 1.6 |
| 2152 | 508208 | 252124 | S | - | - | - |
| 2152 | 508201 | 252104 | S | - | - | - |
| 2152 | 508235 | 252135 | S | - | - | - |
| 2152 | 508225 | 252135 | S | - | - | - |
| 2152 | 508238 | 252121 | S | - | - | - |
| 2152 | 508250 | 252114 | S | - | - | - |
| 2152 | 508241 | 252119 | S | - | - | - |
| 2152 | 508254 | 252119 | S | - | - | - |
| 2153 | 507273 | 252108 | S | 34.3 | 31.377 | 2.923 |
| 2154 | 507283 | 252163 | S | 32.54 | 30.715 | 1.825 |
| 2155 | 507287 | 252184 | S | 32.1 | 30.576 | 1.524 |
| 2251 | 507277 | 252230 | S | 31.57 | 30.19 | 1.38 |
| 2351 | 507266 | 252328 | S | 32.16 | 28.74 | 3.42 |
| 3054 | 507303 | 252066 | S | 36.75 | 34.576 | 2.174 |
| 3055 | 507312 | 252084 | S | 36 | 33.59 | 2.41 |
| 3151 | 507315 | 252107 | S | 34.85 | 31.855 | 2.995 |
| 3152 | 507307 | 252121 | S | 34.1 | 31.746 | 2.354 |
| 3153 | 507309 | 252134 | S | 33.3 | 31.61 | 1.69 |
| 3154 | 507312 | 252145 | S | 32.97 | 31.51 | 1.46 |
| 3155 | 507391 | 252129 | S | 33.4 | 31.004 | 2.396 |
| 3156 | 507394 | 252137 | S | 32.61 | 30.78 | 1.83 |
| 3157 | 507387 | 252168 | S | 32.1 | 30.09 | 2.01 |
| 3158 | 507391 | 252185 | S | 31.729 | 29.889 | 1.84 |
| 3159 | 507320 | 252198 | S | 31.5 | 30.02 | 1.48 |
| 3160 | 507315 | 252180 | S | 31.98 | 30.38 | 1.6 |
| 3251 | 507326 | 252230 | S | 31.38 | 29.49 | 1.89 |
| 3351 | 507343 | 252333 | S | 32.095 | 28.497 | 3.598 |
| 3352 | 507330 | 252317 | S | 32.055 | 29.375 | 2.68 |
| 4052 | 507422 | 252072 | S | 34.42 | 31.31 | 3.11 |
| 4053 | 507440 | 252099 | S | 34.49 | 31.42 | 3.07 |
| 4054 | 507463 | 252067 | S | 35.508 | 33.218 | 2.29 |
| 4058 | 507451 | 252092 | S | 34.89 | 31.38 | 3.51 |
| 4151 | 507427 | 252106 | S | 34.61 | 31.21 | 3.4 |
| 4152 | 507410 | 252117 | S | 34.06 | 31.15 | 2.91 |
| 4153 | 507401 | 252161 | S | 32.26 | 30.29 | 1.97 |
| 4154 | 507489 | 252117 | S | 32.767 | 30.757 | 2.01 |
| 4155 | 507489 | 252179 | S | 31.1 | 29 | 2.1 |
| 4251 | 507403 | 252219 | S | 30.93 | 29.44 | 1.49 |
| 4351 | 507418 | 252323 | S | 31.85 | 28.14 | 3.71 |
| 5151 | 507507 | 252163 | S | 31.27 | 28.79 | 2.48 |
| 5152 | 507512 | 252162 | S | 31.24 | 28.67 | 2.57 |
| 5153 | 507571 | 252110 | S | 31.64 | 29.2 | 2.44 |
| 5154 | 507570 | 252193 | S | 30.23 | 28.79 | 1.44 |
| 5251 | 507565 | 252250 | S | 30.191 | 27.861 | 2.33 |
| 6051 | 507689 | 252078 | S | 31.17 | 28.26 | 2.91 |
| 6053 | 507619 | 252086 | S | 31.28 | 29.4 | 1.88 |
| 6151 | 507695 | 252151 | S | 29.61 | 26.74 | 2.87 |
| 6152 | 507615 | 252184 | S | 29.94 | 28.45 | 1.49 |
| 6153 | 507640 | 252158 | S | 30.58 | 29.09 | 1.49 |
| 6154 | 507605 | 252174 | S | 30.36 | 28.52 | 1.84 |
| 6155 | 507617 | 252188 | S | 29.87 | 28.34 | 1.53 |
| 6251 | 507629 | 252203 | S | 29.97 | 27.21 | 2.76 |
| 7152 | 507747 | 252169 | S | 27.99 | 25.36 | 2.63 |
| 7153 | 507746 | 252168 | S | 28 | 25.4 | 2.6 |

| Manhole Reference | Easting | Northing | Liquid Type | Cover Level | Invert Level | Depth to Invert |
|---|---|---|---|---|---|---|

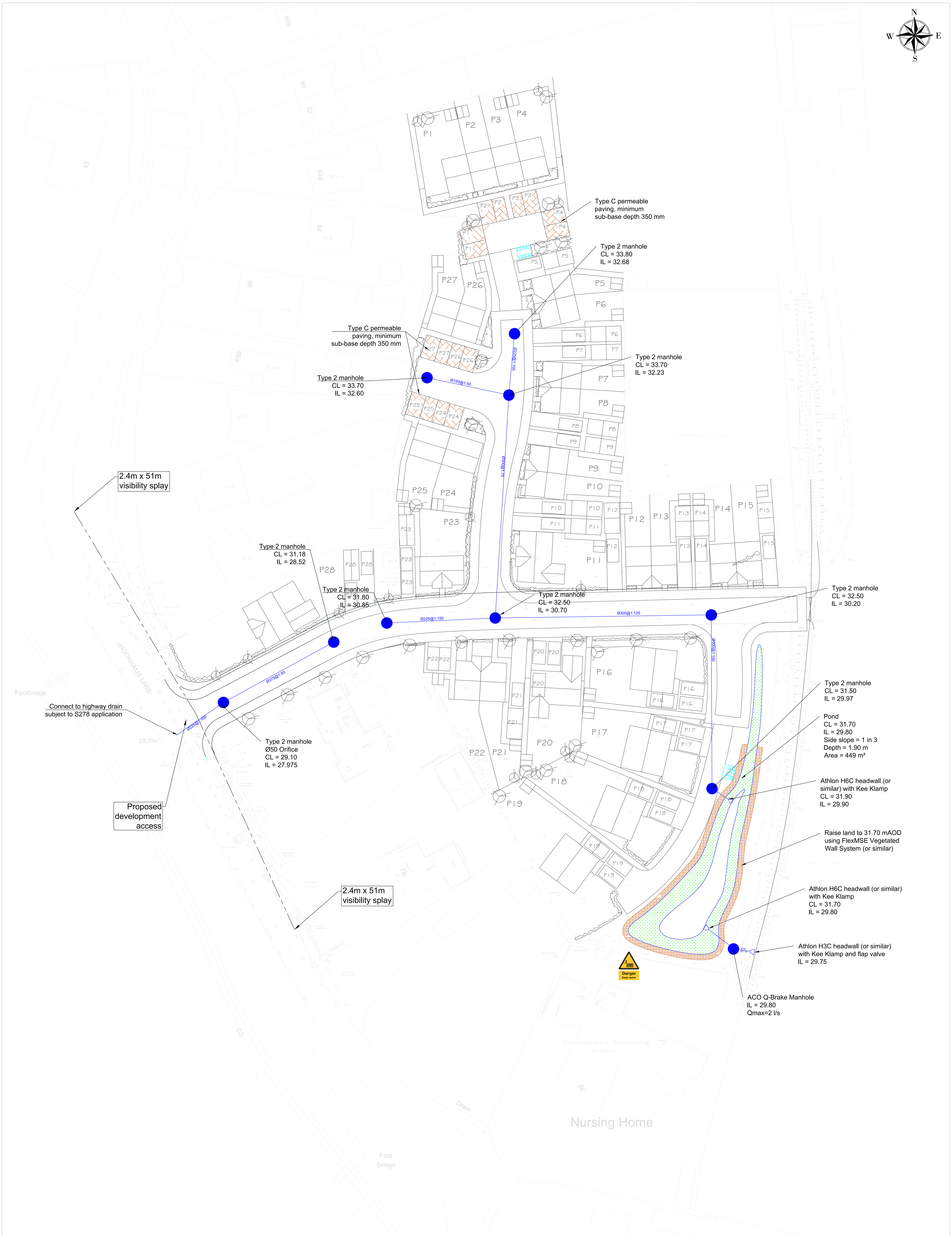
| Manhole Reference | Easting | Northing | Liquid Type | Cover Level | Invert Level | Depth to Invert |
|---|---|---|---|---|---|---|

## ICP SUDS Mean Annual Flood

Input

| | | | |
|---|---|---|---|
| Return Period (years) | 100 | Soil | 0.400 |
| Area (ha) | 1.000 | Urban | 0.000 |
| SAAR (mm) | 568 | Region Number | Region 5 |

| **Results** | **l/s** |
|---|---|
| QBAR Rural | 2.7 |
| QBAR Urban | 2.7 |
| | |
| Q100 years | 9.5 |
| | |
| Q1 year | 2.3 |
| Q30 years | 6.4 |
| Q100 years | 9.5 |




**Notes:**

1. This drawing must be read in conjunction drainage report 2296B_HookhamsLane_FRA_DS.
2. Highway drainage to be in line with local standards.
3. Kerb drains should be installed throughout the development to ensure gravity flow is viable.
4. A health and safety risk assessment, in line with CDM 2015, must be prepared by the principal contractor prior to any work taking place.
5. All calculations shall be submitted to the overseeing Engineer prior to any works commencing.
6. Until technical approval has been obtained from the relevant Authority, it should be understood that all drawings issued are Preliminary and not for construction. Should the contractor commence the work prior to such approval being given, it is entirely at his own risk.
7. The minimum depth of cover to the crown of gravity pipes without protection should be 0.35m for domestic gardens and pathways without any possibility of vehicular access; 0.5m for domestic driveways, parking areas and yards where gross vehicle weight is <7.5 tonnes; 0.9m for domestic driveways, parking areas and narrow streets without footways and where gross vehicle weight is <7.5 tonnes; 0.9m for agricultural land and public open space; 1.2m for highways and parking areas where the gross vehicle weight is >7,5 tonnes.
8. Drainage to be in accordance with BS 7533-13:2009, Building Regulations Part H: Drainage and Waste Disposal and CIRIA SuDS Manual 2015.
9. Cover Class to manholes/inspection chambers are to suit anticipated vehicular loadings in accordance with EN 124 (D400 where potential for HGV loading, C250/B125/A15 in footway trafficked areas not accessible by vehicles.
10. Before handover, all manholes shall be inspected, all rubble removed, and the whole system shall be thoroughly flushed and cleaned.
11. CBR to be confirmed prior to installation of permeable pavements. Contractor to consult with manufacturer for the requirement and thickness of the capping layer.
12. All materials delivered to the site associated to the sub-base storage and filter medium of the permeable pavement must be tested to obtain their porosity and permeability; in line with BS 1377-2:1990 and BS 1377-4:1990
13. Backfill material to drainage trenches under carriageways to be DOT Type 1 sub-base material, elsewhere backfill to be free draining readily compacted material, free from rubbish and organic matter, frozen soil clay lumps and large stones. Joints specification to be provided by manufacturer.
14. Typical pipe bedding to drainage for pipes up to D=525mm is to be Class S (i.e. 10-14mm).
8. The installation of the impermeable liner must be strictly to manufacturer's recommendations. The liner should be cut and sealed appropriately where pipe connections are to be made.
9. A flexible pipe coupling should be used to secure pipes to the socket(s).
10. Appropriate adapter sockets must be provided by the manufacturer for the pipes.
11. Backfill to be compacted in 150mm layers by means of a vibrating plate compactor and installed in accordance with Tables 6/1 or 8/1 of the SHW (Transport Specification for Highway Works).
12. Extra care must be taken once the permeable pavement(s) has been installed so that construction traffic does not impact the porosity due to compaction.
13. The requirement or not for a capping layer under the porous pavement(s) must be assessed by the manufacturer.
14. All joints to be welded to provide watertight structure & 'top hat' seals provided at each pipe penetration.
15. The position of any existing public or private sewers, utility services, plant or apparatus shown on this drawing is believed to be correct, but no warranty to this is expressed or implied. Other such plant or apparatus may also be present but not shown. The Contractor is therefore advised to undertake his own investigation where the presence of any existing sewers, services, plant or apparatus may affect his operations.
16. RAB Consultants accepts no responsibility should the proposed drainage is not installed correctly and to standards, and structural/functional failure occurs.
17. Do not scale from this drawing.
18. 

| | |
|---|---|
| Client: Philips Planning Services | Project: Hookhams Lane |
| Drawing: Outline Surface Water Drainage | Drawing No.: RAB2296B_001 |

Resilience and Flood Risk
Kingsbrook House,
7 Kingsway,
Bedford,
MK42 9BA

| | | |
|---|---|---|
| Drawn by FG | Checked by AT | |
| Approved by AT | Date: 21/01/2020 | Revision 2 |
| | Scale: 1:250 @ A0 | |

Danger
Deep water

A life buoy must be present at all times and the feature must be fenced off and include a warning sign at a visible location.

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 | 30.639 | 0.839 | 2.0 | 178.3 | O K |
| 30 min Summer | 30.818 | 1.018 | 2.0 | 229.0 | O K |
| 60 min Summer | 30.977 | 1.177 | 2.0 | 278.1 | O K |
| 120 min Summer | 31.171 | 1.371 | 2.0 | 343.4 | O K |
| 180 min Summer | 31.275 | 1.475 | 2.0 | 381.3 | O K |
| 240 min Summer | 31.339 | 1.539 | 2.0 | 405.5 | O K |
| 360 min Summer | 31.407 | 1.607 | 2.0 | 431.8 | Flood Risk |
| 480 min Summer | 31.436 | 1.636 | 2.0 | 443.5 | Flood Risk |
| 600 min Summer | 31.448 | 1.648 | 2.0 | 448.2 | Flood Risk |
| 720 min Summer | 31.449 | 1.649 | 2.0 | 448.8 | Flood Risk |
| 960 min Summer | 31.435 | 1.635 | 2.0 | 443.2 | Flood Risk |
| 1440 min Summer | 31.378 | 1.578 | 2.0 | 420.5 | O K |
| 2160 min Summer | 31.278 | 1.478 | 2.0 | 382.3 | O K |
| 2880 min Summer | 31.200 | 1.400 | 2.0 | 354.0 | O K |
| 4320 min Summer | 31.094 | 1.294 | 2.0 | 316.7 | O K |
| 5760 min Summer | 31.016 | 1.216 | 2.0 | 290.9 | O K |
| 7200 min Summer | 30.957 | 1.157 | 2.0 | 271.5 | O K |
| 8640 min Summer | 30.909 | 1.109 | 2.0 | 256.4 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 15 min Summer | 154.750 | 0.0 | 107.8 | 27 |
| 30 min Summer | 99.661 | 0.0 | 111.1 | 42 |
| 60 min Summer | 60.943 | 0.0 | 239.2 | 72 |
| 120 min Summer | 38.086 | 0.0 | 242.4 | 130 |
| 180 min Summer | 28.515 | 0.0 | 256.6 | 190 |
| 240 min Summer | 22.995 | 0.0 | 265.2 | 250 |
| 360 min Summer | 16.687 | 0.0 | 274.6 | 368 |
| 480 min Summer | 13.143 | 0.0 | 279.3 | 488 |
| 600 min Summer | 10.862 | 0.0 | 281.7 | 608 |
| 720 min Summer | 9.267 | 0.0 | 283.0 | 726 |
| 960 min Summer | 7.177 | 0.0 | 283.2 | 964 |
| 1440 min Summer | 4.971 | 0.0 | 279.4 | 1442 |
| 2160 min Summer | 3.429 | 0.0 | 502.2 | 1868 |
| 2880 min Summer | 2.642 | 0.0 | 488.5 | 2228 |
| 4320 min Summer | 1.854 | 0.0 | 468.6 | 3024 |
| 5760 min Summer | 1.458 | 0.0 | 652.0 | 3856 |
| 7200 min Summer | 1.222 | 0.0 | 682.9 | 4680 |
| 8640 min Summer | 1.067 | 0.0 | 715.3 | 5528 |

## 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 |
|---|---|---|---|---|---|
| 10080 min Summer | 30.871 | 1.071 | 2.0 | 244.8 | O K |
| 15 min Winter | 30.718 | 0.918 | 2.0 | 199.9 | O K |
| 30 min Winter | 30.910 | 1.110 | 2.0 | 256.8 | O K |
| 60 min Winter | 31.080 | 1.280 | 2.0 | 312.2 | O K |
| 120 min Winter | 31.288 | 1.488 | 2.0 | 386.1 | O K |
| 180 min Winter | 31.400 | 1.600 | 2.0 | 429.3 | Flood Risk |
| 240 min Winter | 31.470 | 1.670 | 2.0 | 457.2 | Flood Risk |
| 360 min Winter | 31.545 | 1.745 | 2.0 | 488.1 | Flood Risk |
| 480 min Winter | 31.580 | 1.780 | 2.0 | 502.8 | Flood Risk |
| 600 min Winter | 31.595 | 1.795 | 2.0 | 509.5 | Flood Risk |
| 720 min Winter | 31.600 | 1.800 | 2.0 | 511.7 | Flood Risk |
| 960 min Winter | 31.592 | 1.792 | 2.0 | 508.2 | Flood Risk |
| 1440 min Winter | 31.545 | 1.745 | 2.0 | 488.1 | Flood Risk |
| 2160 min Winter | 31.451 | 1.651 | 2.0 | 449.3 | Flood Risk |
| 2880 min Winter | 31.361 | 1.561 | 2.0 | 413.7 | O K |
| 4320 min Winter | 31.235 | 1.435 | 2.0 | 366.6 | O K |
| 5760 min Winter | 31.133 | 1.333 | 2.0 | 330.4 | O K |
| 7200 min Winter | 31.048 | 1.248 | 2.0 | 301.2 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 10080 min Summer | 0.958 | 0.0 | 749.8 | 6352 |
| 15 min Winter | 154.750 | 0.0 | 104.2 | 27 |
| 30 min Winter | 99.661 | 0.0 | 117.1 | 41 |
| 60 min Winter | 60.943 | 0.0 | 232.6 | 70 |
| 120 min Winter | 38.086 | 0.0 | 256.6 | 128 |
| 180 min Winter | 28.515 | 0.0 | 270.8 | 188 |
| 240 min Winter | 22.995 | 0.0 | 279.2 | 246 |
| 360 min Winter | 16.687 | 0.0 | 288.3 | 364 |
| 480 min Winter | 13.143 | 0.0 | 292.5 | 480 |
| 600 min Winter | 10.862 | 0.0 | 294.5 | 598 |
| 720 min Winter | 9.267 | 0.0 | 295.3 | 714 |
| 960 min Winter | 7.177 | 0.0 | 294.8 | 944 |
| 1440 min Winter | 4.971 | 0.0 | 289.5 | 1398 |
| 2160 min Winter | 3.429 | 0.0 | 524.6 | 2040 |
| 2880 min Winter | 2.642 | 0.0 | 519.2 | 2340 |
| 4320 min Winter | 1.854 | 0.0 | 498.3 | 3244 |
| 5760 min Winter | 1.458 | 0.0 | 730.2 | 4152 |
| 7200 min Winter | 1.222 | 0.0 | 764.9 | 5048 |

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 |
|---|---|---|---|---|---|
| 8640 min Winter | 30.974 | 1.174 | 2.0 | 277.0 | O K |
| 10080 min Winter | 30.910 | 1.110 | 2.0 | 256.9 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 8640 min Winter | 1.067 | 0.0 | 801.1 | 5968 |
| 10080 min Winter | 0.958 | 0.0 | 834.7 | 6856 |

## Rainfall Details

| | | | |
|---|---|---|---|
| Rainfall Model | FEH | Winter Storms | Yes |
| Return Period (years) | 100 | Cv (Summer) | 0.750 |
| FEH Rainfall Version | 2013 | Cv (Winter) | 0.840 |
| Site Location | GB 507817 252308 | Shortest Storm (mins) | 15 |
| Data Type | Point | Longest Storm (mins) | 10080 |
| Summer Storms | Yes | Climate Change % | +40 |

## Time Area Diagram

Total Area (ha) 0.621

| **Time From:** | **(mins) To:** | **Area (ha)** | **Time From:** | **(mins) To:** | **Area (ha)** | **Time From:** | **(mins) To:** | **Area (ha)** |
|---|---|---|---|---|---|---|---|---|
| 0 | 4 | 0.207 | 4 | 8 | 0.207 | 8 | 12 | 0.207 |

## Model Details

Storage is Online Cover Level (m) 31.700

## Tank or Pond Structure

Invert Level (m) 29.800

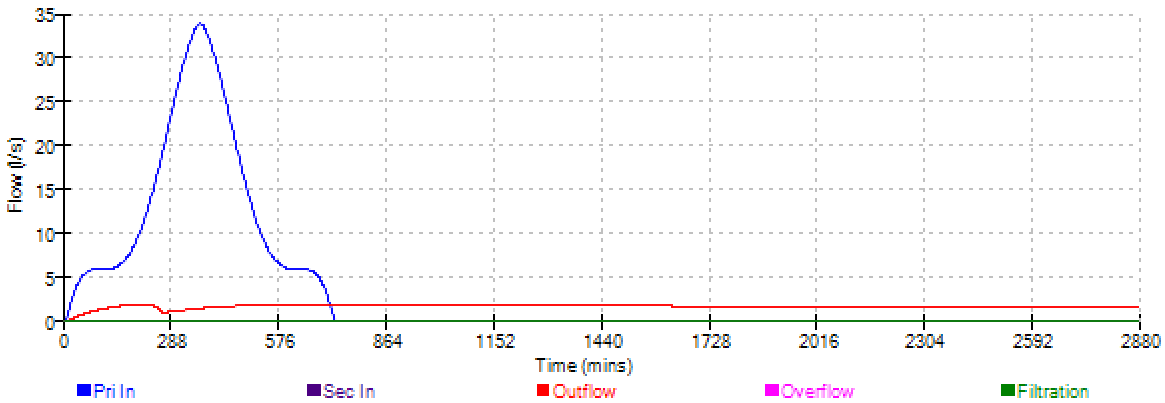
| Depth (m) | Area (m²) | Depth (m) | Area (m²) |
|---|---|---|---|
| 0.000 | 160.0 | 1.900 | 449.0 |

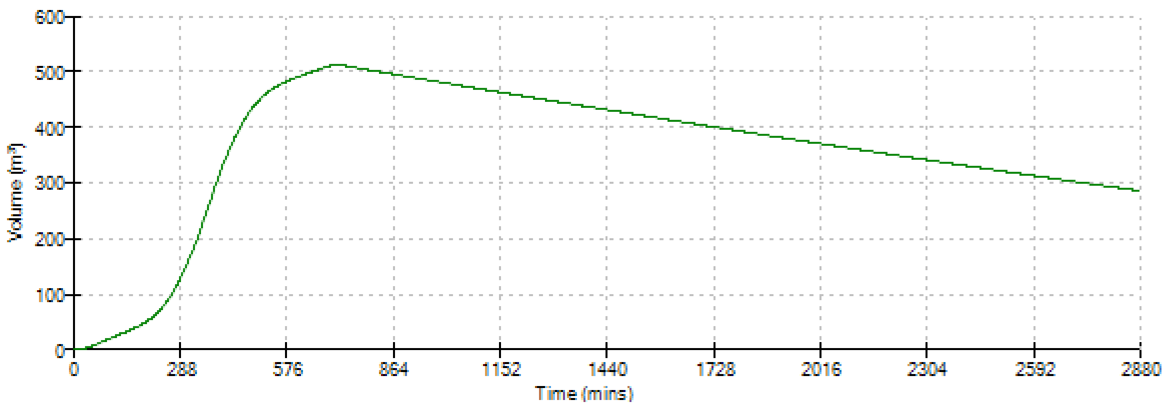
## ACO Q-Brake Outflow Control

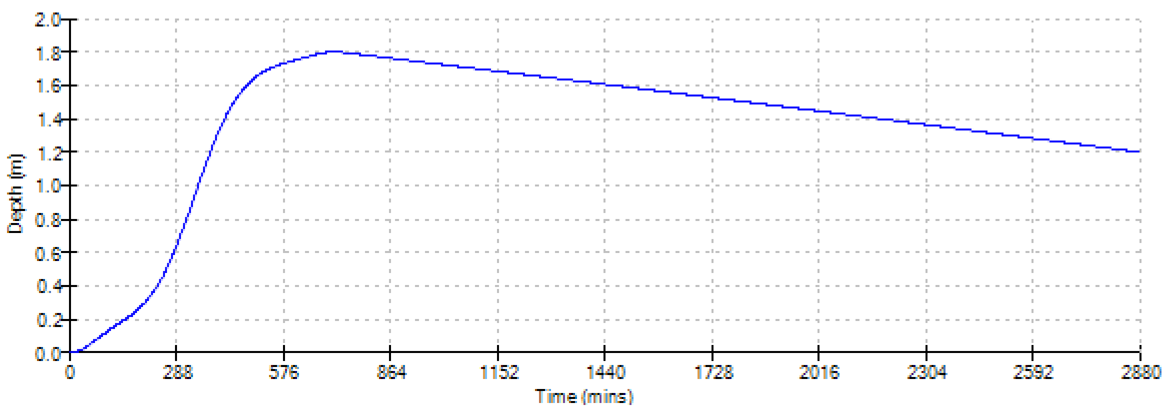
Design Head (m) 1.900 Diameter (mm) 60
Design Flow (l/s) 2.0 Invert Level (m) 29.800

| Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) |
|---|---|---|---|---|---|---|---|
| 0.100 | 1.2 | 1.200 | 1.6 | 3.000 | 2.5 | 7.000 | 3.8 |
| 0.200 | 1.8 | 1.400 | 1.7 | 3.500 | 2.7 | 7.500 | 3.9 |
| 0.300 | 2.0 | 1.600 | 1.8 | 4.000 | 2.9 | 8.000 | 4.0 |
| 0.400 | 1.9 | 1.800 | 1.9 | 4.500 | 3.0 | 8.500 | 4.2 |
| 0.500 | 1.3 | 2.000 | 2.0 | 5.000 | 3.2 | 9.000 | 4.3 |
| 0.600 | 1.1 | 2.200 | 2.1 | 5.500 | 3.4 | 9.500 | 4.4 |
| 0.800 | 1.3 | 2.400 | 2.2 | 6.000 | 3.5 | | |
| 1.000 | 1.4 | 2.600 | 2.3 | 6.500 | 3.6 | | |

Event: 720 min Winter



Summary of Results for 100 year Return Period

| Storm Event | Max Level (m) | Max Depth (m) | Max Control (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|
| 15 min Summer | 30.438 | 0.638 | 2.0 | 126.9 | O K |
| 30 min Summer | 30.581 | 0.781 | 2.0 | 162.9 | O K |
| 60 min Summer | 30.709 | 0.909 | 2.0 | 197.5 | O K |
| 120 min Summer | 30.865 | 1.065 | 2.0 | 243.1 | O K |
| 180 min Summer | 30.949 | 1.149 | 2.0 | 269.0 | O K |
| 240 min Summer | 30.999 | 1.199 | 2.0 | 285.1 | O K |
| 360 min Summer | 31.049 | 1.249 | 2.0 | 301.6 | O K |
| 480 min Summer | 31.067 | 1.267 | 2.0 | 307.8 | O K |
| 600 min Summer | 31.071 | 1.271 | 2.0 | 309.0 | O K |
| 720 min Summer | 31.066 | 1.266 | 2.0 | 307.4 | O K |
| 960 min Summer | 31.043 | 1.243 | 2.0 | 299.7 | O K |
| 1440 min Summer | 30.975 | 1.175 | 2.0 | 277.3 | O K |
| 2160 min Summer | 30.881 | 1.081 | 2.0 | 248.0 | O K |
| 2880 min Summer | 30.809 | 1.009 | 2.0 | 226.4 | O K |
| 4320 min Summer | 30.704 | 0.904 | 2.0 | 196.1 | O K |
| 5760 min Summer | 30.622 | 0.822 | 2.0 | 173.7 | O K |
| 7200 min Summer | 30.551 | 0.751 | 2.0 | 155.2 | O K |
| 8640 min Summer | 30.486 | 0.686 | 2.0 | 138.8 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 15 min Summer | 110.535 | 0.0 | 122.7 | 27 |
| 30 min Summer | 71.187 | 0.0 | 115.1 | 41 |
| 60 min Summer | 43.531 | 0.0 | 202.7 | 72 |
| 120 min Summer | 27.204 | 0.0 | 239.6 | 130 |
| 180 min Summer | 20.368 | 0.0 | 237.6 | 190 |
| 240 min Summer | 16.425 | 0.0 | 231.6 | 250 |
| 360 min Summer | 11.919 | 0.0 | 232.6 | 368 |
| 480 min Summer | 9.388 | 0.0 | 237.6 | 488 |
| 600 min Summer | 7.758 | 0.0 | 240.5 | 606 |
| 720 min Summer | 6.620 | 0.0 | 242.1 | 724 |
| 960 min Summer | 5.127 | 0.0 | 243.1 | 962 |
| 1440 min Summer | 3.550 | 0.0 | 240.4 | 1400 |
| 2160 min Summer | 2.449 | 0.0 | 410.7 | 1712 |
| 2880 min Summer | 1.887 | 0.0 | 421.9 | 2084 |
| 4320 min Summer | 1.324 | 0.0 | 414.7 | 2904 |
| 5760 min Summer | 1.042 | 0.0 | 465.6 | 3752 |
| 7200 min Summer | 0.873 | 0.0 | 487.7 | 4608 |
| 8640 min Summer | 0.762 | 0.0 | 510.8 | 5448 |

## Summary of Results for 100 year Return Period

| Storm Event | Max Level (m) | Max Depth (m) | Max Control (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|
| 10080 min Summer | 30.419 | 0.619 | 2.0 | 122.3 | O K |
| 15 min Winter | 30.501 | 0.701 | 2.0 | 142.3 | O K |
| 30 min Winter | 30.656 | 0.856 | 2.0 | 182.8 | O K |
| 60 min Winter | 30.794 | 0.994 | 2.0 | 221.8 | O K |
| 120 min Winter | 30.963 | 1.163 | 2.0 | 273.5 | O K |
| 180 min Winter | 31.054 | 1.254 | 2.0 | 303.3 | O K |
| 240 min Winter | 31.109 | 1.309 | 2.0 | 322.0 | O K |
| 360 min Winter | 31.166 | 1.366 | 2.0 | 341.8 | O K |
| 480 min Winter | 31.189 | 1.389 | 2.0 | 350.1 | O K |
| 600 min Winter | 31.197 | 1.397 | 2.0 | 352.7 | O K |
| 720 min Winter | 31.195 | 1.395 | 2.0 | 352.1 | O K |
| 960 min Winter | 31.177 | 1.377 | 2.0 | 345.7 | O K |
| 1440 min Winter | 31.116 | 1.316 | 2.0 | 324.4 | O K |
| 2160 min Winter | 31.011 | 1.211 | 2.0 | 289.0 | O K |
| 2880 min Winter | 30.928 | 1.128 | 2.0 | 262.4 | O K |
| 4320 min Winter | 30.791 | 0.991 | 2.0 | 220.9 | O K |
| 5760 min Winter | 30.670 | 0.870 | 2.0 | 186.8 | O K |
| 7200 min Winter | 30.554 | 0.754 | 2.0 | 155.8 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 10080 min Summer | 0.684 | 0.0 | 535.5 | 6256 |
| 15 min Winter | 110.535 | 0.0 | 124.0 | 27 |
| 30 min Winter | 71.187 | 0.0 | 105.5 | 41 |
| 60 min Winter | 43.531 | 0.0 | 226.3 | 70 |
| 120 min Winter | 27.204 | 0.0 | 238.2 | 128 |
| 180 min Winter | 20.368 | 0.0 | 231.1 | 186 |
| 240 min Winter | 16.425 | 0.0 | 236.8 | 246 |
| 360 min Winter | 11.919 | 0.0 | 246.1 | 362 |
| 480 min Winter | 9.388 | 0.0 | 250.8 | 478 |
| 600 min Winter | 7.758 | 0.0 | 253.3 | 596 |
| 720 min Winter | 6.620 | 0.0 | 254.6 | 710 |
| 960 min Winter | 5.127 | 0.0 | 255.1 | 940 |
| 1440 min Winter | 3.550 | 0.0 | 251.8 | 1384 |
| 2160 min Winter | 2.449 | 0.0 | 460.0 | 1944 |
| 2880 min Winter | 1.887 | 0.0 | 464.9 | 2224 |
| 4320 min Winter | 1.324 | 0.0 | 423.0 | 3156 |
| 5760 min Winter | 1.042 | 0.0 | 521.6 | 4048 |
| 7200 min Winter | 0.873 | 0.0 | 546.3 | 4976 |

Summary of Results for 100 year Return Period

| Storm Event | Max Level (m) | Max Depth (m) | Max Control (l/s) | Max Volume (m³) | Status |
| --- | --- | --- | --- | --- | --- |
| 8640 min Winter | 30.407 | 0.607 | 2.0 | 119.5 | O K |
| 10080 min Winter | 30.166 | 0.366 | 2.0 | 66.5 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
| --- | --- | --- | --- | --- |
| 8640 min Winter | 0.762 | 0.0 | 572.2 | 5968 |
| 10080 min Winter | 0.684 | 0.0 | 599.8 | 5944 |

## Rainfall Details

| | | | |
|---|---|---|---|
| Rainfall Model | FEH | Winter Storms | Yes |
| Return Period (years) | 100 | Cv (Summer) | 0.750 |
| FEH Rainfall Version | 2013 | Cv (Winter) | 0.840 |
| Site Location | GB 507817 252308 | Shortest Storm (mins) | 15 |
| Data Type | Point | Longest Storm (mins) | 10080 |
| Summer Storms | Yes | Climate Change % | +0 |

## Time Area Diagram

Total Area (ha) 0.621

| **Time From:** | **(mins) To:** | **Area (ha)** | **Time From:** | **(mins) To:** | **Area (ha)** | **Time From:** | **(mins) To:** | **Area (ha)** |
|---|---|---|---|---|---|---|---|---|
| 0 | 4 | 0.207 | 4 | 8 | 0.207 | 8 | 12 | 0.207 |

## Model Details

Storage is Online Cover Level (m) 31.700

## Tank or Pond Structure

Invert Level (m) 29.800

| Depth (m) | Area (m²) | Depth (m) | Area (m²) |
|---|---|---|---|
| 0.000 | 160.0 | 1.900 | 449.0 |

## ACO Q-Brake Outflow Control

Design Head (m) 1.900 Diameter (mm) 60
Design Flow (l/s) 2.0 Invert Level (m) 29.800

| Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) |
|---|---|---|---|---|---|---|---|
| 0.100 | 1.2 | 1.200 | 1.6 | 3.000 | 2.5 | 7.000 | 3.8 |
| 0.200 | 1.8 | 1.400 | 1.7 | 3.500 | 2.7 | 7.500 | 3.9 |
| 0.300 | 2.0 | 1.600 | 1.8 | 4.000 | 2.9 | 8.000 | 4.0 |
| 0.400 | 1.9 | 1.800 | 1.9 | 4.500 | 3.0 | 8.500 | 4.2 |
| 0.500 | 1.3 | 2.000 | 2.0 | 5.000 | 3.2 | 9.000 | 4.3 |
| 0.600 | 1.1 | 2.200 | 2.1 | 5.500 | 3.4 | 9.500 | 4.4 |
| 0.800 | 1.3 | 2.400 | 2.2 | 6.000 | 3.5 | | |
| 1.000 | 1.4 | 2.600 | 2.3 | 6.500 | 3.6 | | |

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 | 30.298 | 0.498 | 2.0 | 94.5 | O K |
| 30 min Summer | 30.412 | 0.612 | 2.0 | 120.7 | O K |
| 60 min Summer | 30.511 | 0.711 | 2.0 | 145.0 | O K |
| 120 min Summer | 30.634 | 0.834 | 2.0 | 176.9 | O K |
| 180 min Summer | 30.697 | 0.897 | 2.0 | 194.0 | O K |
| 240 min Summer | 30.733 | 0.933 | 2.0 | 204.3 | O K |
| 360 min Summer | 30.768 | 0.968 | 2.0 | 214.2 | O K |
| 480 min Summer | 30.778 | 0.978 | 2.0 | 217.2 | O K |
| 600 min Summer | 30.777 | 0.977 | 2.0 | 216.9 | O K |
| 720 min Summer | 30.770 | 0.970 | 2.0 | 214.9 | O K |
| 960 min Summer | 30.746 | 0.946 | 2.0 | 207.9 | O K |
| 1440 min Summer | 30.687 | 0.887 | 2.0 | 191.4 | O K |
| 2160 min Summer | 30.618 | 0.818 | 2.0 | 172.5 | O K |
| 2880 min Summer | 30.563 | 0.763 | 2.0 | 158.1 | O K |
| 4320 min Summer | 30.475 | 0.675 | 2.0 | 135.9 | O K |
| 5760 min Summer | 30.390 | 0.590 | 2.0 | 115.5 | O K |
| 7200 min Summer | 30.249 | 0.449 | 2.0 | 84.0 | O K |
| 8640 min Summer | 30.175 | 0.375 | 2.0 | 68.3 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 15 min Summer | 82.915 | 0.0 | 96.5 | 27 |
| 30 min Summer | 52.998 | 0.0 | 120.4 | 41 |
| 60 min Summer | 32.184 | 0.0 | 149.8 | 70 |
| 120 min Summer | 20.004 | 0.0 | 186.3 | 130 |
| 180 min Summer | 14.903 | 0.0 | 208.2 | 190 |
| 240 min Summer | 11.985 | 0.0 | 222.9 | 248 |
| 360 min Summer | 8.688 | 0.0 | 234.7 | 368 |
| 480 min Summer | 6.848 | 0.0 | 237.0 | 486 |
| 600 min Summer | 5.672 | 0.0 | 235.8 | 604 |
| 720 min Summer | 4.852 | 0.0 | 232.9 | 724 |
| 960 min Summer | 3.780 | 0.0 | 225.2 | 962 |
| 1440 min Summer | 2.652 | 0.0 | 211.0 | 1248 |
| 2160 min Summer | 1.866 | 0.0 | 312.7 | 1624 |
| 2880 min Summer | 1.461 | 0.0 | 326.6 | 2020 |
| 4320 min Summer | 1.053 | 0.0 | 352.9 | 2860 |
| 5760 min Summer | 0.845 | 0.0 | 377.9 | 3704 |
| 7200 min Summer | 0.720 | 0.0 | 402.2 | 4256 |
| 8640 min Summer | 0.636 | 0.0 | 426.6 | 4848 |

## Summary of Results for 30 year Return Period

| Storm Event | Max Level (m) | Max Depth (m) | Max Control (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|
| 10080 min Summer | 30.130 | 0.330 | 2.0 | 59.2 | O K |
| 15 min Winter | 30.350 | 0.550 | 2.0 | 106.3 | O K |
| 30 min Winter | 30.473 | 0.673 | 2.0 | 135.5 | O K |
| 60 min Winter | 30.581 | 0.781 | 2.0 | 163.0 | O K |
| 120 min Winter | 30.715 | 0.915 | 2.0 | 199.2 | O K |
| 180 min Winter | 30.784 | 0.984 | 2.0 | 218.9 | O K |
| 240 min Winter | 30.825 | 1.025 | 2.0 | 231.0 | O K |
| 360 min Winter | 30.866 | 1.066 | 2.0 | 243.2 | O K |
| 480 min Winter | 30.880 | 1.080 | 2.0 | 247.6 | O K |
| 600 min Winter | 30.882 | 1.082 | 2.0 | 248.3 | O K |
| 720 min Winter | 30.878 | 1.078 | 2.0 | 246.9 | O K |
| 960 min Winter | 30.858 | 1.058 | 2.0 | 240.8 | O K |
| 1440 min Winter | 30.800 | 1.000 | 2.0 | 223.6 | O K |
| 2160 min Winter | 30.715 | 0.915 | 2.0 | 199.1 | O K |
| 2880 min Winter | 30.644 | 0.844 | 2.0 | 179.6 | O K |
| 4320 min Winter | 30.515 | 0.715 | 2.0 | 146.0 | O K |
| 5760 min Winter | 30.351 | 0.551 | 2.0 | 106.5 | O K |
| 7200 min Winter | 30.150 | 0.350 | 2.0 | 63.3 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 10080 min Summer | 0.577 | 0.0 | 451.6 | 5544 |
| 15 min Winter | 82.915 | 0.0 | 108.1 | 27 |
| 30 min Winter | 52.998 | 0.0 | 124.3 | 41 |
| 60 min Winter | 32.184 | 0.0 | 167.8 | 70 |
| 120 min Winter | 20.004 | 0.0 | 208.6 | 128 |
| 180 min Winter | 14.903 | 0.0 | 230.4 | 186 |
| 240 min Winter | 11.985 | 0.0 | 237.7 | 244 |
| 360 min Winter | 8.688 | 0.0 | 237.5 | 360 |
| 480 min Winter | 6.848 | 0.0 | 232.2 | 478 |
| 600 min Winter | 5.672 | 0.0 | 227.4 | 592 |
| 720 min Winter | 4.852 | 0.0 | 224.0 | 708 |
| 960 min Winter | 3.780 | 0.0 | 220.7 | 932 |
| 1440 min Winter | 2.652 | 0.0 | 219.9 | 1362 |
| 2160 min Winter | 1.866 | 0.0 | 350.3 | 1708 |
| 2880 min Winter | 1.461 | 0.0 | 365.8 | 2168 |
| 4320 min Winter | 1.053 | 0.0 | 395.3 | 3116 |
| 5760 min Winter | 0.845 | 0.0 | 423.3 | 4088 |
| 7200 min Winter | 0.720 | 0.0 | 450.5 | 4256 |

Summary of Results for 30 year Return Period

| Storm Event | Max Level (m) | Max Depth (m) | Max Control (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|
| 8640 min Winter | 30.080 | 0.280 | 2.0 | 49.5 | O K |
| 10080 min Winter | 30.038 | 0.238 | 1.9 | 41.5 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 8640 min Winter | 0.636 | 0.0 | 477.9 | 4920 |
| 10080 min Winter | 0.577 | 0.0 | 505.8 | 5552 |

## Rainfall Details

| | | | |
|---|---|---|---|
| Rainfall Model | FEH | Winter Storms | Yes |
| Return Period (years) | 30 | Cv (Summer) | 0.750 |
| FEH Rainfall Version | 2013 | Cv (Winter) | 0.840 |
| Site Location | GB 507817 252308 | Shortest Storm (mins) | 15 |
| Data Type | Point | Longest Storm (mins) | 10080 |
| Summer Storms | Yes | Climate Change % | +0 |

## Time Area Diagram

Total Area (ha) 0.621

| **Time From:** | **(mins) To:** | **Area (ha)** | **Time From:** | **(mins) To:** | **Area (ha)** | **Time From:** | **(mins) To:** | **Area (ha)** |
|---|---|---|---|---|---|---|---|---|
| 0 | 4 | 0.207 | 4 | 8 | 0.207 | 8 | 12 | 0.207 |

## Model Details

Storage is Online Cover Level (m) 31.700

## Tank or Pond Structure

Invert Level (m) 29.800

| Depth (m) | Area (m²) | Depth (m) | Area (m²) |
|---|---|---|---|
| 0.000 | 160.0 | 1.900 | 449.0 |

## ACO Q-Brake Outflow Control

Design Head (m) 1.900 Diameter (mm) 60
Design Flow (l/s) 2.0 Invert Level (m) 29.800

| Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) |
|---|---|---|---|---|---|---|---|
| 0.100 | 1.2 | 1.200 | 1.6 | 3.000 | 2.5 | 7.000 | 3.8 |
| 0.200 | 1.8 | 1.400 | 1.7 | 3.500 | 2.7 | 7.500 | 3.9 |
| 0.300 | 2.0 | 1.600 | 1.8 | 4.000 | 2.9 | 8.000 | 4.0 |
| 0.400 | 1.9 | 1.800 | 1.9 | 4.500 | 3.0 | 8.500 | 4.2 |
| 0.500 | 1.3 | 2.000 | 2.0 | 5.000 | 3.2 | 9.000 | 4.3 |
| 0.600 | 1.1 | 2.200 | 2.1 | 5.500 | 3.4 | 9.500 | 4.4 |
| 0.800 | 1.3 | 2.400 | 2.2 | 6.000 | 3.5 | | |
| 1.000 | 1.4 | 2.600 | 2.3 | 6.500 | 3.6 | | |

## Summary of Results for 2 year Return Period

| Storm Event | Max Level (m) | Max Depth (m) | Max Control (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|
| 15 min Summer | 30.031 | 0.231 | 1.9 | 40.1 | O K |
| 30 min Summer | 30.081 | 0.281 | 2.0 | 49.6 | O K |
| 60 min Summer | 30.126 | 0.326 | 2.0 | 58.3 | O K |
| 120 min Summer | 30.213 | 0.413 | 2.0 | 76.3 | O K |
| 180 min Summer | 30.257 | 0.457 | 2.0 | 85.5 | O K |
| 240 min Summer | 30.281 | 0.481 | 2.0 | 90.9 | O K |
| 360 min Summer | 30.301 | 0.501 | 2.0 | 95.2 | O K |
| 480 min Summer | 30.299 | 0.499 | 2.0 | 94.9 | O K |
| 600 min Summer | 30.287 | 0.487 | 2.0 | 92.1 | O K |
| 720 min Summer | 30.273 | 0.473 | 2.0 | 89.0 | O K |
| 960 min Summer | 30.245 | 0.445 | 2.0 | 83.1 | O K |
| 1440 min Summer | 30.197 | 0.397 | 2.0 | 72.8 | O K |
| 2160 min Summer | 30.139 | 0.339 | 2.0 | 61.0 | O K |
| 2880 min Summer | 30.096 | 0.296 | 2.0 | 52.4 | O K |
| 4320 min Summer | 30.038 | 0.238 | 1.9 | 41.5 | O K |
| 5760 min Summer | 30.003 | 0.203 | 1.8 | 34.8 | O K |
| 7200 min Summer | 29.978 | 0.178 | 1.7 | 30.3 | O K |
| 8640 min Summer | 29.960 | 0.160 | 1.6 | 27.1 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 15 min Summer | 35.972 | 0.0 | 41.8 | 26 |
| 30 min Summer | 22.622 | 0.0 | 52.6 | 40 |
| 60 min Summer | 13.715 | 0.0 | 63.8 | 68 |
| 120 min Summer | 9.322 | 0.0 | 86.8 | 126 |
| 180 min Summer | 7.197 | 0.0 | 100.5 | 186 |
| 240 min Summer | 5.908 | 0.0 | 110.0 | 246 |
| 360 min Summer | 4.387 | 0.0 | 122.5 | 364 |
| 480 min Summer | 3.512 | 0.0 | 130.8 | 482 |
| 600 min Summer | 2.941 | 0.0 | 136.9 | 548 |
| 720 min Summer | 2.539 | 0.0 | 141.8 | 580 |
| 960 min Summer | 2.005 | 0.0 | 149.4 | 682 |
| 1440 min Summer | 1.438 | 0.0 | 160.6 | 932 |
| 2160 min Summer | 1.037 | 0.0 | 173.7 | 1320 |
| 2880 min Summer | 0.828 | 0.0 | 185.0 | 1700 |
| 4320 min Summer | 0.614 | 0.0 | 205.9 | 2424 |
| 5760 min Summer | 0.504 | 0.0 | 225.4 | 3168 |
| 7200 min Summer | 0.438 | 0.0 | 244.6 | 3888 |
| 8640 min Summer | 0.393 | 0.0 | 263.4 | 4592 |

## Summary of Results for 2 year Return Period

| Storm Event | Max Level (m) | Max Depth (m) | Max Control (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|
| 10080 min Summer | 29.946 | 0.146 | 1.5 | 24.6 | O K |
| 15 min Winter | 30.057 | 0.257 | 1.9 | 45.0 | O K |
| 30 min Winter | 30.113 | 0.313 | 2.0 | 55.9 | O K |
| 60 min Winter | 30.163 | 0.363 | 2.0 | 66.0 | O K |
| 120 min Winter | 30.264 | 0.464 | 2.0 | 87.1 | O K |
| 180 min Winter | 30.317 | 0.517 | 2.0 | 98.8 | O K |
| 240 min Winter | 30.348 | 0.548 | 2.0 | 105.9 | O K |
| 360 min Winter | 30.375 | 0.575 | 2.0 | 112.0 | O K |
| 480 min Winter | 30.380 | 0.580 | 2.0 | 113.1 | O K |
| 600 min Winter | 30.375 | 0.575 | 2.0 | 112.0 | O K |
| 720 min Winter | 30.364 | 0.564 | 2.0 | 109.4 | O K |
| 960 min Winter | 30.326 | 0.526 | 2.0 | 100.9 | O K |
| 1440 min Winter | 30.238 | 0.438 | 2.0 | 81.6 | O K |
| 2160 min Winter | 30.147 | 0.347 | 2.0 | 62.7 | O K |
| 2880 min Winter | 30.084 | 0.284 | 2.0 | 50.2 | O K |
| 4320 min Winter | 30.009 | 0.209 | 1.8 | 35.9 | O K |
| 5760 min Winter | 29.965 | 0.165 | 1.6 | 27.9 | O K |
| 7200 min Winter | 29.936 | 0.136 | 1.5 | 22.8 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 10080 min Summer | 0.361 | 0.0 | 282.3 | 5344 |
| 15 min Winter | 35.972 | 0.0 | 46.8 | 26 |
| 30 min Winter | 22.622 | 0.0 | 58.9 | 39 |
| 60 min Winter | 13.715 | 0.0 | 71.5 | 68 |
| 120 min Winter | 9.322 | 0.0 | 97.2 | 126 |
| 180 min Winter | 7.197 | 0.0 | 112.5 | 184 |
| 240 min Winter | 5.908 | 0.0 | 123.2 | 242 |
| 360 min Winter | 4.387 | 0.0 | 137.2 | 358 |
| 480 min Winter | 3.512 | 0.0 | 146.5 | 474 |
| 600 min Winter | 2.941 | 0.0 | 153.4 | 586 |
| 720 min Winter | 2.539 | 0.0 | 158.8 | 698 |
| 960 min Winter | 2.005 | 0.0 | 167.3 | 914 |
| 1440 min Winter | 1.438 | 0.0 | 179.9 | 1034 |
| 2160 min Winter | 1.037 | 0.0 | 194.6 | 1412 |
| 2880 min Winter | 0.828 | 0.0 | 207.2 | 1788 |
| 4320 min Winter | 0.614 | 0.0 | 230.6 | 2512 |
| 5760 min Winter | 0.504 | 0.0 | 252.5 | 3232 |
| 7200 min Winter | 0.438 | 0.0 | 273.9 | 3968 |

Summary of Results for 2 year Return Period

| Storm Event | Max Level (m) | Max Depth (m) | Max Control (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|
| 8640 min Winter | 29.916 | 0.116 | 1.3 | 19.3 | O K |
| 10080 min Winter | 29.901 | 0.101 | 1.3 | 16.8 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 8640 min Winter | 0.393 | 0.0 | 295.1 | 4672 |
| 10080 min Winter | 0.361 | 0.0 | 316.2 | 5352 |

## Rainfall Details

| | | | |
| --- | --- | --- | --- |
| Rainfall Model | FEH | Winter Storms | Yes |
| Return Period (years) | 2 | Cv (Summer) | 0.750 |
| FEH Rainfall Version | 2013 | Cv (Winter) | 0.840 |
| Site Location | GB 507817 252308 | Shortest Storm (mins) | 15 |
| Data Type | Point | Longest Storm (mins) | 10080 |
| Summer Storms | Yes | Climate Change % | +0 |

## Time Area Diagram

Total Area (ha) 0.621

| **Time From:** | **(mins) To:** | **Area (ha)** | **Time From:** | **(mins) To:** | **Area (ha)** | **Time From:** | **(mins) To:** | **Area (ha)** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 4 | 0.207 | 4 | 8 | 0.207 | 8 | 12 | 0.207 |

## Model Details

Storage is Online Cover Level (m) 31.700

## Tank or Pond Structure

Invert Level (m) 29.800

| Depth (m) | Area (m²) | Depth (m) | Area (m²) |
|---|---|---|---|
| 0.000 | 160.0 | 1.900 | 449.0 |

## ACO Q-Brake Outflow Control

Design Head (m) 1.900 Diameter (mm) 60
Design Flow (l/s) 2.0 Invert Level (m) 29.800

| Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) |
|---|---|---|---|---|---|---|---|
| 0.100 | 1.2 | 1.200 | 1.6 | 3.000 | 2.5 | 7.000 | 3.8 |
| 0.200 | 1.8 | 1.400 | 1.7 | 3.500 | 2.7 | 7.500 | 3.9 |
| 0.300 | 2.0 | 1.600 | 1.8 | 4.000 | 2.9 | 8.000 | 4.0 |
| 0.400 | 1.9 | 1.800 | 1.9 | 4.500 | 3.0 | 8.500 | 4.2 |
| 0.500 | 1.3 | 2.000 | 2.0 | 5.000 | 3.2 | 9.000 | 4.3 |
| 0.600 | 1.1 | 2.200 | 2.1 | 5.500 | 3.4 | 9.500 | 4.4 |
| 0.800 | 1.3 | 2.400 | 2.2 | 6.000 | 3.5 | | |
| 1.000 | 1.4 | 2.600 | 2.3 | 6.500 | 3.6 | | |

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

| Storm Event | Max Level (m) | Max Depth (m) | Max Control (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|
| 15 min Summer | 30.706 | 0.906 | 2.0 | 196.6 | O K |
| 30 min Summer | 30.896 | 1.096 | 2.0 | 252.5 | O K |
| 60 min Summer | 31.064 | 1.264 | 2.0 | 306.8 | O K |
| 120 min Summer | 31.269 | 1.469 | 2.0 | 379.1 | O K |
| 180 min Summer | 31.380 | 1.580 | 2.0 | 421.3 | O K |
| 240 min Summer | 31.448 | 1.648 | 2.0 | 448.4 | Flood Risk |
| 360 min Summer | 31.521 | 1.721 | 2.0 | 478.2 | Flood Risk |
| 480 min Summer | 31.554 | 1.754 | 2.0 | 492.1 | Flood Risk |
| 600 min Summer | 31.569 | 1.769 | 2.0 | 498.1 | Flood Risk |
| 720 min Summer | 31.572 | 1.772 | 2.0 | 499.6 | Flood Risk |
| 960 min Summer | 31.561 | 1.761 | 2.0 | 494.9 | Flood Risk |
| 1440 min Summer | 31.508 | 1.708 | 2.0 | 472.5 | Flood Risk |
| 2160 min Summer | 31.407 | 1.607 | 2.0 | 432.0 | Flood Risk |
| 2880 min Summer | 31.328 | 1.528 | 2.0 | 401.3 | O K |
| 4320 min Summer | 31.220 | 1.420 | 2.0 | 361.2 | O K |
| 5760 min Summer | 31.144 | 1.344 | 2.0 | 334.2 | O K |
| 7200 min Summer | 31.086 | 1.286 | 2.0 | 314.2 | O K |
| 8640 min Summer | 31.041 | 1.241 | 2.0 | 299.1 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 15 min Summer | 154.750 | 0.0 | 103.9 | 27 |
| 30 min Summer | 99.661 | 0.0 | 116.2 | 42 |
| 60 min Summer | 60.943 | 0.0 | 232.9 | 72 |
| 120 min Summer | 38.086 | 0.0 | 254.7 | 130 |
| 180 min Summer | 28.515 | 0.0 | 268.9 | 190 |
| 240 min Summer | 22.995 | 0.0 | 277.5 | 250 |
| 360 min Summer | 16.687 | 0.0 | 286.8 | 370 |
| 480 min Summer | 13.143 | 0.0 | 291.4 | 488 |
| 600 min Summer | 10.862 | 0.0 | 293.7 | 608 |
| 720 min Summer | 9.267 | 0.0 | 294.7 | 726 |
| 960 min Summer | 7.177 | 0.0 | 294.7 | 966 |
| 1440 min Summer | 4.971 | 0.0 | 290.5 | 1442 |
| 2160 min Summer | 3.429 | 0.0 | 521.9 | 1936 |
| 2880 min Summer | 2.642 | 0.0 | 516.5 | 2280 |
| 4320 min Summer | 1.854 | 0.0 | 494.1 | 3036 |
| 5760 min Summer | 1.458 | 0.0 | 718.1 | 3872 |
| 7200 min Summer | 1.222 | 0.0 | 752.2 | 4688 |
| 8640 min Summer | 1.067 | 0.0 | 787.9 | 5536 |

## 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 |
|---|---|---|---|---|---|
| 10080 min Summer | 31.006 | 1.206 | 2.0 | 287.6 | O K |
| 15 min Winter | 30.789 | 0.989 | 2.0 | 220.3 | O K |
| 30 min Winter | 30.993 | 1.193 | 2.0 | 283.1 | O K |
| 60 min Winter | 31.173 | 1.373 | 2.0 | 344.3 | O K |
| 120 min Winter | 31.392 | 1.592 | 2.0 | 426.1 | O K |
| 180 min Winter | 31.512 | 1.712 | 2.0 | 474.2 | Flood Risk |
| 240 min Winter | 31.586 | 1.786 | 2.0 | 505.3 | Flood Risk |
| 360 min Winter | 31.666 | 1.866 | 2.0 | 540.3 | Flood Risk |
| 480 min Winter | 31.704 | 1.904 | 2.0 | 557.3 | FLOOD |
| 600 min Winter | 31.722 | 1.922 | 2.0 | 565.5 | FLOOD |
| 720 min Winter | 31.730 | 1.930 | 2.0 | 568.7 | FLOOD |
| 960 min Winter | 31.725 | 1.925 | 2.0 | 566.5 | FLOOD |
| 1440 min Winter | 31.681 | 1.881 | 2.0 | 547.2 | Flood Risk |
| 2160 min Winter | 31.591 | 1.791 | 2.0 | 507.8 | Flood Risk |
| 2880 min Winter | 31.500 | 1.700 | 2.0 | 469.5 | Flood Risk |
| 4320 min Winter | 31.376 | 1.576 | 2.0 | 419.8 | O K |
| 5760 min Winter | 31.278 | 1.478 | 2.0 | 382.4 | O K |
| 7200 min Winter | 31.196 | 1.396 | 2.0 | 352.7 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 10080 min Summer | 0.958 | 0.0 | 818.4 | 6360 |
| 15 min Winter | 154.750 | 0.0 | 109.0 | 27 |
| 30 min Winter | 99.661 | 0.0 | 122.3 | 41 |
| 60 min Winter | 60.943 | 0.0 | 241.1 | 70 |
| 120 min Winter | 38.086 | 0.0 | 269.0 | 128 |
| 180 min Winter | 28.515 | 0.0 | 283.2 | 188 |
| 240 min Winter | 22.995 | 0.0 | 291.6 | 246 |
| 360 min Winter | 16.687 | 0.0 | 300.5 | 364 |
| 480 min Winter | 13.143 | 1.9 | 304.6 | 480 |
| 600 min Winter | 10.862 | 10.1 | 306.5 | 598 |
| 720 min Winter | 9.267 | 13.3 | 307.1 | 714 |
| 960 min Winter | 7.177 | 11.0 | 306.2 | 946 |
| 1440 min Winter | 4.971 | 0.0 | 300.3 | 1402 |
| 2160 min Winter | 3.429 | 0.0 | 552.9 | 2056 |
| 2880 min Winter | 2.642 | 0.0 | 546.3 | 2596 |
| 4320 min Winter | 1.854 | 0.0 | 522.9 | 3252 |
| 5760 min Winter | 1.458 | 0.0 | 804.3 | 4200 |
| 7200 min Winter | 1.222 | 0.0 | 842.4 | 5112 |

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 |
|---|---|---|---|---|---|
| 8640 min Winter | 31.128 | 1.328 | 2.0 | 328.5 | O K |
| 10080 min Winter | 31.070 | 1.270 | 2.0 | 308.8 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 8640 min Winter | 1.067 | 0.0 | 882.4 | 5976 |
| 10080 min Winter | 0.958 | 0.0 | 869.2 | 6864 |

## Rainfall Details

| | | | |
|---|---|---|---|
| Rainfall Model | FEH | Winter Storms | Yes |
| Return Period (years) | 100 | Cv (Summer) | 0.750 |
| FEH Rainfall Version | 2013 | Cv (Winter) | 0.840 |
| Site Location | GB 507817 252308 | Shortest Storm (mins) | 15 |
| Data Type | Point | Longest Storm (mins) | 10080 |
| Summer Storms | Yes | Climate Change % | +40 |

## Time Area Diagram

Total Area (ha) 0.684

| **Time From:** | **(mins) To:** | **Area (ha)** | **Time From:** | **(mins) To:** | **Area (ha)** | **Time From:** | **(mins) To:** | **Area (ha)** |
|---|---|---|---|---|---|---|---|---|
| 0 | 4 | 0.228 | 4 | 8 | 0.228 | 8 | 12 | 0.228 |

## Model Details

Storage is Online Cover Level (m) 31.700

## Tank or Pond Structure

Invert Level (m) 29.800

| Depth (m) | Area (m²) | Depth (m) | Area (m²) |
|---|---|---|---|
| 0.000 | 160.0 | 1.900 | 449.0 |

## ACO Q-Brake Outflow Control

Design Head (m) 1.900 Diameter (mm) 60
Design Flow (l/s) 2.0 Invert Level (m) 29.800

| Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) |
|---|---|---|---|---|---|---|---|
| 0.100 | 1.2 | 1.200 | 1.6 | 3.000 | 2.5 | 7.000 | 3.8 |
| 0.200 | 1.8 | 1.400 | 1.7 | 3.500 | 2.7 | 7.500 | 3.9 |
| 0.300 | 2.0 | 1.600 | 1.8 | 4.000 | 2.9 | 8.000 | 4.0 |
| 0.400 | 1.9 | 1.800 | 1.9 | 4.500 | 3.0 | 8.500 | 4.2 |
| 0.500 | 1.3 | 2.000 | 2.0 | 5.000 | 3.2 | 9.000 | 4.3 |
| 0.600 | 1.1 | 2.200 | 2.1 | 5.500 | 3.4 | 9.500 | 4.4 |
| 0.800 | 1.3 | 2.400 | 2.2 | 6.000 | 3.5 | | |
| 1.000 | 1.4 | 2.600 | 2.3 | 6.500 | 3.6 | | |

Event: 720 min Winter