# PROPOSED SOLAR PV SCHEME AND BATTERY ENERGY STORAGE SYSTEM (BESS) ON LAND ADJACENT TO THE A614, WORKSOP, S80 3PA

FLOOD RISK ASSESSMENT AND SURFACE WATER DRAINAGE STRATEGY

25/03/2024

J-15416

Nijhuis Saur Industries | UK & Eire

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| Report No. | Issue Detail | Originator | Date | Checked By | Date |
|---|---|---|---|---|---|
| 01 | One Planet Developments Ltd. | HG | 25/03/2024 | HG | 25/03/2024 |

**For:** One Planet Developments Ltd

**Job No:** J-15416
**Date:** March 24
**Edition:** 01

# CONTENTS



# APPENDICES

# 1.0 INTRODUCTION

One Planet Developments Limited are proposing to install a new Solar PV Scheme and Battery Energy Storage System (BESS) on land adjacent to the A614, Worksop, S80 3PA.

As the site is over 1 hectare (ha) in size, it is necessary to produce a Flood Risk Assessment for the site that focuses on the surface water runoff from the site to ensure that flood risk is not increased downstream due to the proposed development.

The National Planning Policy Framework (NPPF) and associated planning practice guidance (PPG) requires applicants to demonstrate that developments are safe for their lifetime and do not increase flood risk elsewhere. They also set out that major developments should include Sustainable Drainage Systems (SuDS) unless clearly inappropriate.

In order to address this requirement, Nijhuis Industries UK and Ireland Ltd. have been commissioned to develop a Sustainable Drainage System (SuDS) for the proposed development.

An initial inspection of the EA indicative flood map for planning shows the site is primarily located within Flood Zone 1. A small portion of the red line boundary is within Flood Zones 2/3. It is noted that the proposed development area is located outside of the Flood Zones. Therefore, the primary aim of this assessment is to ensure that the development of the site does not increase flood risk to properties downstream of the site. This is achieved by providing a suitable drainage scheme that manages surface water runoff created by the development.

This report comprises the FRA for the proposed development, in line with the National Planning Policy Framework (NPPF), Planning Practice Guidance (PPG) and Bassetlaw District Council.

## 2.0 SITE LOCATION AND DESCRIPTION

The approximate OSGR for the site is SK 65576 74813. The Site is located on agricultural fields two kilometres to the north west of Bothamsall adjacent to the A614 and to the south of the River Poulter. The Site comprises five fields of agricultural land currently used for arable agriculture and bordered by mature woodland. The Site is mainly flat with one field sloping gently towards the River Poulter.

A site location plan, showing the proposed site boundary, is shown in **Figure 2.1** below; the proposed site layout is included in **Appendix A**.

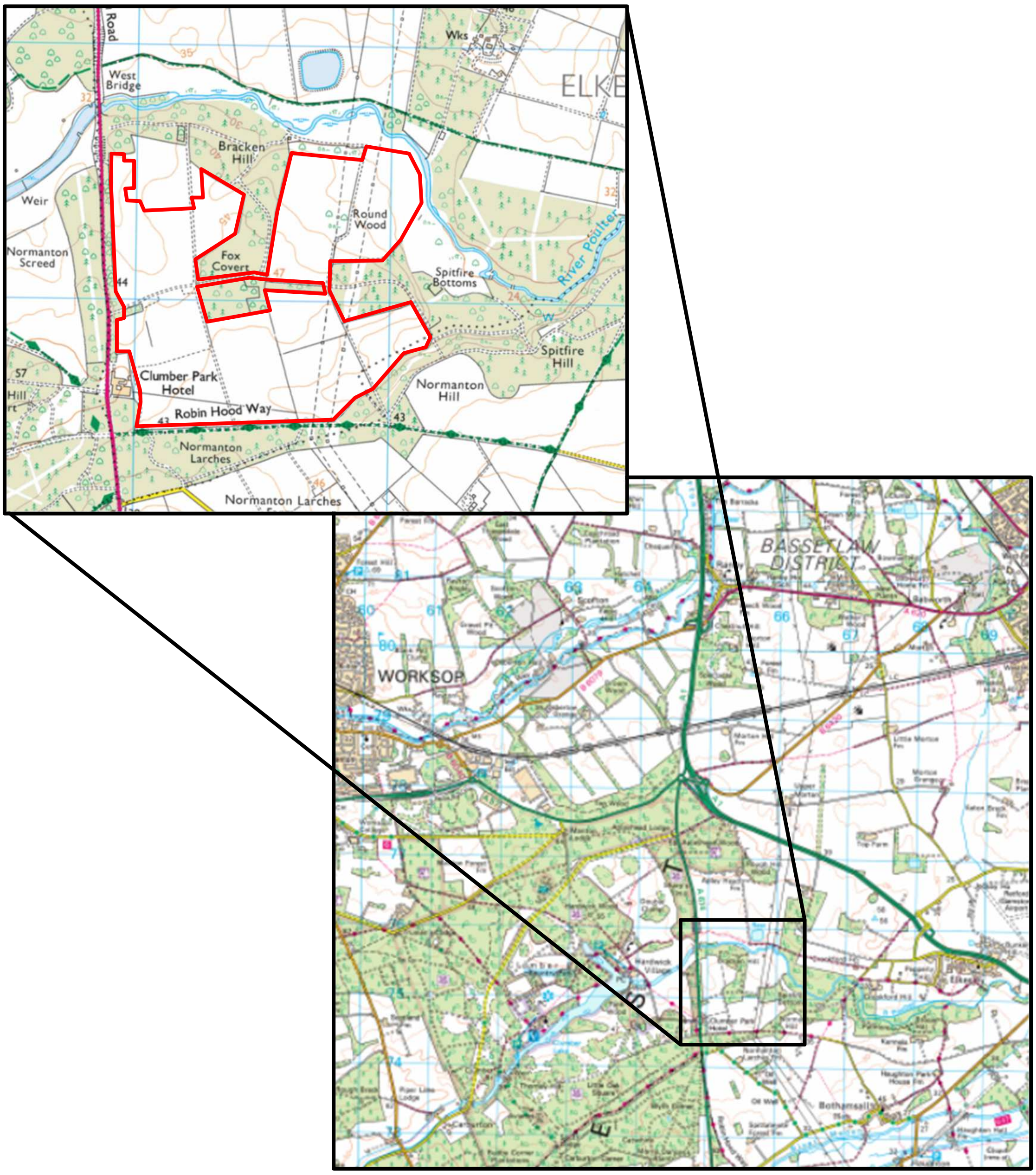



**Figure 2.1. Site Location Plan**

# 3.0 FLOOD RISK

## 3.1 Fluvial and Tidal Flooding

The nearest watercourse is the River Poulter which is to the north/north-east of the red line boundary as indicated below. The site layout plan has included a minimum 20m buffer from the edge of the arable field nearest to the watercourse.

The Environment Agency's Flood Map for Planning, shown below in **Figure 3.1**, indicates that a small portion of the red line boundary is within Flood Zones 2/3. However, when looking at the proposed development areas, they have all been set back from the red line boundary to ensure that the proposed development area is fully within Flood Zone 1. Therefore, the proposed development site is located within Flood Zone 1 (low risk), as such the development site is not considered to be at risk from either fluvial or tidal flooding. Therefore, flooding from these sources will not be considered further within this report.

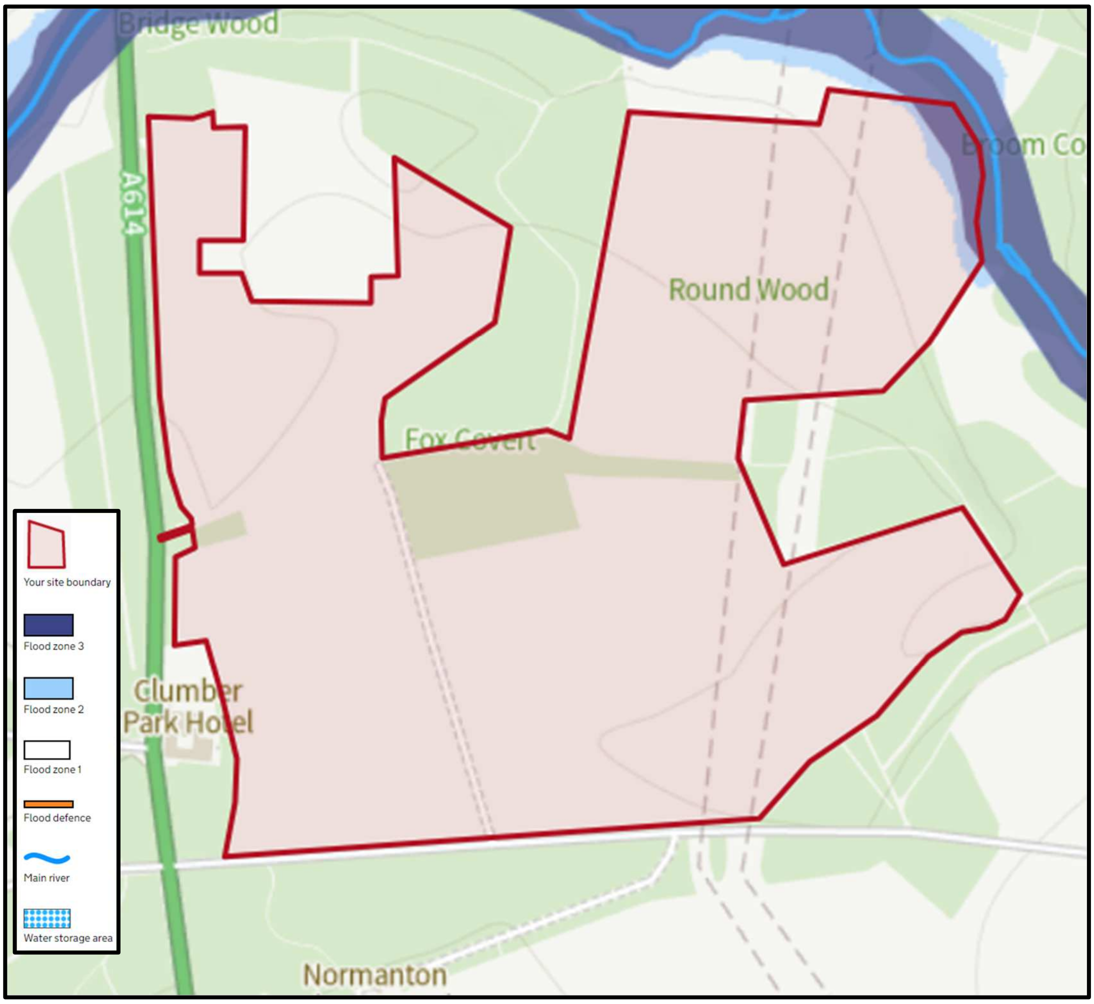



**Figure 3.1. EA Indicative Flood Map**

## 3.2 Groundwater Flooding

Natural England manages and runs the multi-organisation partnership known as MAGIC. This organisation has produced a web-based mapping resource which provides a range of information for the UK including soil types and structure as well as groundwater vulnerability and aquifer categorisation.

Figure 3.3 below shows that the majority of the site is in an area classified as having a 'medium--high' and 'high' risk of groundwater vulnerability.

Given the nature of the development, with vulnerable infrastructure raised above the ground level, it is considered that groundwater flooding does not pose a significant risk to most of the development site. Therefore, groundwater flooding will not be considered further within this report.

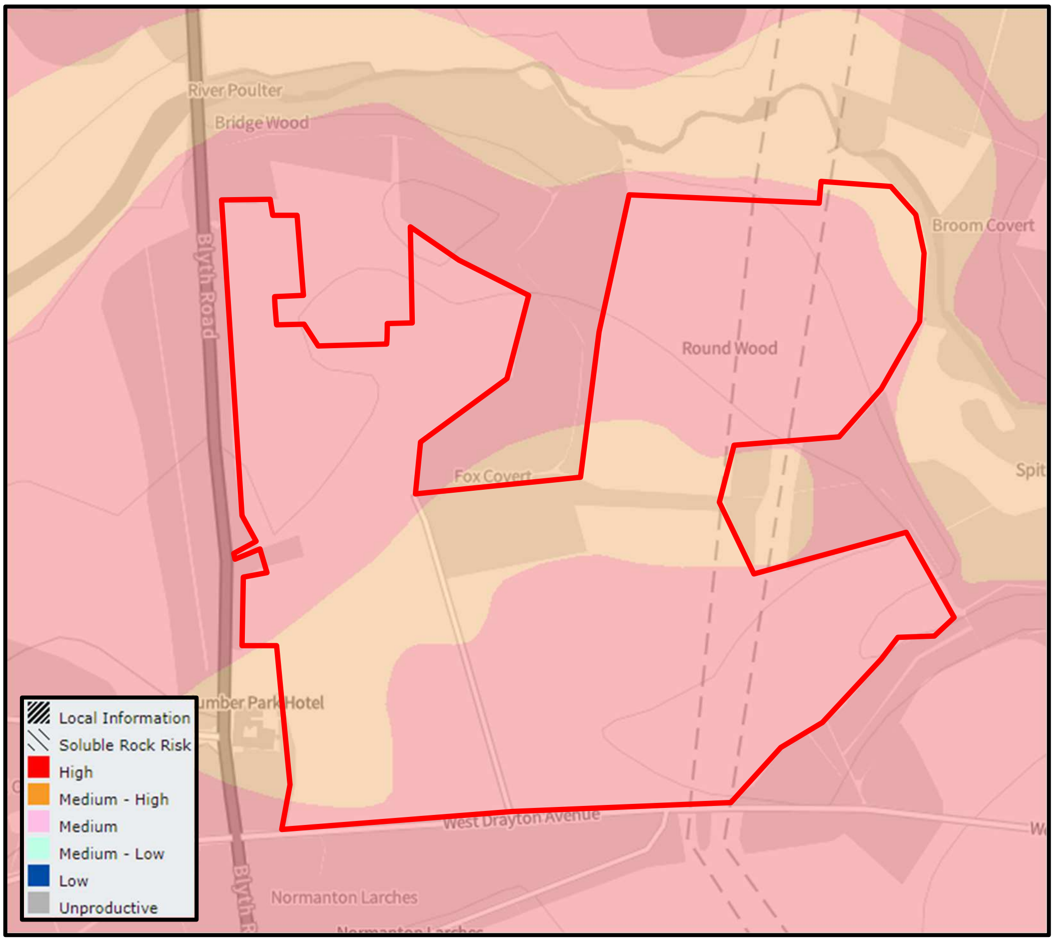



**Figure 3.2 Areas Susceptible to Groundwater Flooding Map**

## 3.3 Overland/Surface Water Flooding

The Environment Agency map shown below in **Figure 3.3** shows the risk of flooding from surface water for the site. It indicates that the majority of the site is at very low risk. There are some localised areas across the site that are at risk of surface water flooding.

The areas at risk of surface water flooding primarily have potential depths of up to 300mm with very small areas at risk of up to 900mm.

The site layout plan shows that there are only to be solar panels located in these areas at risk of surface water flooding and therefore the risk to the other site infrastructure is deemed to be low. It is recommended that, if possible, the panels in these localised areas are a minimum of 0.9m above the ground level. It is noted that the proposed detail for the panels shows the front leading edge at 0.9m.

It is noted that the BESS element of the development is outside of all areas at risk of surface water flooding.

It is recommended that as good practice all infrastructure should be a minimum of 300mm above ground level which will protect them from any residual surface water flooding. Due to the nature of the site this can be easily achieved. As such, this flooding mechanism will not be considered further within the report.

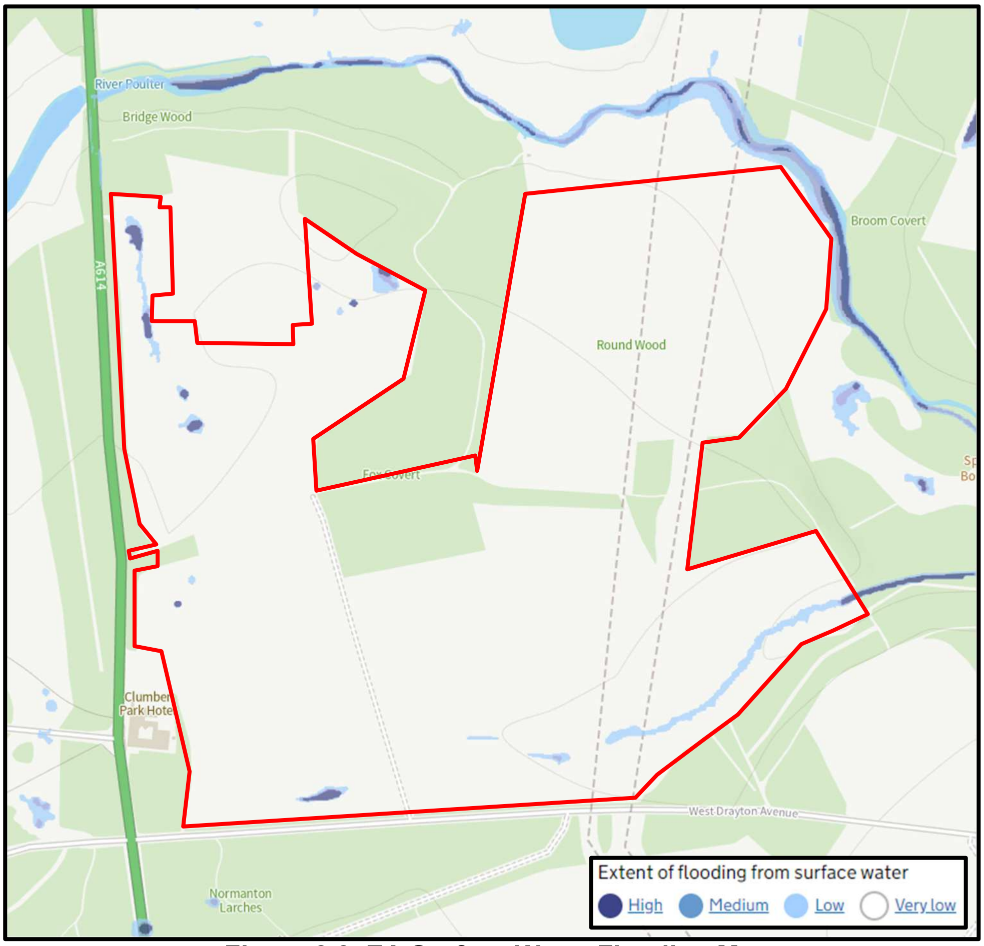



**Figure 3.3. EA Surface Water Flooding Map**

## 4.0 SUSTAINABLE DRAINAGE SCHEME (SUDS)

### 4.1 Overview

SuDS is a concept that incorporates long-term environmental and social factors in order to design surface water drainage systems, in accordance with the ideals of sustainable development. SuDS takes into account the quantity and quality of surface water runoff and the value of surface water to the urban and rural environments. Many existing urban drainage systems can cause problems of flooding, pollution or damage to the environment, so it is the aim of the SuDS to avoid this in the future.

Most proposed urbanisation creates impermeable surfaces which will need drainage solutions to remove surface water runoff. Traditionally, it is only quantity of flow that has been accounted for in drainage solutions, preventing floods locally by conveying the water away from the site swiftly in underground pipes. These traditional methods frequently alter natural flow patterns which can lead to problems elsewhere in the catchment area. More recently, water quality issues must be accounted for, in order to avoid pollutants from urban areas being transported into rivers or groundwater.

Other aspects, such as water resources, community facilities, landscaping and provision of wildlife habitats have been largely ignored; a well-designed and well-managed SuDS can offer the following benefits:

- management of runoff flow rates, reducing the environmental impact of urbanisation
- maintenance or enhancement of water quality
- consideration to the requirements of the local community
- enhancement of biodiversity in urban watercourses
- maintain the natural groundwater level

### 4.2 Design Standards

Design of the site drainage infrastructure and Sustainable Drainage System (SuDS) is to be carried out in line with best practices and to industry standard design procedures. A number of publications, including design guidance and best practice guidance will be applied to different components of the final infrastructure. The sections below provide an overview of the design standards to be used on this project for various aspects of the infrastructure design.

### 4.3 The CIRIA SuDS Manual

This document is a comprehensive publication covering the design, construction, operation and maintenance of SuDS. The advice and best practice outlined in this document has been utilised in the design of the site SuDS features, which have been detailed in this report.

### 4.4 Building Regulations Part H

Building Regulations Part H ‘Drainage and Waste Disposal’ covers the design and installation of surface water and foul water systems. All private drainage including pipes, manholes, down pipes, and other drainage infrastructure on the site should be designed and installed in accordance with this document.

### 4.5 The Wallingford Procedure

Developed by HR Wallingford, this publication covers the design of urban drainage systems. In addition, the document includes regional rainfall data for use in design for varying return period events. Basic sizing calculations for the swales and the estimation of the runoff volumes have been made using this method.

## 4.6 National Planning Policy Framework

The National Planning Policy Framework (NPPF) contains the policy relating to the appropriate assessment of flood risk within the UK. The associated technical guidance provides further details on the definitions, classifications, and constraints used to apply national policy to new developments.

It contains details on flood zone definition, site-specific FRA's, vulnerability classifications, appropriate development, climate change allowances, residual risk management, flood resilience, the sequential test, and the exception test.

## 4.7 Percolation Testing

In view of the relatively small areas of impermeable surface being introduced across the site by the Solar PV infrastructure, there will be a minimal impact on the runoff rates, resulting from the development. The subsoil percolation rate will have no impact on the difference between pre and post-development runoff rates as the ground's surface will remain extensively greenfield.

During the design of the conceptual SuDS layout, it is considered that the primary function of the SuDS will be the interception and storage of water until such time as it evaporates or permeates back to groundwater.

In addition to this, the soils on the site have been indicated to be 'freely draining slightly acid sandy soils' as per the information from Land Information System shown below. This indicates that the soil is anticipated to be freely draining and therefore the proposed drainage for the Solar PV infrastructure is considered to be appropriate.


**Figure 4.1. Soilscape Map Extract**

With regards to the BESS element of the development, it is required that this area is bunded to be able to capture fire water for safe disposal. As such an appropriate surface water drainage system will be designed to account for this.

### 4.8 Environmental Considerations

The nature of the development means that runoff could originate from the solar panel arrays, solar panel pile systems and inverters. The runoff from the panels poses a low environmental risk. It has been assumed that any additional foul/industrial waste from the maintenance and operation of the park will be disposed of elsewhere.

With regards to the BESS, consideration has been given to the environmental risk with regards to potential fire water which has been assessed within the SuDS information further within this report.

The use of heavy plant on-site during construction may cause the topsoil to be disrupted which in turn can pose a pollution risk to local watercourses. Although the swales may provide some benefits, it is advised that silt fences are installed during the construction phase of the project to intercept silt laden runoff, if construction traffic or adverse weather is likely to cause damage to the topsoil.

## 5.0 SUDS DESIGN – SOLAR PV SITE

The impermeable areas across the solar PV site are small and the soil is considered to be freely draining, therefore no formal drainage is required. As such a pragmatic approach has been taken to promote infiltration and create storage across the site. This involves the installation of swale features running parallel to the site contours within downslope areas of the site. These features will intercept and distribute flows, create storage, attenuate runoff and promote infiltration across the site.

Since the solar panels are located on a sloped frame between approximately 0.9m on the lowest edge and 3.0m at the higher edge above ground level, it is anticipated that rain falling on each solar panel table will run off the panels and flow/infiltrate in the sheltered rain shadow area underneath the down-slope modules. A minimum of 10mm gap surrounding the panels will allow water to drain off each module.

The SuDS design will not consider the runoff from the access and maintenance roads as these are likely to be constructed of grass tracks/unbound crushed stones/gravel or similar permeable materials, which will allow infiltration of water in these areas. The access roads will, therefore, not increase surface water runoff rates from the site.

The proposed solar PV modules are anticipated to be supported by steel racking systems, which are to be set on driven piles. The proposed number of support posts approximately equates to an increase in the impermeable area of 197m$^2$.

The impermeable area of the 17 PV power stations and associated additional infrastructure totals 507m$^2$, so in total the impermeable area including the proposed support posts is 704m$^2$.

A conservative estimate of the volume of runoff from the total impermeable area has been calculated for a 6-hour duration, 1 in 100-year rainfall event to be approximately 83.2m$^3$.

Based on an application area of 88.72ha and a runoff volume of 83.2m$^3$ the potential depth of runoff covering the site would be 0.09mm. This is a negligible depth of water across the site and is likely to infiltrate into the ground as per the existing scenario. This volume of runoff is anticipated to infiltrate before it would flow beyond the site boundary and therefore there is no impact to third party sites. Nevertheless, in order to adopt a pragmatic approach and further promote infiltration across the site, a system of swales is proposed to manage the surface water runoff. The details showing surface water management features are outlined in the drawing in **Appendix A**.

To ensure interception of flows and a maintainable system, an oversized system has been implemented which will reduce the runoff rate to less than the predeveloped rates; thus, the developed site reduces the potential flood risk of the undeveloped site.

It is proposed to install swales of 0.2m base width and 0.15m depth with side slopes of 1 in 4. The layout of these swales is shown in more detail in Appendix A. The system should provide around 1,915m of swales which will provide up to 0.12m$^3$/m of storage located on the downslope boundaries. This totals around 230m$^3$ of storage which is more than 2.5 times the minimum required storage in order to capture to overland flow from the whole site.

Provided the swales outlined above are installed prior to other on-site construction works, it is anticipated that the runoff from the construction phase would be suitably managed. The swales will also serve to improve the water quality of runoff discharged from the site.

Calculations are included within **Appendix B** of this report.

### 5.1 Maintenance Requirements

Maintenance of the drainage network is essential to ensure the optimal performance of the drainage elements. The CIRIA SuDS Manual provides information on the maintenance of swales and the relevant extract is shown below.

**TABLE 17.1 Operation and maintenance requirements for swales**

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

**Figure 5.1. The CIRIA SuDS Manual Extract**

## 6.0 SUDS DESIGN – BESS

A section of the site is designated as a Battery Energy Storage System (BESS). This area consists of a number of battery storage containers, designed to store energy to feed back to the National Grid. The nature of layout of the BESS means that there is a concentration of impermeable area, therefore, it is pertinent that the surface water runoff from this part of the development is sufficiently intercepted and disposed of to prevent additional runoff from leaving the site.

Further to this, it is proposed that the batteries will be bunded to prevent any contaminated runoff in the event of a fire. The bunded area of the battery storage will be connected via an outlet pipe to the attenuation system. A valve is to be fitted to the outlet from the bund so that the area can be fully contained in the event of a fire and should the water become polluted.

Therefore, it is proposed that the surface water runoff from the BESS development will be captured, stored and attenuated on-site and discharged to a suitable receptor. Due to the nature of the ground conditions being sandy and freely draining, it is proposed that the outfall from the basin will discharge into the ground through a series of land drains. The access tracks will be formed of crushed stone and therefore will remain permeable in nature.

In line with best practice, the runoff rate from the development should not exceed pre-development greenfield runoff rates and should allow for climate change.

The impermeable area of the battery storage was calculated to have an impermeable area of 570m$^2$. Based on this impermeable area, an ICP-SuDS rate of 0.1 l/s was calculated. This flow rate is too low to be able to attenuate due to small size of orifice required which has a high risk of blockage and therefore failure. Therefore, a rate of 0.7 l/s will be used as this can be easily achieved by a flow control device. Using this rate an attenuation basin is sized with a base area of 18m$^2$ with a ground level of 129m$^2$ with a depth of 1m.

The runoff from the battery storage areas will naturally flow northwards, where it will be captured and conveyed to the attenuation basin. The outfall from the attenuation system will be controlled to the rates outlined above. This ensures that the runoff from the site is controlled to pre-development rates.

Due to the freely draining nature of the ground conditions it is proposed that the outfall from the basin will drain into land drains adjacent to the basin.

The basin is required to provide the ability to collect any potential firewater.

The calculations are included within **Appendix B**.

### 6.1 Maintenance Requirements

Maintenance of the drainage network is essential to ensure the optimal performance of the drainage elements. The CIRIA SuDS Manual provides information on the maintenance of attenuation basin and the relevant extract is shown below.

**TABLE 22.1 Operation and maintenance requirements for detention basins**

| Maintenance schedule | Required action | Typical frequency |
|---|---|---|
| Regular maintenance | Remove litter and debris | Monthly |
| | Cut grass – for spillways and access routes | Monthly (during growing season), or as required |
| | Cut grass – meadow grass in and around basin | Half yearly (spring – before nesting season, and autumn) |
| | Manage other vegetation and remove nuisance plants | Monthly (at start, then as required) |
| | Inspect inlets, outlets and overflows for blockages, and clear if required. | Monthly |
| | Inspect banksides, structures, pipework etc for evidence of physical damage | Monthly |
| | Inspect inlets and facility surface for silt accumulation. Establish appropriate silt removal frequencies. | Monthly (for first year), then annually or as required |
| | Check any penstocks and other mechanical devices | Annually |
| | Tidy all dead growth before start of growing season | Annually |
| | Remove sediment from inlets, outlet and forebay | Annually (or as required) |
| | Manage wetland plants in outlet pool – where provided | Annually (as set out in Chapter 23) |
| Occasional maintenance | Reseed areas of poor vegetation growth | As required |
| | Prune and trim any trees and remove cuttings | Every 2 years, or as required |
| | Remove sediment from inlets, outlets, forebay and main basin when required | Every 5 years, or as required (likely to be minimal requirements where effective upstream source control is provided) |
| Remedial actions | Repair erosion or other damage by reseeding or re-turfing | As required |
| | Realignment of rip-rap | As required |
| | Repair/rehabilitation of inlets, outlets and overflows | As required |
| | Relevel uneven surfaces and reinstate design levels | As required |

**Figure 6.1. The CIRIA SuDS Manual Extract**

## 7.0 EFFECT ON ADJACENT SITES

As outlined in **Section 5.0,** the extent of the impermeable areas introduced across the PV site by the proposed development is extremely small. Therefore, any additional runoff from the impermeable areas will be limited and more than adequately managed by the swale system. As such, there will be no impact on neighbouring sites as a result of the proposed development.

In addition, the pragmatic approach to the design of the swales will provide an improved storage and interception capacity. This capacity will reduce flood risk to adjacent sites from surface water runoff, when compared to the pre-development situation.

With regards to the BESS element of the development proposal, a suitably designed SuDS has been outlined for the site which will ensure that the surface water runoff for the 1 in 100 year event with an allowance for climate change will be managed on site. This will ensure that there is no adverse impact on adjacent third party sites.

## 8.0 RESIDUAL RISKS AFTER DEVELOPMENT

For the Solar PV site area, the capacity of the swales has been oversized to manage runoff and to promote infiltration across the site. As such the swales have ample capacity to contend with runoff from the impermeable areas of the site under rainfall events in excess of the 1 in 100 year storm.

The drainage system proposed has been specifically designed for the volume of surface runoff resulting from the respective infrastructure. Therefore, any unauthorised future connections into the site drainage network will potentially overload the system. Any future development on the site, beyond the current proposal, should be suitably planned and considered, especially if new impermeable areas are to be introduced to the site.

As long as these factors are considered in the design of the development there is the capacity to manage any associated residual risks.

## 9.0 CONCLUSIONS AND RECOMMENDATIONS

The study has investigated the mechanisms for flooding at the proposed solar farm and battery energy storage system on land adjacent to the A614, Worksop, S80 3OA. The development area of the site is in Flood Zone 1 (low risk) and as such this report has focused on reducing the risks associated with surface water runoff. There are small areas of the site at risk of surface water flooding, but these areas only have solar panels in which are set 900mm above the ground level and therefore above the surface water flood risk.

Developments over 1ha in size in Flood Zone 1, require a Flood Risk Assessment to ensure flood risk is not increased to areas downstream of the development site. This study has investigated the impact that the development proposal will have on surface water runoff rates from the site.

For the Solar PV element of the proposal, it has been shown that the impermeable area created by the development is very small, relative to the site area, and as such will only have a small impact on the runoff rates from the site. The SuDS scheme proposed will effectively reduce the runoff rate to less than the undeveloped (current) runoff rates, because storage and infiltration on site will be improved. A swale system, shown on the drawing included in **Appendix A**, has been proposed to allow the interception, redistribution and infiltration of the flows from across the site.

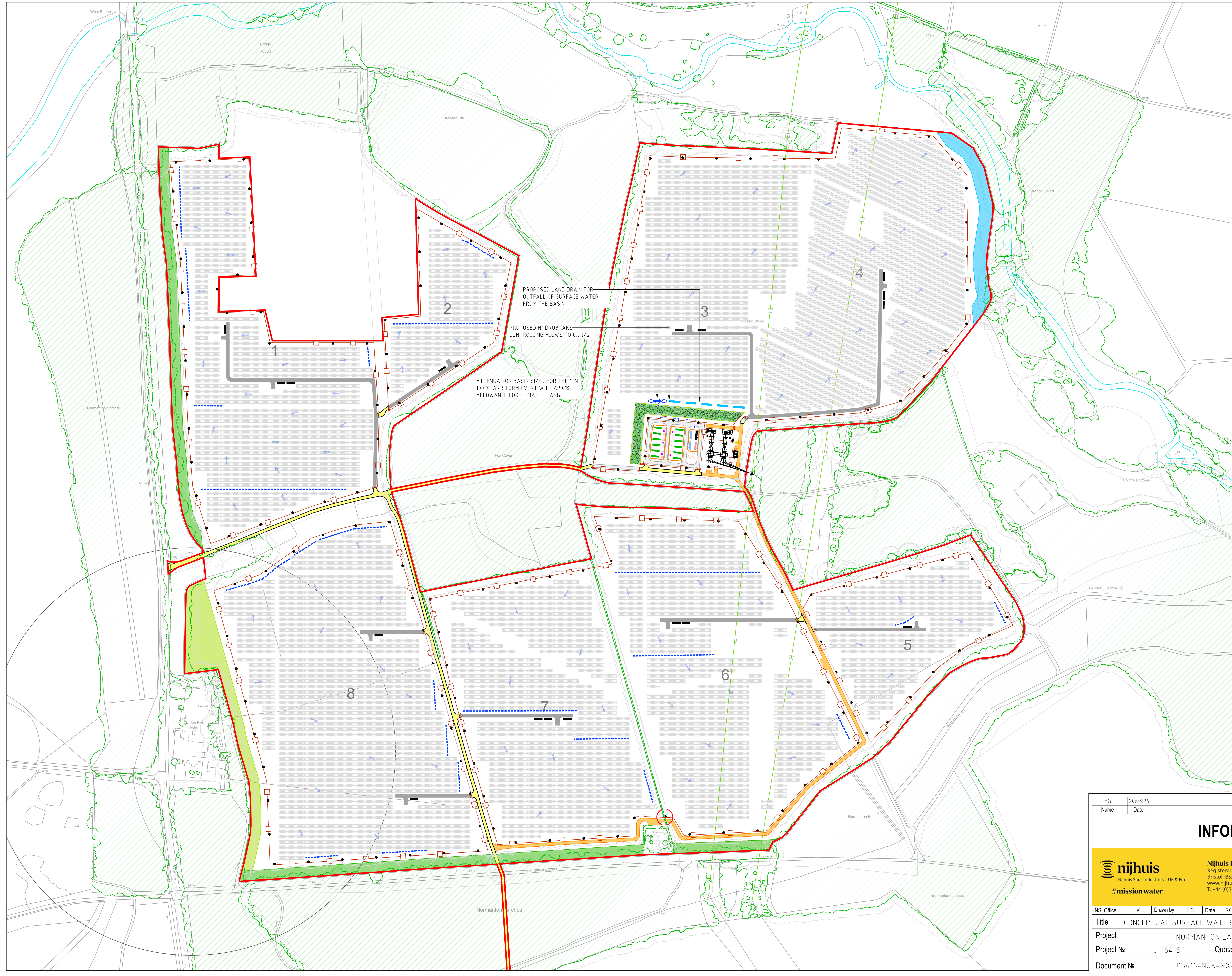
For the BESS element of the proposal, an attenuation basin has been outlined to capture, store and attenuate the surface water runoff to greenfield runoff rates.

If the recommendations made in this report are followed during the development of the site, the proposed development will deliver betterment by reducing the surface water discharge rate from the site and therefore flood risk will be minimised.

On the basis of this report and by reference to EA flood maps, it is concluded that the developed site area is located within Flood Zone 1 and, therefore, is not at any direct risk of flooding. The National Planning Policy Framework and associated Planning Practice Guidance states 'All uses of land are appropriate in this zone' from a flooding perspective. Consequently, with regard to flood risk, the proposed development is entirely appropriate in this area.

Provided the recommendations outlined in this report are adopted in the development proposal then there is the capacity to manage the surface water runoff from the development onsite without causing a detrimental risk to the groundwater beneath.

# APPENDIX A CONCEPTUAL SUDS LAYOUT

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### KEY

- PROPOSED SITE BOUNDARY
- PROPOSED SWALE
- BUND
- PROPOSED SURFACE WATER CONVEYANCE PIPE AND VALVE
- PROPOSED ATTENUATION BASIN
- HYDROBRAKE
- OVERLAND FLOW ARROW

| Name | Date | Remarks | Revision |
|---|---|---|---|
| HG | 20:03:24 | PRELIMINARY | P01 |

# INFORMATION


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part of saur mission water


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|---|---|---|---|
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| Checked by | HG |
| Release Date | 20:03:24 |
| Size | A1 |
| Sheet | 1 OF 1 |
| Scale | 1:2500 |
| Unit | M |

# APPENDIX B CALCULATIONS

## ICP SUDS Mean Annual Flood

Input

| | | | |
|---|---|---|---|
| Return Period (years) | 100 | Soil | 0.150 |
| Area (ha) | 88.720 | Urban | 0.000 |
| SAAR (mm) | 616 | Region Number | Region 4 |

| **Results** | **l/s** |
|---|---|
| QBAR Rural | 29.0 |
| QBAR Urban | 29.0 |
| Q100 years | 74.6 |
| Q1 year | 24.1 |
| Q30 years | 56.9 |
| Q100 years | 74.6 |

## ICP SUDS Mean Annual Flood

Input

| | | | |
|---|---|---|---|
| Return Period (years) | 100 | Soil | 0.150 |
| Area (ha) | 88.720 | Urban | 0.000 |
| SAAR (mm) | 924 | Region Number | Region 4 |

| **Results** | **l/s** |
|---|---|
| QBAR Rural | 46.7 |
| QBAR Urban | 46.7 |
| | |
| Q100 years | 120.0 |
| | |
| Q1 year | 38.7 |
| Q30 years | 91.5 |
| Q100 years | 120.0 |

| | | | |
|---|---|---|---|
| Volume of Runoff Calculations | | Site: | Land Adjacent to the A614, Worksop |
| Client: | One Planet Developments Ltd. | Date: | 25/03/2024 |
| | | | |
| Engineer: | Nijhuis Industries | | |
| Location: | Land Adjacent to the A614, Worksop | | |

| SITE INFORMATION | | |
|---|---|---|
| Pre-development total area | 887200 | m² |
| Pre-development permeable area | 887200 | m² |
| Pre-development impermeable area | 0 | m² |
| Post-development total area | 887200 | m² |
| Post-development permeable area | 886496 | m² |
| Post-development impermeable area | 704 | m² |

| RAINFALL EVENT INFORMATION | | |
|---|---|---|
| Return period | 100 | year |
| ICP-SUDS post-development runoff rate inclusive of 50% increase due to climate change (see attached | 120 | l/s |
| ICP-SUDS post-development runoff rate inclusive of 50% increase due to climate change (see attached | 120 | l/s |
| Duration of rainfall event | 6 | hours |
| Depth of Rainfall (calculated using Wallingford Procedure including 50% increase for climate change) | 118.17 | mm |

| RUNOFF CALCULATION | | |
|---|---|---|
| Pre-development permeable area runoff | 2592000 | litres |
| Pre-development impermeable area runoff | 0 | litres |
| **Total pre-development runoff** | **2592** | **m³** |
| Post-development permeable area runoff | 2592000 | litres |
| Post-development impermeable area runoff | 83191.7 | litres |
| **Total post-development runoff (without mitigation)** | **2675.2** | **m³** |
| **Difference in runoff** | **83.2** | **m³** |

## ICP SUDS Mean Annual Flood

Input

| | | | |
|---|---|---|---|
| Return Period (years) | 100 | Soil | 0.150 |
| Area (ha) | 0.060 | Urban | 0.000 |
| SAAR (mm) | 616 | Region Number | Region 4 |

| **Results** | **l/s** |
|---|---|
| QBAR Rural | 0.0 |
| QBAR Urban | 0.0 |
| | |
| Q100 years | 0.1 |
| | |
| Q1 year | 0.0 |
| Q30 years | 0.0 |
| Q100 years | 0.1 |

## Summary of Results for 100 year Return Period (+50%)

| Storm Event | Max Level (m) | Max Depth (m) | Max Control (l/s) | Max Overflow (l/s) | Max Σ Outflow (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|---|---|
| 15 min Summer | 99.436 | 0.436 | 0.6 | 0.0 | 0.6 | 15.0 | O K |
| 30 min Summer | 99.512 | 0.512 | 0.6 | 0.0 | 0.6 | 19.3 | O K |
| 60 min Summer | 99.575 | 0.575 | 0.6 | 0.0 | 0.6 | 23.5 | O K |
| 120 min Summer | 99.620 | 0.620 | 0.7 | 0.0 | 0.7 | 26.7 | O K |
| 180 min Summer | 99.634 | 0.634 | 0.7 | 0.0 | 0.7 | 27.8 | O K |
| 240 min Summer | 99.636 | 0.636 | 0.7 | 0.0 | 0.7 | 27.9 | O K |
| 360 min Summer | 99.626 | 0.626 | 0.7 | 0.0 | 0.7 | 27.2 | O K |
| 480 min Summer | 99.614 | 0.614 | 0.7 | 0.0 | 0.7 | 26.3 | O K |
| 600 min Summer | 99.603 | 0.603 | 0.7 | 0.0 | 0.7 | 25.4 | O K |
| 720 min Summer | 99.592 | 0.592 | 0.6 | 0.0 | 0.6 | 24.7 | O K |
| 960 min Summer | 99.571 | 0.571 | 0.6 | 0.0 | 0.6 | 23.2 | O K |
| 1440 min Summer | 99.530 | 0.530 | 0.6 | 0.0 | 0.6 | 20.5 | O K |
| 2160 min Summer | 99.469 | 0.469 | 0.6 | 0.0 | 0.6 | 16.8 | O K |
| 2880 min Summer | 99.406 | 0.406 | 0.6 | 0.0 | 0.6 | 13.4 | O K |
| 4320 min Summer | 99.255 | 0.255 | 0.6 | 0.0 | 0.6 | 6.8 | O K |
| 5760 min Summer | 99.153 | 0.153 | 0.6 | 0.0 | 0.6 | 3.5 | O K |
| 7200 min Summer | 99.096 | 0.096 | 0.6 | 0.0 | 0.6 | 2.0 | O K |
| 8640 min Summer | 99.068 | 0.068 | 0.5 | 0.0 | 0.5 | 1.4 | O K |
| 10080 min Summer | 99.058 | 0.058 | 0.5 | 0.0 | 0.5 | 1.1 | O K |
| 15 min Winter | 99.470 | 0.470 | 0.6 | 0.0 | 0.6 | 16.8 | O K |
| 30 min Winter | 99.550 | 0.550 | 0.6 | 0.0 | 0.6 | 21.8 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Overflow Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|---|
| 15 min Summer | 145.717 | 0.0 | 15.6 | 0.0 | 22 |
| 30 min Summer | 95.659 | 0.0 | 20.4 | 0.0 | 37 |
| 60 min Summer | 59.825 | 0.0 | 25.6 | 0.0 | 66 |
| 120 min Summer | 36.152 | 0.0 | 30.9 | 0.0 | 124 |
| 180 min Summer | 26.569 | 0.0 | 34.1 | 0.0 | 182 |
| 240 min Summer | 21.228 | 0.0 | 36.3 | 0.0 | 242 |
| 360 min Summer | 15.410 | 0.0 | 39.5 | 0.0 | 334 |
| 480 min Summer | 12.280 | 0.0 | 42.0 | 0.0 | 390 |
| 600 min Summer | 10.289 | 0.0 | 44.0 | 0.0 | 452 |
| 720 min Summer | 8.901 | 0.0 | 45.7 | 0.0 | 518 |
| 960 min Summer | 7.075 | 0.0 | 48.4 | 0.0 | 656 |
| 1440 min Summer | 5.113 | 0.0 | 52.4 | 0.0 | 928 |
| 2160 min Summer | 3.688 | 0.0 | 56.7 | 0.0 | 1340 |
| 2880 min Summer | 2.922 | 0.0 | 60.0 | 0.0 | 1732 |
| 4320 min Summer | 2.102 | 0.0 | 64.7 | 0.0 | 2384 |
| 5760 min Summer | 1.662 | 0.0 | 68.2 | 0.0 | 3056 |
| 7200 min Summer | 1.385 | 0.0 | 71.0 | 0.0 | 3680 |
| 8640 min Summer | 1.193 | 0.0 | 73.4 | 0.0 | 4408 |
| 10080 min Summer | 1.051 | 0.0 | 75.5 | 0.0 | 5136 |
| 15 min Winter | 145.717 | 0.0 | 17.4 | 0.0 | 22 |
| 30 min Winter | 95.659 | 0.0 | 22.9 | 0.0 | 36 |

## Summary of Results for 100 year Return Period (+50%)

| Storm Event | Max Level (m) | Max Depth (m) | Max Control (l/s) | Max Overflow (l/s) | Max Σ Outflow (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|---|---|
| 60 min Winter | 99.617 | 0.617 | 0.7 | 0.0 | 0.7 | 26.5 | O K |
| 120 min Winter | 99.668 | 0.668 | 0.7 | 0.0 | 0.7 | 30.4 | O K |
| 180 min Winter | 99.686 | 0.686 | 0.7 | 0.0 | 0.7 | 31.9 | O K |
| 240 min Winter | 99.691 | 0.691 | 0.7 | 0.0 | 0.7 | 32.3 | O K |
| 360 min Winter | 99.686 | 0.686 | 0.7 | 0.0 | 0.7 | 31.9 | O K |
| 480 min Winter | 99.673 | 0.673 | 0.7 | 0.0 | 0.7 | 30.8 | O K |
| 600 min Winter | 99.659 | 0.659 | 0.7 | 0.0 | 0.7 | 29.7 | O K |
| 720 min Winter | 99.646 | 0.646 | 0.7 | 0.0 | 0.7 | 28.7 | O K |
| 960 min Winter | 99.620 | 0.620 | 0.7 | 0.0 | 0.7 | 26.7 | O K |
| 1440 min Winter | 99.563 | 0.563 | 0.6 | 0.0 | 0.6 | 22.7 | O K |
| 2160 min Winter | 99.474 | 0.474 | 0.6 | 0.0 | 0.6 | 17.1 | O K |
| 2880 min Winter | 99.366 | 0.366 | 0.6 | 0.0 | 0.6 | 11.5 | O K |
| 4320 min Winter | 99.149 | 0.149 | 0.6 | 0.0 | 0.6 | 3.4 | O K |
| 5760 min Winter | 99.070 | 0.070 | 0.6 | 0.0 | 0.6 | 1.4 | O K |
| 7200 min Winter | 99.054 | 0.054 | 0.5 | 0.0 | 0.5 | 1.1 | O K |
| 8640 min Winter | 99.046 | 0.046 | 0.4 | 0.0 | 0.4 | 0.9 | O K |
| 10080 min Winter | 99.040 | 0.040 | 0.4 | 0.0 | 0.4 | 0.8 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Overflow Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|---|
| 60 min Winter | 59.825 | 0.0 | 28.6 | 0.0 | 64 |
| 120 min Winter | 36.152 | 0.0 | 34.6 | 0.0 | 122 |
| 180 min Winter | 26.569 | 0.0 | 38.2 | 0.0 | 180 |
| 240 min Winter | 21.228 | 0.0 | 40.6 | 0.0 | 236 |
| 360 min Winter | 15.410 | 0.0 | 44.3 | 0.0 | 346 |
| 480 min Winter | 12.280 | 0.0 | 47.0 | 0.0 | 446 |
| 600 min Winter | 10.289 | 0.0 | 49.3 | 0.0 | 478 |
| 720 min Winter | 8.901 | 0.0 | 51.1 | 0.0 | 554 |
| 960 min Winter | 7.075 | 0.0 | 54.2 | 0.0 | 708 |
| 1440 min Winter | 5.113 | 0.0 | 58.7 | 0.0 | 1010 |
| 2160 min Winter | 3.688 | 0.0 | 63.6 | 0.0 | 1444 |
| 2880 min Winter | 2.922 | 0.0 | 67.2 | 0.0 | 1852 |
| 4320 min Winter | 2.102 | 0.0 | 72.5 | 0.0 | 2384 |
| 5760 min Winter | 1.662 | 0.0 | 76.4 | 0.0 | 2992 |
| 7200 min Winter | 1.385 | 0.0 | 79.6 | 0.0 | 3672 |
| 8640 min Winter | 1.193 | 0.0 | 82.2 | 0.0 | 4408 |
| 10080 min Winter | 1.051 | 0.0 | 84.5 | 0.0 | 5136 |

## Rainfall Details

| | | | |
|---|---|---|---|
| Rainfall Model | FSR | Winter Storms | Yes |
| Return Period (years) | 100 | Cv (Summer) | 0.750 |
| Region | England and Wales | Cv (Winter) | 0.840 |
| M5-60 (mm) | 19.700 | Shortest Storm (mins) | 15 |
| Ratio R | 0.401 | Longest Storm (mins) | 10080 |
| Summer Storms | Yes | Climate Change % | +50 |

## Time Area Diagram

Total Area (ha) 0.057

| **Time From:** | **(mins) To:** | **Area (ha)** | **Time From:** | **(mins) To:** | **Area (ha)** |
|---|---|---|---|---|---|
| 0 | 4 | 0.028 | 4 | 8 | 0.029 |

## Model Details

Storage is Online Cover Level (m) 100.000

## Tank or Pond Structure

Invert Level (m) 99.000

| Depth (m) | Area (m²) | Depth (m) | Area (m²) | Depth (m) | Area (m²) |
|---|---|---|---|---|---|
| 0.000 | 18.0 | 1.000 | 128.4 | 1.001 | 128.6 |

## Hydro-Brake® Optimum Outflow Control

| | |
|---|---|
| Unit Reference | MD-SHE-0042-7000-0700-7000 |
| Design Head (m) | 0.700 |
| Design Flow (l/s) | 0.7 |
| Flush-Flo™ | Calculated |
| Objective | Minimise upstream storage |
| Application | Surface |
| Sump Available | Yes |
| Diameter (mm) | 42 |
| Invert Level (m) | 99.000 |
| Minimum Outlet Pipe Diameter (mm) | 75 |
| Suggested Manhole Diameter (mm) | 1200 |

| Control Points | Head (m) | Flow (l/s) | Control Points | Head (m) | Flow (l/s) |
|---|---|---|---|---|---|
| Design Point (Calculated) | 0.700 | 0.7 | Kick-Flo® | 0.373 | 0.5 |
| Flush-Flo™ | 0.185 | 0.6 | Mean Flow over Head Range | - | 0.6 |

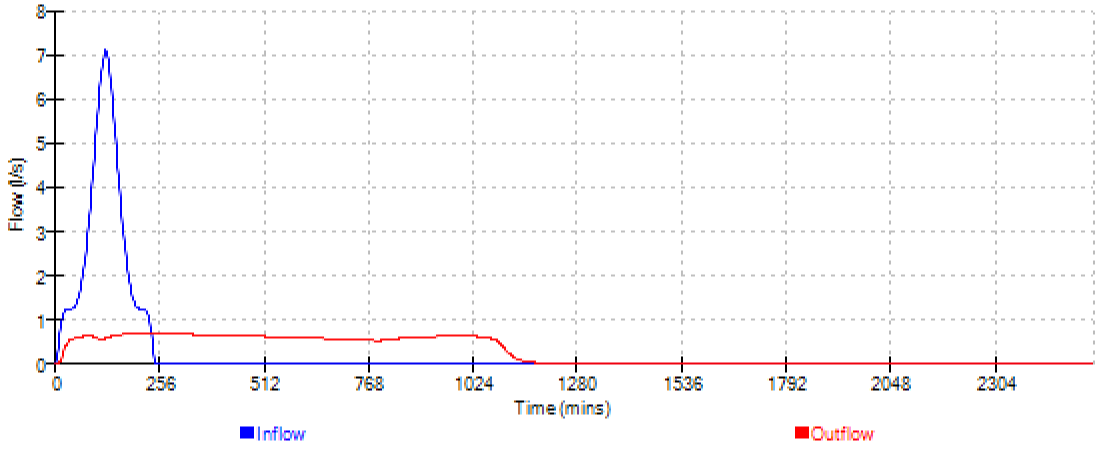
The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

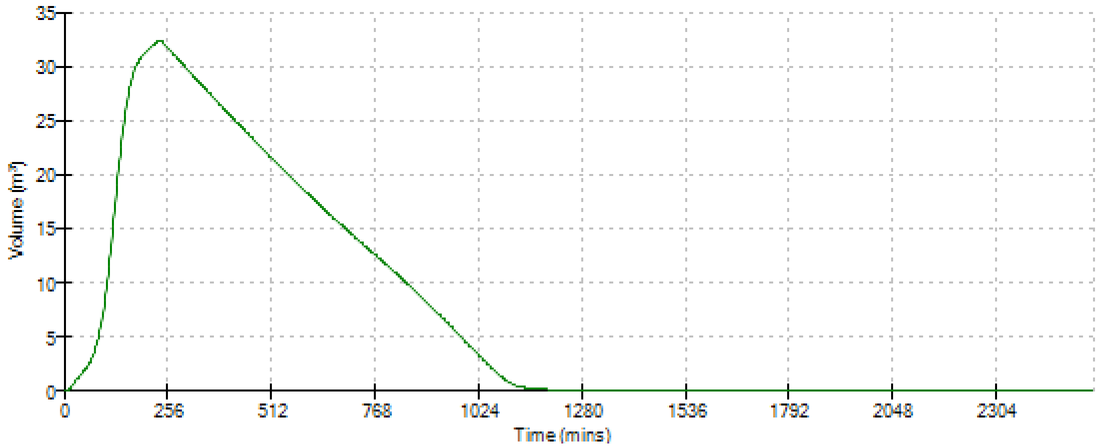
| Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) | Depth (m) | Flow (l/s) |
|---|---|---|---|---|---|---|---|
| 0.100 | 0.6 | 1.200 | 0.9 | 3.000 | 1.3 | 7.000 | 2.0 |
| 0.200 | 0.6 | 1.400 | 0.9 | 3.500 | 1.4 | 7.500 | 2.0 |
| 0.300 | 0.6 | 1.600 | 1.0 | 4.000 | 1.5 | 8.000 | 2.1 |
| 0.400 | 0.5 | 1.800 | 1.1 | 4.500 | 1.6 | 8.500 | 2.2 |
| 0.500 | 0.6 | 2.000 | 1.1 | 5.000 | 1.7 | 9.000 | 2.2 |
| 0.600 | 0.7 | 2.200 | 1.2 | 5.500 | 1.8 | 9.500 | 2.3 |
| 0.800 | 0.7 | 2.400 | 1.2 | 6.000 | 1.8 | | |
| 1.000 | 0.8 | 2.600 | 1.3 | 6.500 | 1.9 | | |

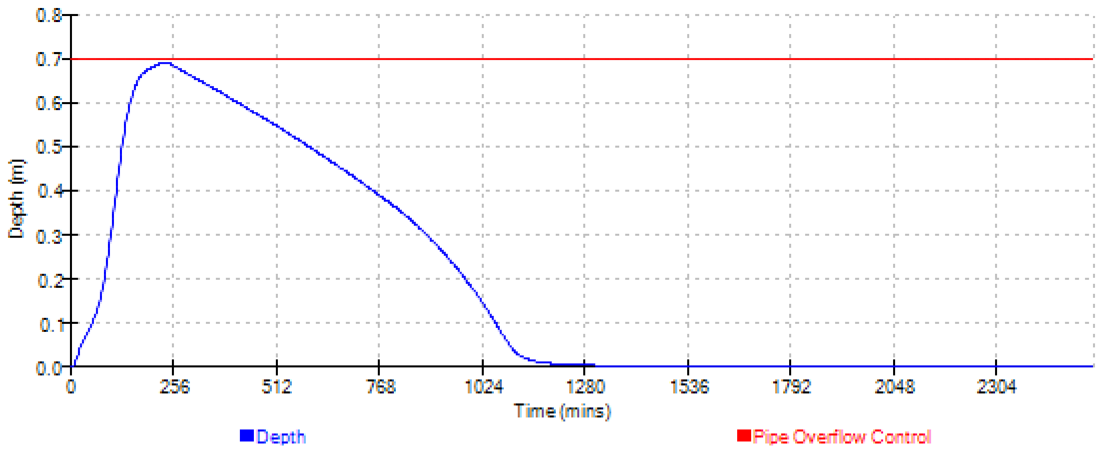
## Pipe Overflow Control

| | | | |
|---|---|---|---|
| Diameter (m) | 0.100 | Entry Loss Coefficient | 0.500 |
| Slope (1:X) | 10.0 | Coefficient of Contraction | 0.600 |
| Length (m) | 10.000 | Upstream Invert Level (m) | 99.700 |
| Roughness k (mm) | 0.600 | | |

## Event: 240 min Winter



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