

Drainage Strategy Report

Mulberry Lodge Development at

73-77 Park Street, Wombwell, Barnsley



For

CAS Behavioural Health

September 2017

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15682-H-RP-001 R2



Scope

This report has been commissioned by CAS Behavioural Health to assess the potential drainage proposals for the development at Park Street, Wombwell, Barnsley.

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Report Ref:	15682-H-RP-001 R2	
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Checked by:	Gavin Shepherd	

Revision	Comments	Date
R1	Initial Issue.	
R2	Updated appendix IV – Schematic Drainage Layout.	29.09.2017

Notation

DIA	Drainage Impact Assessment
EA	Environment Agency
FRA	Flood Risk Assessment
IDB	Internal Drainage Board
LLFA	Lead Local Flood Authority
NPPF	National Planning Policy Framework
NPPG	National Planning Practice Guidance
SFRA	Strategic Flood Risk Assessment
SuDS	Sustainable Drainage Systems

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Appendix II	Impermeable Areas Plan
Appendix III	Microdrainage Storage Calculations
Appendix IV	Schematic Drainage Layout

1. Introduction

1.1 Background

Mason Clark Associates has been commissioned by CAS Behavioural Health to undertake a Strategy Report for a development at Park Street, Wombwell in Barnsley.

This drainage assessment is carried out in accordance with the requirements of the National Planning Policy Guidance (NPPG), Environment Agency Guidance Note 3 and part H of the Building Regulations.

The objective of the assessment is to demonstrate that a drainage solution exists for the site, not to produce a technical design.

1.2 Existing Site

The current site consists of a vacant plot, bounded by dwellings on either side with Park Street to the south-west and a disused canal/watercourse to the north-east. The canal forms part of the Dearne and Dove Canal, which is currently derelict and is not navigable. There are plans by the Barnsley, Dearne and Dove Canals Trust to attempt to restore this canal and the Barnsley Canal in order to allow for navigation between the Sheffield and South Yorkshire Navigation and the Aire and Calder navigation, however no formal plans or timescales are currently known.

While there may have been some development on the land in the past, the plot has not been developed for a number of years, and is therefore considered to be greenfield for the purpose of this report.

1.3 Proposed Development

The current proposal for the site consists of the construction of a new, 10 bedroom care facility for CAS Behavioural Health. A separate block on the northern side of the site will house offices and IT facilities for the development.

Layout plans can be found in Appendix I of this report.

1.4 Topography, Hydrology and Geology

Topographical levels at the site are unknown, however it can be observed that site levels fall at a moderate gradient towards the watercourse to the north. The site also features a noticeable step down from the main road, which indicates that the site has not had any form of vehicle or pedestrian access in recent years.

Data from the BGS suggests that the bedrock beneath the site consists of Sandstone from the Oaks Rock Formation. There are no recorded superficial geological deposits at the site. A nearby borehole record (ref: SE40SW229), indicates topsoil down to a depth of 0.15m bgl, followed by clayey sand down to 0.6m bgl, followed by very sandy clay to 0.85m bgl, below which lies the sandstone bedrock.

It should be noted that the above borehole lies approximately 500m away from the site, and should therefore be taken as indicative of the soils within the wider area rather than a complete record of soils present at the site.

As of the writing of this report, ground investigation works are currently being carried out and would therefore give a more accurate indication of the ground conditions present at the site.

2. Flood Risk

According to Flood Risk maps provided by the Environment Agency the site is located in flood zone 1, which is land designated as having less than a 1 in 1,000 annual probability of river or sea flooding. However there may still be a risk from other sources of flooding at the site, such as surface water and groundwater, which are not considered within the flood zone designations.

In order to fully assess the risk of flooding to the proposed development, a separate Flood Risk Assessment should be carried out in accordance with available guidance from the EA/planning authority.

3. Existing Drainage

As the site is undeveloped, there is no existing private drainage within the boundary. There is however an existing Yorkshire Water sewer which flows south to north through the site and across the disused canal.

4 Surface Water Drainage Proposals

Section H3 of the Building Regulations 2010 states that the hierarchy for surface water disposal should be considered, where priority is given to; 1. Infiltration systems, 2. Watercourses and as a last resort 3. The public sewer.

The total area of the site is approximately 2865m². The impermeable areas added to the land as a result of the development come from 3 main sources – the new car park/access, the main building and the separate O.T block to the north. External paved areas are to use a permeable paving system to reduce runoff. The total impermeable area added by the development is therefore 1003.2m²

A plan of the impermeable areas can be found in Appendix II.

4.1 Sustainable Drainage Systems

Sustainable drainage Overview

Drainage systems can contribute to sustainable development and improve urban design, by balancing the different issues that influence the development of communities. Approaches to manage surface water that take account of water quantity (flooding), water quality (pollution) and amenity issues are collectively referred to as Sustainable Drainage Systems (SuDS).

SuDS mimic nature and typically manage rainfall close to where it falls. SuDS can be designed to slow water down (attenuate) before it enters streams, rivers and other watercourses, they provide areas to store water in natural contours and can be used to allow water to soak (infiltrate) into the ground or evaporated from surface water and lost or transpired from vegetation (known as evapotranspiration).

SUDS are technically regarded a sequence of management practices, control structures and strategies designed to efficiently and sustainably drain surface water, while minimising pollution and managing the impact on water quality of local water bodies.

SuDS are more sustainable than traditional drainage methods because they:

- Manage runoff volumes and flow rates from hard surfaces, reducing the impact of urbanisation on flooding

- Protect or enhance water quality (reducing pollution from runoff)
- Protect natural flow regimes in watercourses
- Are sympathetic to the environment and the needs of the local community
- Provide an attractive habitat for wildlife in urban watercourses
- Provide opportunities for evapotranspiration from vegetation and surface water
- Encourage natural groundwater/aquifer recharge (where appropriate)
- Create better places to live, work and play.

SuDS principles

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

- Storing runoff and releasing it slowly (attenuation)
- Allowing water to soak into the ground (infiltration)
- Slowly transporting (conveying) water on the surface
- Filtering out pollutants
- Allowing sediments to settle out by controlling the flow of the water

The above was taken from www.susdrain.org

4.2 Drainage Via Infiltration

The BGS/borehole records as described in section 1.4 do not give a clear indication of whether infiltration methods of disposal may be suitable for the site. Sandy soils are generally well suited to infiltration, while clay soils are generally taken as impermeable. Soils at the site may be more/less sand/clayey, depending on local variations in the ground conditions.

The suitability of the site towards infiltration methods of disposal will be confirmed by percolation testing which is currently being carried out as of the issue of this report. The size of a potential soakaway could then be calculated based on an infiltration rate derived from the test results.

4.3 Drainage to Watercourse

The disused canal to the northern boundary of the site would in theory provide an ideal outlet for surface water, however it is currently derelict and therefore cannot be used to discharge surface water. The canal forms part of the Dearne and Dove Canal, and is part of the group of canals which are proposed to be reopened by Inland Waterways and the Canal and River Trust. As of the issue of this report, the case for the reopening of the canal is still being made, and no formal plans are yet in place.

4.4 Drainage to Public Sewer

If percolation testing shows the site to be unsuitable for the discharge of surface water, then surface water should be discharged to the public sewer. Discharge from the site should be restricted to a rate as close to greenfield runoff as possible. Based on a site area of 2865m², and assuming a greenfield runoff rate of 1.4 l/s/ha, this gives an estimated runoff rate of 0.4 l/s. As this would result in extremely low flow rates with a small flow control device potentially susceptible to blockages, it is instead recommended to increase the flow restriction to a rate of 5 l/s. This rate is to be agreed by Yorkshire Water.

4.5 Attenuation Requirements

In order to ensure that flood risk in the surrounding area is not increased as a result of the development it is required to store surface water runoff on site up to and including the 1 in 100 year event, plus a factor of 30% to account for an increase in rainfall intensity as a result of climate change.

General practice for Local Authorities states that surface water up to the 1 in 30 year event plus 30% for climate change is to be stored below ground/within dedicated attenuation systems, such as geocellular crates or a retention basin. Additional surface water from the 1 in 100 year event plus 30% can be stored above ground in areas of hardstanding, where site levels are designed to retain water in low risk areas such as car parks, and the drainage system is designed as to allow for surcharging during this event.

The feasibility of storing surface water above ground via design of site levels should be determined at the detailed design stage. Otherwise, attenuation should be sized as to store all runoff up to and including the 1 in 100 year event, plus 30% for climate change.

Assuming that surface water is discharged to the public sewer at a restricted rate of 5 l/s, estimated storage volumes are given in table1 below. Geocellular storage crates have been used to model the attenuation.

Table 1: Storage Estimations

	1 in 30 year event (m³)	1 in 100 year event (m³)
Current Year	12.1	19.1
Plus 30% Climate Change	18.8	28.2

Due to the relatively low volumes given above, and the rapid change in levels across the site, it is recommended that all surface water is stored below ground for up to the 1 in 100 year event plus 30%. Full storage calculations should be carried out at the detailed design stage.

Microdrainage storage calculations can be found in Appendix III. A schematic drainage layout can be found in Appendix IV.

4.6 Maintenance Requirements

The maintenance regime for the site will depend on the extents of the adoptable drainage system and the method of surface water attenuation. Yorkshire Water will generally adopt the following systems:

- Underground concrete structures including the following:
 - Oversized Pipes
 - Box Culverts
 - Carlow tanks
- Above ground *offline* storage structures including the following:
 - Detention basins

- Swales

Once detailed proposals are available consultation should be opened with Yorkshire Water with a view towards establishing what systems will be accepted for adoption. Other systems, such as geocellular storage crates and soakaways will not be considered for adoption, and maintenance would be privately managed.

An indicative maintenance regime for geocellular crates can be found in table 2 below:

Table 2: Maintenance Schedule for Geocellular Storage Crates

Schedule	Required Action	Frequency
Regular Maintenance	Inspect and identify any areas that are not operating correctly. If required, take remedial action.	Months for 3 months, then annually
	Remove sediment from pre-treatment structures and/or internal forbays.	Annually, or as required
Remedial Action	Repair/rehabilitate inlets, outlets and vents	Annually, or as required
Monitoring	Inspect/check all inlets, outlets and vents	Annually
	Survey inside of tank for sediment build-up and remove if necessary	Every 5 years, or as required.

5. Foul Water Drainage Proposals

It is recommended that all foul water is discharged via gravity to the public sewer, which is located within the site boundary. Outlets from kitchen areas should be fitted with a grease trap, as to prevent grease and fats from kitchen waste from entering the public sewer system.

A schematic drainage layout can be found in Appendix IV.

6. Conclusions

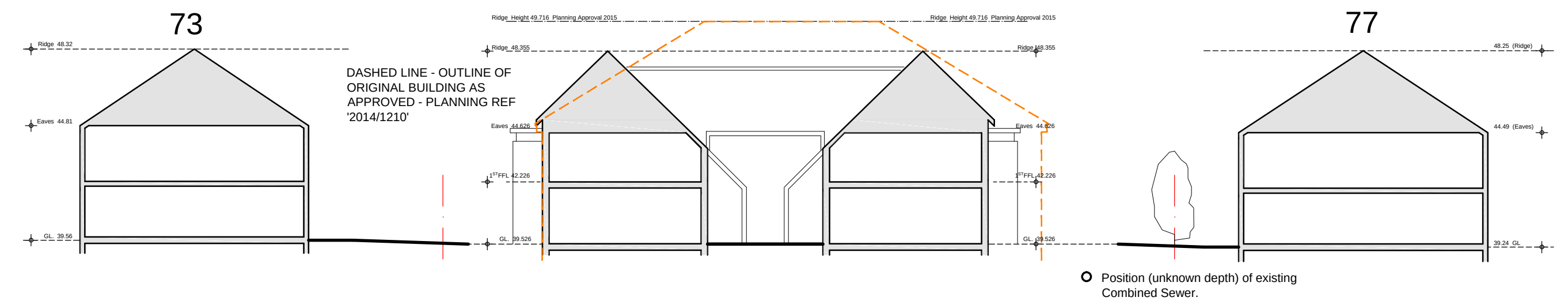
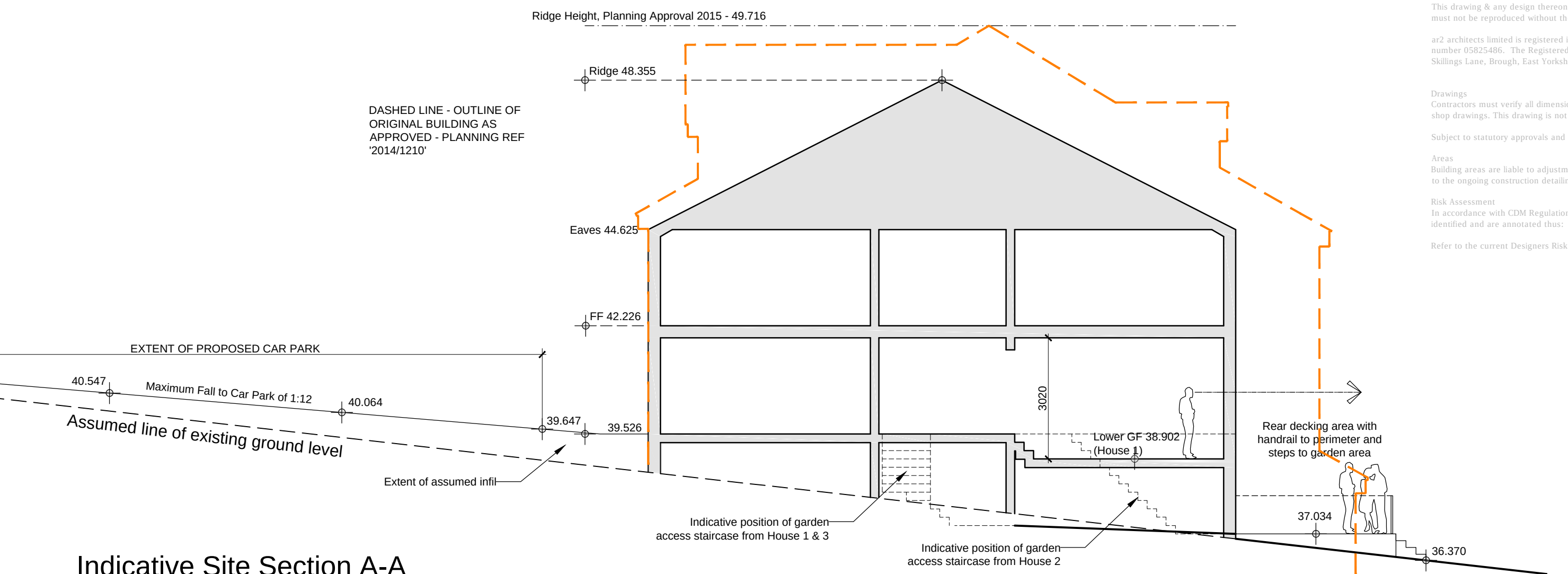
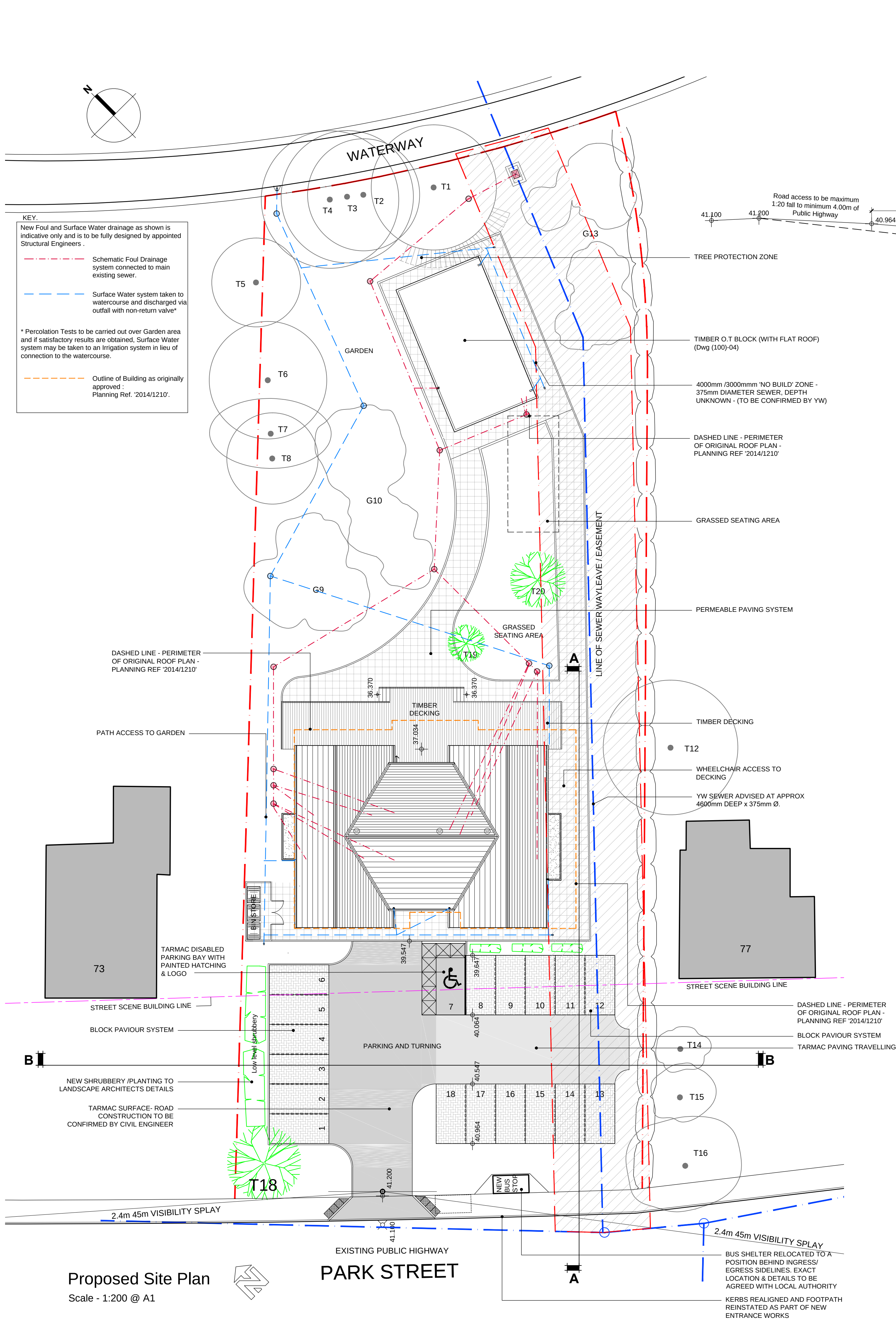
- The existing site is considered to be undeveloped, and is subject to greenfield runoff rates.
- The total area of the site is 2865 m². The proposed impermeable areas of the site total 1003m².
- No private drainage is believed to exist at the current site, however a Yorkshire Water sewer passes through the site in a north-south direction.
- Ground conditions as indicated by BGS data and borehole records indicate that infiltration methods of surface water disposal may be suitable, but must be confirmed by on-site tests.
- Percolation testing is currently being carried out at the site, and will determine whether discharge via infiltration can be carried out at the site. If test results show the site to be amenable towards infiltration, a required soakaway size can be determined from the test results.
- Otherwise, surface water should be discharged to the public sewer, at a restricted rate of 5 l/s. This figure is to be agreed by Yorkshire Water.
- The watercourse to the north is a disused canal, and is therefore not considered to be suitable for the discharge of surface water. While plans to restore the watercourse are being discussed, no formal plans are currently in place.
- The required storage volume for the 1 in 100 year event plus 30% climate change is 28.2m³.
- It is recommended to store all surface water from the above event underground within a dedicated storage medium such as geocellular storage crates or oversized pipes.
- The maintenance regime for the attenuation system will depend upon the type of system specified and whether the storage is offered up for adoption to Yorkshire Water. Once more details are available consultation should be opened up with Yorkshire Water with a view towards their requirements for adopting the attenuation system. Otherwise, maintenance would be privately managed by the client, or a third party on the client's behalf.
- Foul water should be discharged via gravity to the adjacent public sewer. All outlets from kitchen/food preparation areas should be fitted with a grease trap.

7. References

- National Planning Policy Framework - <https://www.gov.uk/government/publications/national-planning-policy-framework--2>
- UK Building Regulations – Approved Documents - <http://www.planningportal.gov.uk/buildingregulations/approveddocuments/>
- Climate Change Allowances for Planners - https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/296964/LIT_8496_5306da.pdf

Appendix I

Site Layout Plans



LANNING

ar² architects ltd

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Project	Job Number	AR229-1
MULBERRY LODGE, 10 BEDROOM CARE FACILITY, LAND BETWEEN 73 & 77, PARK STREET, WOMBWELL.		

Client
CAS BEHAVIOURAL HEALTH

Drawing Title	Drawing Size A
.....	

Drawn MCW	Date 07.07.2017	Scale 1:100 & 200	Cadfile -
Reviewed by RRB	Drawing No. (100)-03		Rev. P1

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Drawings:
Contractors must verify all dimensions on site before commencing any work or shop drawings. This drawing is not to be scaled. Use figured dimensions only.

Subject to statutory approvals and survey.

Areas:
Building areas are liable to adjustment over the course of the design process due to the ongoing construction detailing developments.

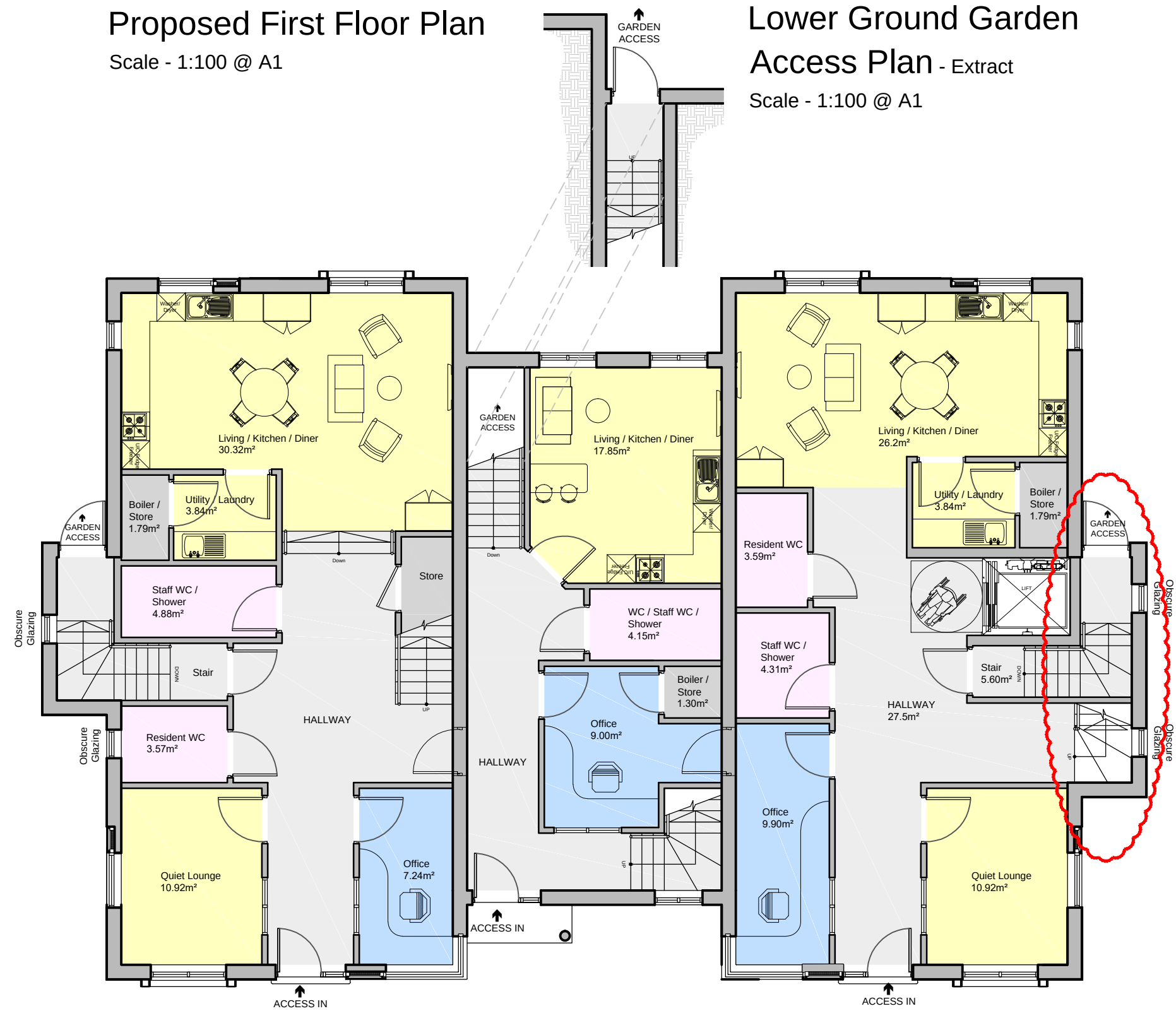
Risk Assessment:
In accordance with CDM Regulation 7, 11 & 15, significant hazards have been identified and are annotated thus:

Refer to the current Designers Risk Information Schedule for further details.

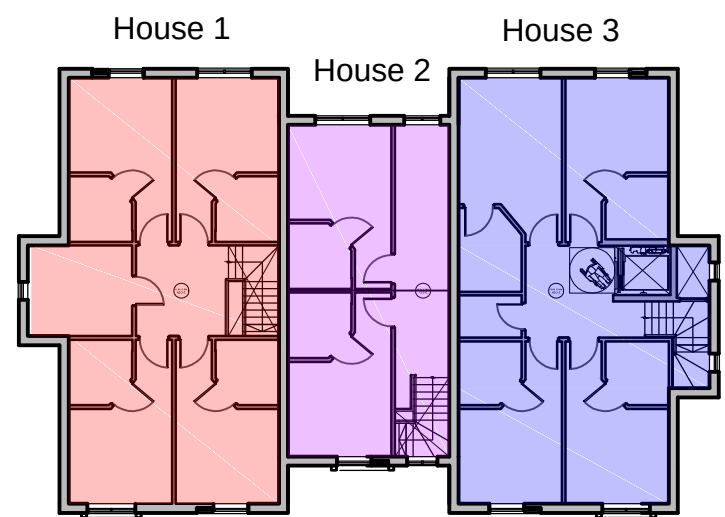


Proposed First Floor Plan
Scale - 1:100 @ A1

Lower Ground Garden
Access Plan - Extract
Scale - 1:100 @ A1



Proposed Ground Floor Plan
Scale - 1:100 @ A1



Key Plan - First Floor



Key Plan - Ground Floor

Gross internal floor area:	547m ²
Total bedrooms:	10
Ground Floor GIA:	273.5m ²
First Floor GIA:	273.5m ²
House 1 Bedroom Number:	4
GIA:	208m ²
House 2 Bedroom Number:	2
GIA:	117m ²
House 3 Bedroom Number:	4
GIA:	211m ²
Cabin GIA:	79.5m ²

Lower Ground Floor GIA and layout
to be agreed

KEY:

- Bedroom
- Bathroom
- Social Activity Space
- Staff Facilities
- Circulation
- Storage
- Activity Suite

revisions

PLANNING



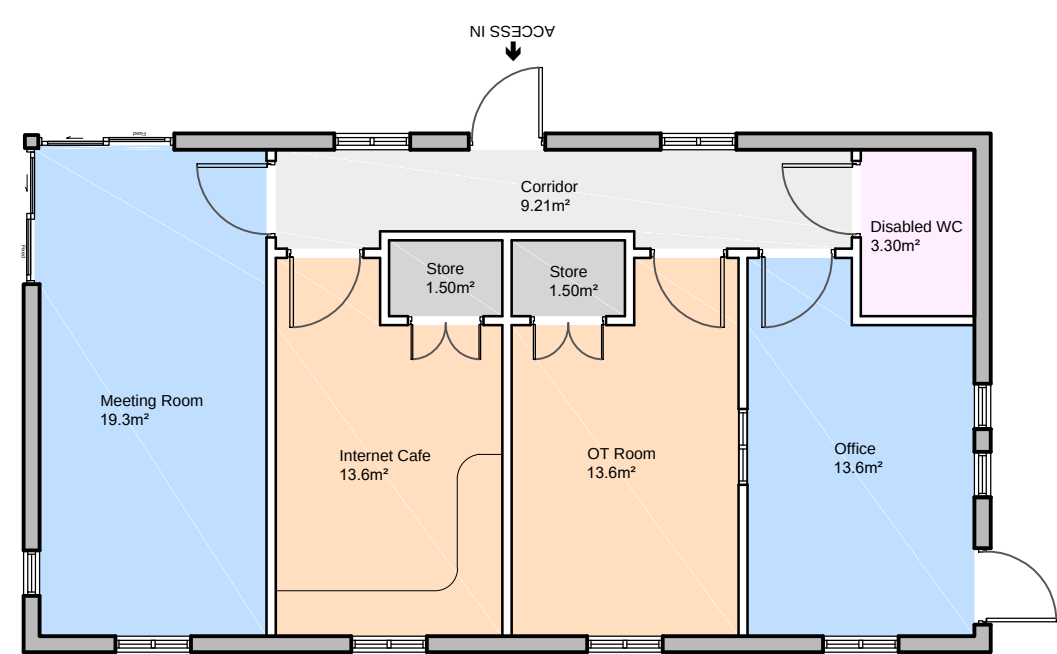
Project: MULBERRY LODGE, 10 BEDROOM CARE FACILITY
LAND BETWEEN 73 & 77, PARK STREET,
WOMBWELL.

Client:
CAS BEHAVIOURAL HEALTH

Drawing Title: PROPOSED
GROUND FLOOR & FIRST FLOOR PLANS
Drawing Size: A1

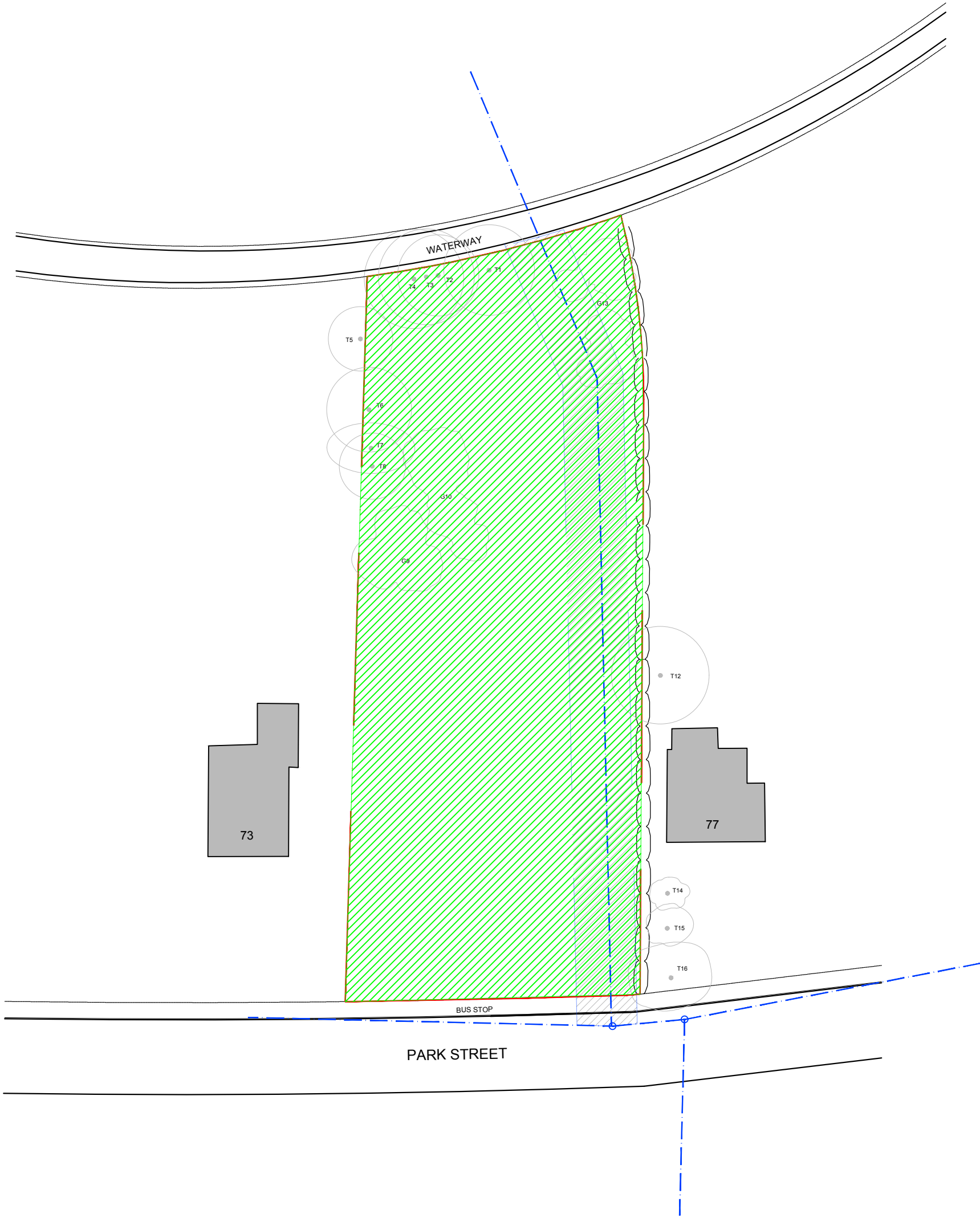
Drawn: GH	Date: 10.08.2017	Scale: 1:100	Cadfile: -
Reviewed by: RRB	Drawing No: (100)-01	Rev: P1	

Proposed O.T. Block Floor Plan
Scale - 1:100 @ A1

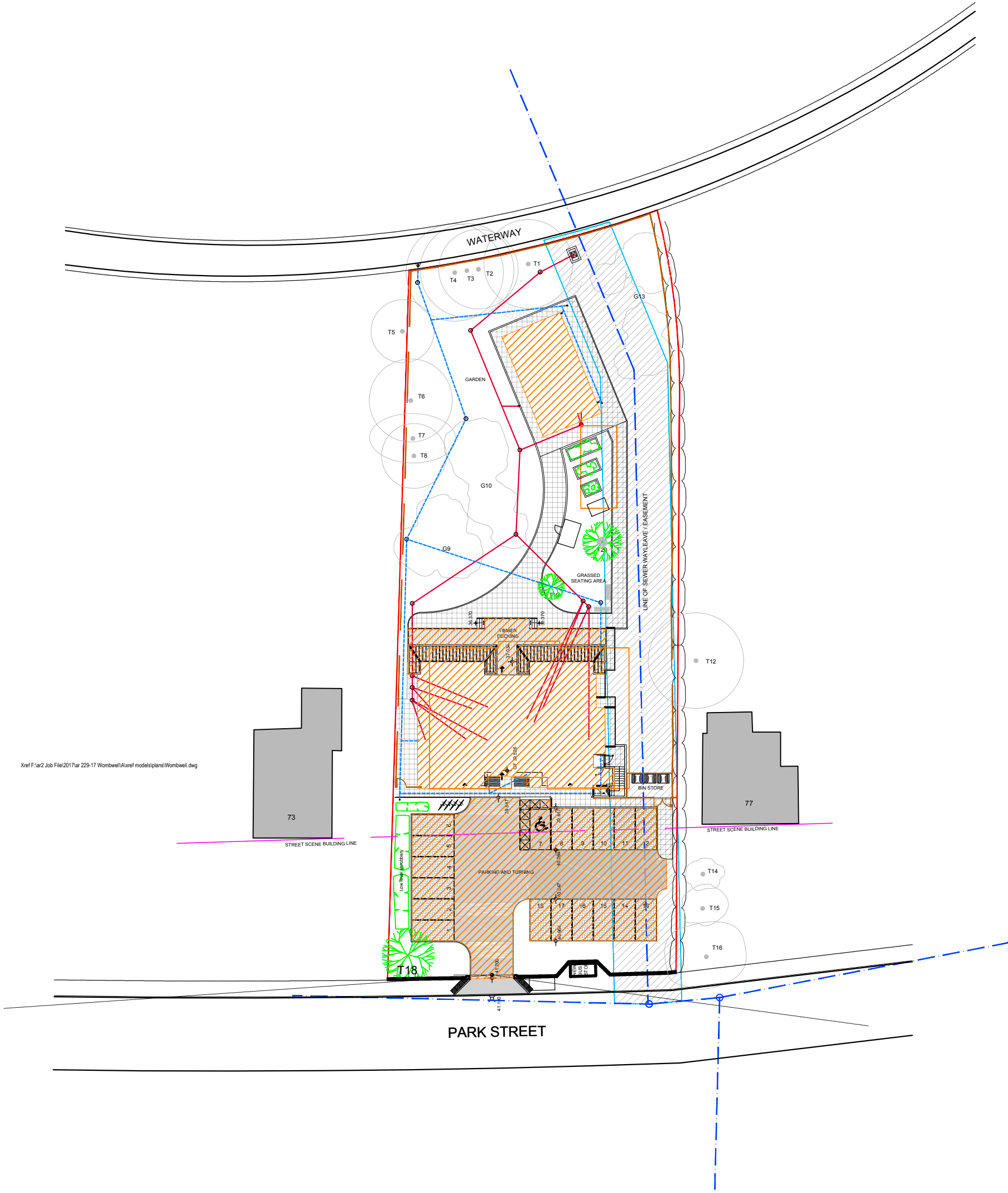


Appendix II

Impermeable Areas Plan



Existing Site
Scale 1:500



Proposed Site
Scale 1:500

Notes

1. This drawing is subject to copyright and must not be reproduced, stored or transmitted in any form without prior permission from Mason Clark Associates.
2. This drawing is not to be scaled. All dimensions are to be checked on site by the contractor. Any discrepancies are to be notified to Mason Clark Associates. Obtain instructions prior to works commencing.
3. This drawing is to be read in conjunction with the relevant contract drawings and documents, including the NBS specification.
4. All dimensions are in millimetres and all levels are in metres AOD unless noted otherwise.
5. All work shall be carried out in accordance with Local Authority, Statutory Authority and Health & Safety Regulations.

Key

- Site Area = 2865m²
- Proposed impermeable Areas:
 - Car park/access road = 482.5m²
 - Main Building = 425m²
 - O.T Block = 95.7m²
 - Total = 1003.2m²

Rev	Details	By	Date
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CAS Behavioural Health			
Project:			
Mulberry Lodge			
Title:			
Impermeable Areas			
Drawn: AP		Checked:	Date: Sept 2017
Scale @ A1:		As Shown	
Drawing No: 15682-H-DR-201		Rev:	P1

Appendix III

Microdrainage Storage Calculations

Mason Clark Associates							Page 2
Church House 44 Newland Park Hull HU5 2DW			CAS Mulberry Lodge SW Attenuation (5 l/s) 1 in 30 year				
Date Sept 2017 File 1 in 30 year.srcx			Designed by AP Checked by				
XP Solutions			Source Control 2015.1				
<u>Summary of Results for 30 year Return Period</u>							
Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	99.395	0.795	0.0	5.0	5.0	12.1	O K
60 min Winter	99.399	0.799	0.0	5.0	5.0	12.1	O K
120 min Winter	99.258	0.658	0.0	5.0	5.0	10.0	O K
180 min Winter	99.047	0.447	0.0	5.0	5.0	6.8	O K
240 min Winter	98.875	0.275	0.0	5.0	5.0	4.2	O K
360 min Winter	98.726	0.126	0.0	4.7	4.7	1.9	O K
480 min Winter	98.702	0.102	0.0	3.8	3.8	1.6	O K
600 min Winter	98.689	0.089	0.0	3.3	3.3	1.4	O K
720 min Winter	98.681	0.081	0.0	2.9	2.9	1.2	O K
960 min Winter	98.671	0.071	0.0	2.3	2.3	1.1	O K
1440 min Winter	98.659	0.059	0.0	1.7	1.7	0.9	O K
2160 min Winter	98.649	0.049	0.0	1.2	1.2	0.7	O K
2880 min Winter	98.644	0.044	0.0	1.0	1.0	0.7	O K
4320 min Winter	98.637	0.037	0.0	0.7	0.7	0.6	O K
5760 min Winter	98.633	0.033	0.0	0.6	0.6	0.5	O K
7200 min Winter	98.630	0.030	0.0	0.5	0.5	0.5	O K
8640 min Winter	98.628	0.028	0.0	0.4	0.4	0.4	O K
10080 min Winter	98.626	0.026	0.0	0.4	0.4	0.4	O K
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)			
30 min Winter	45.828	0.0	19.2	32			
60 min Winter	29.238	0.0	24.6	50			
120 min Winter	18.112	0.0	30.4	88			
180 min Winter	13.534	0.0	34.1	120			
240 min Winter	10.952	0.0	36.8	146			
360 min Winter	8.106	0.0	40.8	194			
480 min Winter	6.544	0.0	44.0	252			
600 min Winter	5.539	0.0	46.5	310			
720 min Winter	4.832	0.0	48.7	374			
960 min Winter	3.892	0.0	52.3	492			
1440 min Winter	2.866	0.0	57.8	724			
2160 min Winter	2.108	0.0	63.7	1092			
2880 min Winter	1.693	0.0	68.3	1436			
4320 min Winter	1.242	0.0	75.1	2204			
5760 min Winter	0.996	0.0	80.3	2912			
7200 min Winter	0.839	0.0	84.6	3568			
8640 min Winter	0.730	0.0	88.3	4344			
10080 min Winter	0.648	0.0	91.5	4960			
©1982-2015 XP Solutions							

Mason Clark Associates		Page 3
Church House 44 Newland Park Hull HU5 2DW	CAS Mulberry Lodge SW Attenuation (5 l/s) 1 in 30 year	
Date Sept 2017 File 1 in 30 year.srcx	Designed by AP Checked by	
XP Solutions	Source Control 2015.1	

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.000	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.100

Time (mins)	Area	Time (mins)	Area	Time (mins)	Area
From: To:	(ha)	From: To:	(ha)	From: To:	(ha)
0 4	0.033	4 8	0.033	8 12	0.034

Mason Clark Associates		Page 4
Church House 44 Newland Park Hull HU5 2DW	CAS Mulberry Lodge SW Attenuation (5 l/s) 1 in 30 year	
Date Sept 2017 File 1 in 30 year.srcx	Designed by AP Checked by	
XP Solutions Source Control 2015.1		

Model Details

Storage is Online Cover Level (m) 100.000

Cellular Storage Structure

Invert Level (m) 98.600 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m ²)	Inf. Area (m ²)	Depth (m)	Area (m ²)	Inf. Area (m ²)
0.000	16.0	16.0	0.900	0.0	28.8
0.800	16.0	28.8			

Hydro-Brake Optimum® Outflow Control

Unit Reference MD-SHE-0109-5000-0800-5000
Design Head (m) 0.800
Design Flow (l/s) 5.0
Flush-Flo™ Calculated
Objective Minimise upstream storage
Diameter (mm) 109
Invert Level (m) 98.600
Minimum Outlet Pipe Diameter (mm) 150
Suggested Manhole Diameter (mm) 1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.800	5.0
Flush-Flo™	0.242	5.0
Kick-Flo®	0.537	4.2
Mean Flow over Head Range	-	4.3

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	3.7	1.200	6.0	3.000	9.3	7.000	13.9
0.200	5.0	1.400	6.5	3.500	10.0	7.500	14.4
0.300	5.0	1.600	6.9	4.000	10.6	8.000	14.8
0.400	4.8	1.800	7.3	4.500	11.3	8.500	15.2
0.500	4.5	2.000	7.7	5.000	11.8	9.000	15.7
0.600	4.4	2.200	8.0	5.500	12.4	9.500	16.1
0.800	5.0	2.400	8.4	6.000	12.9		
1.000	5.5	2.600	8.7	6.500	13.4		

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Mason Clark Associates		Page 1
Church House 44 Newland Park Hull HU5 2DW	CAS Mulberry Lodge SW Attenuation (5 l/s) 1 in 30 year + 30%	
Date Sept 2017 File 1 in 30 year + 30%.srcx	Designed by AP Checked by	
XP Solutions	Source Control 2015.1	

Summary of Results for 30 year Return Period (+30%)

Half Drain Time : 34 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	99.117	0.517	0.0	5.0	5.0	12.3	O K
30 min Summer	99.251	0.651	0.0	5.0	5.0	15.5	O K
60 min Summer	99.293	0.693	0.0	5.0	5.0	16.5	O K
120 min Summer	99.254	0.654	0.0	5.0	5.0	15.5	O K
180 min Summer	99.184	0.584	0.0	5.0	5.0	13.9	O K
240 min Summer	99.091	0.491	0.0	5.0	5.0	11.7	O K
360 min Summer	98.937	0.337	0.0	5.0	5.0	8.0	O K
480 min Summer	98.833	0.233	0.0	5.0	5.0	5.5	O K
600 min Summer	98.769	0.169	0.0	4.9	4.9	4.0	O K
720 min Summer	98.733	0.133	0.0	4.7	4.7	3.2	O K
960 min Summer	98.707	0.107	0.0	4.0	4.0	2.5	O K
1440 min Summer	98.685	0.085	0.0	3.0	3.0	2.0	O K
2160 min Summer	98.669	0.069	0.0	2.2	2.2	1.6	O K
2880 min Summer	98.661	0.061	0.0	1.8	1.8	1.4	O K
4320 min Summer	98.651	0.051	0.0	1.3	1.3	1.2	O K
5760 min Summer	98.645	0.045	0.0	1.1	1.1	1.1	O K
7200 min Summer	98.641	0.041	0.0	0.9	0.9	1.0	O K
8640 min Summer	98.638	0.038	0.0	0.8	0.8	0.9	O K
10080 min Summer	98.636	0.036	0.0	0.7	0.7	0.8	O K
15 min Winter	99.197	0.597	0.0	5.0	5.0	14.2	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	89.487	0.0	16.8	22
30 min Summer	59.577	0.0	22.3	32
60 min Summer	38.009	0.0	28.5	50
120 min Summer	23.546	0.0	35.3	86
180 min Summer	17.594	0.0	39.6	120
240 min Summer	14.237	0.0	42.7	152
360 min Summer	10.537	0.0	47.4	210
480 min Summer	8.507	0.0	51.0	266
600 min Summer	7.201	0.0	54.0	322
720 min Summer	6.281	0.0	56.5	376
960 min Summer	5.060	0.0	60.7	494
1440 min Summer	3.726	0.0	67.1	734
2160 min Summer	2.740	0.0	74.0	1100
2880 min Summer	2.201	0.0	79.2	1440
4320 min Summer	1.614	0.0	87.2	2200
5760 min Summer	1.295	0.0	93.2	2888
7200 min Summer	1.091	0.0	98.1	3608
8640 min Summer	0.948	0.0	102.4	4288
10080 min Summer	0.843	0.0	106.2	5120
15 min Winter	89.487	0.0	18.8	22

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Mason Clark Associates							Page 2
Church House 44 Newland Park Hull HU5 2DW			CAS Mulberry Lodge SW Attenuation (5 l/s) 1 in 30 year + 30%				
Date Sept 2017 File 1 in 30 year + 30%.srcx			Designed by AP Checked by				
XP Solutions			Source Control 2015.1				
<u>Summary of Results for 30 year Return Period (+30%)</u>							
Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	99.347	0.747	0.0	5.0	5.0	17.7	O K
60 min Winter	99.394	0.794	0.0	5.0	5.0	18.8	O K
120 min Winter	99.323	0.723	0.0	5.0	5.0	17.2	O K
180 min Winter	99.209	0.609	0.0	5.0	5.0	14.5	O K
240 min Winter	99.057	0.457	0.0	5.0	5.0	10.9	O K
360 min Winter	98.839	0.239	0.0	5.0	5.0	5.7	O K
480 min Winter	98.738	0.138	0.0	4.7	4.7	3.3	O K
600 min Winter	98.712	0.112	0.0	4.2	4.2	2.7	O K
720 min Winter	98.699	0.099	0.0	3.7	3.7	2.3	O K
960 min Winter	98.684	0.084	0.0	3.0	3.0	2.0	O K
1440 min Winter	98.669	0.069	0.0	2.2	2.2	1.6	O K
2160 min Winter	98.657	0.057	0.0	1.6	1.6	1.4	O K
2880 min Winter	98.651	0.051	0.0	1.3	1.3	1.2	O K
4320 min Winter	98.643	0.043	0.0	1.0	1.0	1.0	O K
5760 min Winter	98.638	0.038	0.0	0.8	0.8	0.9	O K
7200 min Winter	98.635	0.035	0.0	0.7	0.7	0.8	O K
8640 min Winter	98.632	0.032	0.0	0.6	0.6	0.8	O K
10080 min Winter	98.630	0.030	0.0	0.5	0.5	0.7	O K
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)			
30 min Winter	59.577	0.0	25.0	33			
60 min Winter	38.009	0.0	31.9	54			
120 min Winter	23.546	0.0	39.5	92			
180 min Winter	17.594	0.0	44.3	128			
240 min Winter	14.237	0.0	47.8	160			
360 min Winter	10.537	0.0	53.1	214			
480 min Winter	8.507	0.0	57.2	262			
600 min Winter	7.201	0.0	60.5	316			
720 min Winter	6.281	0.0	63.3	374			
960 min Winter	5.060	0.0	68.0	490			
1440 min Winter	3.726	0.0	75.1	732			
2160 min Winter	2.740	0.0	82.8	1092			
2880 min Winter	2.201	0.0	88.7	1460			
4320 min Winter	1.614	0.0	97.6	2200			
5760 min Winter	1.295	0.0	104.4	2848			
7200 min Winter	1.091	0.0	109.9	3624			
8640 min Winter	0.948	0.0	114.7	4400			
10080 min Winter	0.843	0.0	118.9	5064			
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Mason Clark Associates		Page 3
Church House 44 Newland Park Hull HU5 2DW	CAS Mulberry Lodge SW Attenuation (5 l/s) 1 in 30 year + 30%	
Date Sept 2017 File 1 in 30 year + 30%.srcx	Designed by AP Checked by	
XP Solutions	Source Control 2015.1	

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	30	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.000	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.100

Time (mins)	Area	Time (mins)	Area	Time (mins)	Area
From: To:	(ha)	From: To:	(ha)	From: To:	(ha)
0 4	0.033	4 8	0.033	8 12	0.034

Mason Clark Associates		Page 4
Church House 44 Newland Park Hull HU5 2DW	CAS Mulberry Lodge SW Attenuation (5 l/s) 1 in 30 year + 30%	
Date Sept 2017 File 1 in 30 year + 30%.srcx	Designed by AP Checked by	
XP Solutions Source Control 2015.1		

Model Details

Storage is Online Cover Level (m) 100.000

Cellular Storage Structure

Invert Level (m) 98.600 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m ²)	Inf. Area (m ²)	Depth (m)	Area (m ²)	Inf. Area (m ²)
0.000	25.0	25.0	0.900	0.0	41.0
0.800	25.0	41.0			

Hydro-Brake Optimum® Outflow Control

Unit Reference MD-SHE-0109-5000-0800-5000
Design Head (m) 0.800
Design Flow (l/s) 5.0
Flush-Flo™ Calculated
Objective Minimise upstream storage
Diameter (mm) 109
Invert Level (m) 98.600
Minimum Outlet Pipe Diameter (mm) 150
Suggested Manhole Diameter (mm) 1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.800	5.0
Flush-Flo™	0.242	5.0
Kick-Flo®	0.537	4.2
Mean Flow over Head Range	-	4.3

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	3.7	1.200	6.0	3.000	9.3	7.000	13.9
0.200	5.0	1.400	6.5	3.500	10.0	7.500	14.4
0.300	5.0	1.600	6.9	4.000	10.6	8.000	14.8
0.400	4.8	1.800	7.3	4.500	11.3	8.500	15.2
0.500	4.5	2.000	7.7	5.000	11.8	9.000	15.7
0.600	4.4	2.200	8.0	5.500	12.4	9.500	16.1
0.800	5.0	2.400	8.4	6.000	12.9		
1.000	5.5	2.600	8.7	6.500	13.4		

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Mason Clark Associates							Page 1
Church House 44 Newland Park Hull HU5 2DW			CAS Mulberry Lodge SW Attenuation (5 l/s) 1 in 100 year				
Date Sept 2017 File 1 in 100 year.srcx			Designed by AP Checked by				
XP Solutions			Source Control 2015.1				
<u>Summary of Results for 100 year Return Period</u> Half Drain Time : 35 minutes.							
Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	99.113	0.513	0.0	5.0	5.0	12.2	O K
30 min Summer	99.255	0.655	0.0	5.0	5.0	15.5	O K
60 min Summer	99.302	0.702	0.0	5.0	5.0	16.7	O K
120 min Summer	99.265	0.665	0.0	5.0	5.0	15.8	O K
180 min Summer	99.192	0.592	0.0	5.0	5.0	14.1	O K
240 min Summer	99.095	0.495	0.0	5.0	5.0	11.8	O K
360 min Summer	98.934	0.334	0.0	5.0	5.0	7.9	O K
480 min Summer	98.828	0.228	0.0	5.0	5.0	5.4	O K
600 min Summer	98.765	0.165	0.0	4.9	4.9	3.9	O K
720 min Summer	98.730	0.130	0.0	4.7	4.7	3.1	O K
960 min Summer	98.705	0.105	0.0	3.9	3.9	2.5	O K
1440 min Summer	98.683	0.083	0.0	2.9	2.9	2.0	O K
2160 min Summer	98.668	0.068	0.0	2.2	2.2	1.6	O K
2880 min Summer	98.659	0.059	0.0	1.7	1.7	1.4	O K
4320 min Summer	98.649	0.049	0.0	1.2	1.2	1.2	O K
5760 min Summer	98.644	0.044	0.0	1.0	1.0	1.0	O K
7200 min Summer	98.640	0.040	0.0	0.8	0.8	0.9	O K
8640 min Summer	98.637	0.037	0.0	0.7	0.7	0.9	O K
10080 min Summer	98.634	0.034	0.0	0.6	0.6	0.8	O K
15 min Winter	99.193	0.593	0.0	5.0	5.0	14.1	O K
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)			
15 min Summer	89.024	0.0	16.7	22			
30 min Summer	59.849	0.0	22.4	32			
60 min Summer	38.413	0.0	28.8	50			
120 min Summer	23.812	0.0	35.7	86			
180 min Summer	17.737	0.0	39.9	120			
240 min Summer	14.290	0.0	42.9	152			
360 min Summer	10.505	0.0	47.3	210			
480 min Summer	8.441	0.0	50.6	266			
600 min Summer	7.118	0.0	53.4	320			
720 min Summer	6.190	0.0	55.7	376			
960 min Summer	4.959	0.0	59.5	494			
1440 min Summer	3.622	0.0	65.2	736			
2160 min Summer	2.640	0.0	71.3	1100			
2880 min Summer	2.107	0.0	75.8	1468			
4320 min Summer	1.530	0.0	82.6	2200			
5760 min Summer	1.218	0.0	87.7	2888			
7200 min Summer	1.019	0.0	91.7	3632			
8640 min Summer	0.882	0.0	95.3	4368			
10080 min Summer	0.781	0.0	98.4	5032			
15 min Winter	89.024	0.0	18.7	22			
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Church House 44 Newland Park Hull HU5 2DW			CAS Mulberry Lodge SW Attenuation (5 l/s) 1 in 100 year				
Date Sept 2017 File 1 in 100 year.srcx			Designed by AP Checked by				
XP Solutions			Source Control 2015.1				
<u>Summary of Results for 100 year Return Period</u>							
Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	99.351	0.751	0.0	5.0	5.0	17.8	O K
60 min Winter	99.405	0.805	0.0	5.0	5.0	19.1	O K
120 min Winter	99.336	0.736	0.0	5.0	5.0	17.5	O K
180 min Winter	99.219	0.619	0.0	5.0	5.0	14.7	O K
240 min Winter	99.062	0.462	0.0	5.0	5.0	11.0	O K
360 min Winter	98.837	0.237	0.0	5.0	5.0	5.6	O K
480 min Winter	98.736	0.136	0.0	4.7	4.7	3.2	O K
600 min Winter	98.711	0.111	0.0	4.1	4.1	2.6	O K
720 min Winter	98.698	0.098	0.0	3.6	3.6	2.3	O K
960 min Winter	98.683	0.083	0.0	2.9	2.9	2.0	O K
1440 min Winter	98.667	0.067	0.0	2.1	2.1	1.6	O K
2160 min Winter	98.656	0.056	0.0	1.6	1.6	1.3	O K
2880 min Winter	98.649	0.049	0.0	1.2	1.2	1.2	O K
4320 min Winter	98.641	0.041	0.0	0.9	0.9	1.0	O K
5760 min Winter	98.637	0.037	0.0	0.7	0.7	0.9	O K
7200 min Winter	98.633	0.033	0.0	0.6	0.6	0.8	O K
8640 min Winter	98.631	0.031	0.0	0.5	0.5	0.7	O K
10080 min Winter	98.629	0.029	0.0	0.5	0.5	0.7	O K
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)			
30 min Winter	59.849	0.0	25.1	33			
60 min Winter	38.413	0.0	32.3	54			
120 min Winter	23.812	0.0	40.0	92			
180 min Winter	17.737	0.0	44.7	128			
240 min Winter	14.290	0.0	48.0	160			
360 min Winter	10.505	0.0	52.9	214			
480 min Winter	8.441	0.0	56.7	262			
600 min Winter	7.118	0.0	59.8	314			
720 min Winter	6.190	0.0	62.4	372			
960 min Winter	4.959	0.0	66.6	496			
1440 min Winter	3.622	0.0	73.0	738			
2160 min Winter	2.640	0.0	79.8	1104			
2880 min Winter	2.107	0.0	84.9	1448			
4320 min Winter	1.530	0.0	92.5	2204			
5760 min Winter	1.218	0.0	98.2	2928			
7200 min Winter	1.019	0.0	102.7	3560			
8640 min Winter	0.882	0.0	106.7	4392			
10080 min Winter	0.781	0.0	110.2	5128			
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Mason Clark Associates		Page 3
Church House 44 Newland Park Hull HU5 2DW	CAS Mulberry Lodge SW Attenuation (5 l/s) 1 in 100 year	
Date Sept 2017 File 1 in 100 year.srcx	Designed by AP Checked by	
XP Solutions	Source Control 2015.1	

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)	19.000	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time Area Diagram

Total Area (ha) 0.100

Time (mins)	Area	Time (mins)	Area	Time (mins)	Area
From: To:	(ha)	From: To:	(ha)	From: To:	(ha)
0 4	0.033	4 8	0.033	8 12	0.034

Mason Clark Associates		Page 4																																																																																																									
Church House 44 Newland Park Hull HU5 2DW	CAS Mulberry Lodge SW Attenuation (5 l/s) 1 in 100 year																																																																																																										
Date Sept 2017 File 1 in 100 year.srcx	Designed by AP Checked by																																																																																																										
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Source Control 2015.1																																																																																																											
<u>Model Details</u> Storage is Online Cover Level (m) 100.000 <u>Cellular Storage Structure</u> Invert Level (m) 98.600 Safety Factor 2.0 Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95 Infiltration Coefficient Side (m/hr) 0.00000 <table border="1"> <thead> <tr> <th>Depth (m)</th> <th>Area (m²)</th> <th>Inf. Area (m²)</th> <th>Depth (m)</th> <th>Area (m²)</th> <th>Inf. Area (m²)</th> </tr> </thead> <tbody> <tr> <td>0.000</td> <td>25.0</td> <td>25.0</td> <td>0.900</td> <td>0.0</td> <td>41.0</td> </tr> <tr> <td>0.800</td> <td>25.0</td> <td>41.0</td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <u>Hydro-Brake Optimum® Outflow Control</u> Unit Reference MD-SHE-0109-5000-0800-5000 Design Head (m) 0.800 Design Flow (l/s) 5.0 Flush-Flo™ Calculated Objective Minimise upstream storage Diameter (mm) 109 Invert Level (m) 98.600 Minimum Outlet Pipe Diameter (mm) 150 Suggested Manhole Diameter (mm) 1200 <table border="1"> <thead> <tr> <th>Control Points</th> <th>Head (m)</th> <th>Flow (l/s)</th> </tr> </thead> <tbody> <tr> <td>Design Point (Calculated)</td> <td>0.800</td> <td>5.0</td> </tr> <tr> <td>Flush-Flo™</td> <td>0.242</td> <td>5.0</td> </tr> <tr> <td>Kick-Flo®</td> <td>0.537</td> <td>4.2</td> </tr> <tr> <td>Mean Flow over Head Range</td> <td>-</td> <td>4.3</td> </tr> </tbody> </table> 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 <table border="1"> <thead> <tr> <th>Depth (m)</th> <th>Flow (l/s)</th> <th>Depth (m)</th> <th>Flow (l/s)</th> <th>Depth (m)</th> <th>Flow (l/s)</th> <th>Depth (m)</th> <th>Flow (l/s)</th> </tr> </thead> <tbody> <tr><td>0.100</td><td>3.7</td><td>1.200</td><td>6.0</td><td>3.000</td><td>9.3</td><td>7.000</td><td>13.9</td></tr> <tr><td>0.200</td><td>5.0</td><td>1.400</td><td>6.5</td><td>3.500</td><td>10.0</td><td>7.500</td><td>14.4</td></tr> <tr><td>0.300</td><td>5.0</td><td>1.600</td><td>6.9</td><td>4.000</td><td>10.6</td><td>8.000</td><td>14.8</td></tr> <tr><td>0.400</td><td>4.8</td><td>1.800</td><td>7.3</td><td>4.500</td><td>11.3</td><td>8.500</td><td>15.2</td></tr> <tr><td>0.500</td><td>4.5</td><td>2.000</td><td>7.7</td><td>5.000</td><td>11.8</td><td>9.000</td><td>15.7</td></tr> <tr><td>0.600</td><td>4.4</td><td>2.200</td><td>8.0</td><td>5.500</td><td>12.4</td><td>9.500</td><td>16.1</td></tr> <tr><td>0.800</td><td>5.0</td><td>2.400</td><td>8.4</td><td>6.000</td><td>12.9</td><td></td><td></td></tr> <tr><td>1.000</td><td>5.5</td><td>2.600</td><td>8.7</td><td>6.500</td><td>13.4</td><td></td><td></td></tr> </tbody> </table>			Depth (m)	Area (m ²)	Inf. Area (m ²)	Depth (m)	Area (m ²)	Inf. Area (m ²)	0.000	25.0	25.0	0.900	0.0	41.0	0.800	25.0	41.0				Control Points	Head (m)	Flow (l/s)	Design Point (Calculated)	0.800	5.0	Flush-Flo™	0.242	5.0	Kick-Flo®	0.537	4.2	Mean Flow over Head Range	-	4.3	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	0.100	3.7	1.200	6.0	3.000	9.3	7.000	13.9	0.200	5.0	1.400	6.5	3.500	10.0	7.500	14.4	0.300	5.0	1.600	6.9	4.000	10.6	8.000	14.8	0.400	4.8	1.800	7.3	4.500	11.3	8.500	15.2	0.500	4.5	2.000	7.7	5.000	11.8	9.000	15.7	0.600	4.4	2.200	8.0	5.500	12.4	9.500	16.1	0.800	5.0	2.400	8.4	6.000	12.9			1.000	5.5	2.600	8.7	6.500	13.4		
Depth (m)	Area (m ²)	Inf. Area (m ²)	Depth (m)	Area (m ²)	Inf. Area (m ²)																																																																																																						
0.000	25.0	25.0	0.900	0.0	41.0																																																																																																						
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0.100	3.7	1.200	6.0	3.000	9.3	7.000	13.9																																																																																																				
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<u>Summary of Results for 100 year Return Period (+30%)</u> Half Drain Time : 51 minutes. <table><tr><th>Storm Event</th><th>Max Level (m)</th><th>Max Depth (m)</th><th>Max Infiltration (l/s)</th><th>Max Control (l/s)</th><th>Max Σ Outflow (l/s)</th><th>Max Volume (m³)</th><th>Status</th></tr><tr><td>15 min Summer</td><td>99.099</td><td>0.499</td><td>0.0</td><td>5.0</td><td>5.0</td><td>17.1</td><td>O K</td></tr><tr><td>30 min Summer</td><td>99.245</td><td>0.645</td><td>0.0</td><td>5.0</td><td>5.0</td><td>22.1</td><td>O K</td></tr><tr><td>60 min Summer</td><td>99.317</td><td>0.717</td><td>0.0</td><td>5.0</td><td>5.0</td><td>24.5</td><td>O K</td></tr><tr><td>120 min Summer</td><td>99.308</td><td>0.708</td><td>0.0</td><td>5.0</td><td>5.0</td><td>24.2</td><td>O K</td></tr><tr><td>180 min Summer</td><td>99.261</td><td>0.661</td><td>0.0</td><td>5.0</td><td>5.0</td><td>22.6</td><td>O K</td></tr><tr><td>240 min Summer</td><td>99.204</td><td>0.604</td><td>0.0</td><td>5.0</td><td>5.0</td><td>20.6</td><td>O K</td></tr><tr><td>360 min Summer</td><td>99.067</td><td>0.467</td><td>0.0</td><td>5.0</td><td>5.0</td><td>16.0</td><td>O K</td></tr><tr><td>480 min Summer</td><td>98.954</td><td>0.354</td><td>0.0</td><td>5.0</td><td>5.0</td><td>12.1</td><td>O K</td></tr><tr><td>600 min Summer</td><td>98.869</td><td>0.269</td><td>0.0</td><td>5.0</td><td>5.0</td><td>9.2</td><td>O K</td></tr><tr><td>720 min Summer</td><td>98.808</td><td>0.208</td><td>0.0</td><td>5.0</td><td>5.0</td><td>7.1</td><td>O K</td></tr><tr><td>960 min Summer</td><td>98.738</td><td>0.138</td><td>0.0</td><td>4.7</td><td>4.7</td><td>4.7</td><td>O K</td></tr><tr><td>1440 min Summer</td><td>98.701</td><td>0.101</td><td>0.0</td><td>3.8</td><td>3.8</td><td>3.5</td><td>O K</td></tr><tr><td>2160 min Summer</td><td>98.680</td><td>0.080</td><td>0.0</td><td>2.8</td><td>2.8</td><td>2.7</td><td>O K</td></tr><tr><td>2880 min Summer</td><td>98.669</td><td>0.069</td><td>0.0</td><td>2.2</td><td>2.2</td><td>2.4</td><td>O K</td></tr><tr><td>4320 min Summer</td><td>98.657</td><td>0.057</td><td>0.0</td><td>1.6</td><td>1.6</td><td>2.0</td><td>O K</td></tr><tr><td>5760 min Summer</td><td>98.650</td><td>0.050</td><td>0.0</td><td>1.3</td><td>1.3</td><td>1.7</td><td>O K</td></tr><tr><td>7200 min Summer</td><td>98.646</td><td>0.046</td><td>0.0</td><td>1.1</td><td>1.1</td><td>1.6</td><td>O K</td></tr><tr><td>8640 min Summer</td><td>98.642</td><td>0.042</td><td>0.0</td><td>0.9</td><td>0.9</td><td>1.4</td><td>O K</td></tr><tr><td>10080 min Summer</td><td>98.640</td><td>0.040</td><td>0.0</td><td>0.8</td><td>0.8</td><td>1.4</td><td>O K</td></tr><tr><td>15 min Winter</td><td>99.174</td><td>0.574</td><td>0.0</td><td>5.0</td><td>5.0</td><td>19.6</td><td>O K</td></tr></table> <table><tr><th>Storm Event</th><th>Rain (mm/hr)</th><th>Flooded Volume (m³)</th><th>Discharge Volume (m³)</th><th>Time-Peak (mins)</th></tr><tr><td>15 min Summer</td><td>115.731</td><td>0.0</td><td>21.7</td><td>22</td></tr><tr><td>30 min Summer</td><td>77.804</td><td>0.0</td><td>29.2</td><td>34</td></tr><tr><td>60 min Summer</td><td>49.937</td><td>0.0</td><td>37.4</td><td>54</td></tr><tr><td>120 min Summer</td><td>30.956</td><td>0.0</td><td>46.4</td><td>88</td></tr><tr><td>180 min Summer</td><td>23.058</td><td>0.0</td><td>51.9</td><td>124</td></tr><tr><td>240 min Summer</td><td>18.577</td><td>0.0</td><td>55.7</td><td>158</td></tr><tr><td>360 min Summer</td><td>13.656</td><td>0.0</td><td>61.4</td><td>222</td></tr><tr><td>480 min Summer</td><td>10.974</td><td>0.0</td><td>65.8</td><td>280</td></tr><tr><td>600 min Summer</td><td>9.254</td><td>0.0</td><td>69.4</td><td>336</td></tr><tr><td>720 min Summer</td><td>8.046</td><td>0.0</td><td>72.4</td><td>392</td></tr><tr><td>960 min Summer</td><td>6.447</td><td>0.0</td><td>77.4</td><td>502</td></tr><tr><td>1440 min Summer</td><td>4.709</td><td>0.0</td><td>84.7</td><td>736</td></tr><tr><td>2160 min Summer</td><td>3.432</td><td>0.0</td><td>92.7</td><td>1100</td></tr><tr><td>2880 min Summer</td><td>2.739</td><td>0.0</td><td>98.6</td><td>1468</td></tr><tr><td>4320 min Summer</td><td>1.989</td><td>0.0</td><td>107.4</td><td>2156</td></tr><tr><td>5760 min Summer</td><td>1.583</td><td>0.0</td><td>113.9</td><td>2872</td></tr><tr><td>7200 min Summer</td><td>1.325</td><td>0.0</td><td>119.2</td><td>3624</td></tr><tr><td>8640 min Summer</td><td>1.147</td><td>0.0</td><td>123.8</td><td>4368</td></tr><tr><td>10080 min Summer</td><td>1.015</td><td>0.0</td><td>127.9</td><td>5072</td></tr><tr><td>15 min Winter</td><td>115.731</td><td>0.0</td><td>24.3</td><td>23</td></tr></table>								Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status	15 min Summer	99.099	0.499	0.0	5.0	5.0	17.1	O K	30 min Summer	99.245	0.645	0.0	5.0	5.0	22.1	O K	60 min Summer	99.317	0.717	0.0	5.0	5.0	24.5	O K	120 min Summer	99.308	0.708	0.0	5.0	5.0	24.2	O K	180 min Summer	99.261	0.661	0.0	5.0	5.0	22.6	O K	240 min Summer	99.204	0.604	0.0	5.0	5.0	20.6	O K	360 min Summer	99.067	0.467	0.0	5.0	5.0	16.0	O K	480 min Summer	98.954	0.354	0.0	5.0	5.0	12.1	O K	600 min Summer	98.869	0.269	0.0	5.0	5.0	9.2	O K	720 min Summer	98.808	0.208	0.0	5.0	5.0	7.1	O K	960 min Summer	98.738	0.138	0.0	4.7	4.7	4.7	O K	1440 min Summer	98.701	0.101	0.0	3.8	3.8	3.5	O K	2160 min Summer	98.680	0.080	0.0	2.8	2.8	2.7	O K	2880 min Summer	98.669	0.069	0.0	2.2	2.2	2.4	O K	4320 min Summer	98.657	0.057	0.0	1.6	1.6	2.0	O K	5760 min Summer	98.650	0.050	0.0	1.3	1.3	1.7	O K	7200 min Summer	98.646	0.046	0.0	1.1	1.1	1.6	O K	8640 min Summer	98.642	0.042	0.0	0.9	0.9	1.4	O K	10080 min Summer	98.640	0.040	0.0	0.8	0.8	1.4	O K	15 min Winter	99.174	0.574	0.0	5.0	5.0	19.6	O K	Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)	15 min Summer	115.731	0.0	21.7	22	30 min Summer	77.804	0.0	29.2	34	60 min Summer	49.937	0.0	37.4	54	120 min Summer	30.956	0.0	46.4	88	180 min Summer	23.058	0.0	51.9	124	240 min Summer	18.577	0.0	55.7	158	360 min Summer	13.656	0.0	61.4	222	480 min Summer	10.974	0.0	65.8	280	600 min Summer	9.254	0.0	69.4	336	720 min Summer	8.046	0.0	72.4	392	960 min Summer	6.447	0.0	77.4	502	1440 min Summer	4.709	0.0	84.7	736	2160 min Summer	3.432	0.0	92.7	1100	2880 min Summer	2.739	0.0	98.6	1468	4320 min Summer	1.989	0.0	107.4	2156	5760 min Summer	1.583	0.0	113.9	2872	7200 min Summer	1.325	0.0	119.2	3624	8640 min Summer	1.147	0.0	123.8	4368	10080 min Summer	1.015	0.0	127.9	5072	15 min Winter	115.731	0.0	24.3	23
Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status																																																																																																																																																																																																																																																																																	
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2160 min Summer	98.680	0.080	0.0	2.8	2.8	2.7	O K																																																																																																																																																																																																																																																																																	
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Mason Clark Associates		Page 3
Church House 44 Newland Park Hull HU5 2DW	CAS Mulberry Lodge SW Attenuation (5 l/s) 1 in 100 year + 30%	
Date Sept 2017 File 1 in 100 year + 30%.srcx	Designed by AP Checked by	
XP Solutions	Source Control 2015.1	

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)	19.000	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.100

Time (mins)	Area	Time (mins)	Area	Time (mins)	Area
From: To:	(ha)	From: To:	(ha)	From: To:	(ha)
0 4	0.033	4 8	0.033	8 12	0.034

Mason Clark Associates		Page 4
Church House 44 Newland Park Hull HU5 2DW	CAS Mulberry Lodge SW Attenuation (5 l/s) 1 in 100 year + 30%	
Date Sept 2017 File 1 in 100 year + 30%.srcx	Designed by AP Checked by	
XP Solutions Source Control 2015.1		

Model Details

Storage is Online Cover Level (m) 100.000

Cellular Storage Structure

Invert Level (m) 98.600 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m ²)	Inf. Area (m ²)	Depth (m)	Area (m ²)	Inf. Area (m ²)
0.000	36.0	36.0	0.900	0.0	55.2
0.800	36.0	55.2			

Hydro-Brake Optimum® Outflow Control

Unit Reference MD-SHE-0109-5000-0800-5000
Design Head (m) 0.800
Design Flow (l/s) 5.0
Flush-Flo™ Calculated
Objective Minimise upstream storage
Diameter (mm) 109
Invert Level (m) 98.600
Minimum Outlet Pipe Diameter (mm) 150
Suggested Manhole Diameter (mm) 1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.800	5.0
Flush-Flo™	0.242	5.0
Kick-Flo®	0.537	4.2
Mean Flow over Head Range	-	4.3

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	3.7	1.200	6.0	3.000	9.3	7.000	13.9
0.200	5.0	1.400	6.5	3.500	10.0	7.500	14.4
0.300	5.0	1.600	6.9	4.000	10.6	8.000	14.8
0.400	4.8	1.800	7.3	4.500	11.3	8.500	15.2
0.500	4.5	2.000	7.7	5.000	11.8	9.000	15.7
0.600	4.4	2.200	8.0	5.500	12.4	9.500	16.1
0.800	5.0	2.400	8.4	6.000	12.9		
1.000	5.5	2.600	8.7	6.500	13.4		

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Appendix IV

Schematic Drainage Layout



1. All private drainage works are to be constructed in accordance with the relevant provisions of BS EN 752 including by reference BS 8301, Building Regulations part H and Sewers for Adoption 6th edition.
2. The Contractor **MUST** confirm invert levels of existing points of connection prior to commencement of drainage works.
3. Manhole invert levels relate to the downstream pipe. Pipes at manholes to be laid soffit to soffit level.
4. Unless otherwise shown, foul pipes to be 100mm Ø laid at 1 in 40 minimum gradient unless one w.c. connected where gradient may be 1 in 80 minimum.
5. Unless otherwise shown surface water pipes to be 150mm Ø laid at 1 in 100 minimum gradient.
6. Where cover to top of pipe barrel is less than 900mm in lightly trafficked areas and 600mm in not trafficked areas, pipe to have minimum 150mm ST4 concrete surround.

1. This drawing is subject to copyright and must not be reproduced, stored or transmitted in any form without prior permission from Mason Clark Associates.
2. This drawing is not to be scaled. All dimensions are to be checked on site by the contractor. Any discrepancies are to be notified to Mason Clark Associates. Obtain instructions prior to works commencing.
3. This drawing is to be read in conjunction with the relevant contract drawings and documents, including the NBS specification.
4. All dimensions are in millimetres and all levels are in metres AOD unless noted otherwise.
5. All work shall be carried out in accordance with Local Authority, Statutory Authority and Health & Safety Regulations.

1. The shown drainage layout is indicative only, and should not be used for construction.
2. Final drainage system to be confirmed at detailed design stage, and subject to layout of SVPs and RWPs as designed by the architect/M&E engineer.
3. Inverts, cover levels and pipe sizes to be confirmed at detailed design stage.
4. SW connection to public sewer TBC following percolation test results.

	Surface Water
	Foul Water
	Surface Water Manhole
	Surface Water Access Chamber
	Rain water pipe
	Channel Drain
	Highway Gully (375x750) and C250 cover and frame with 1500 pipe (Class Z Bedding)
	Foul Water Manhole (public sewer)
	Foul Water Access Chamber
	Soil vent pipe
	Existing Combined Water Sewer (public sewer)

- Where cover to pipe barrel located beneath highways is less than 1200mm, pipes are to be protected with concrete surround (bed type Z) Grade C20 in accordance with sewers for adoption 6th edition, table 2.4.
- Manhole cover levels where not shown are to be confirmed at later stage. Covers are to be fixed to a profile corresponding to the surrounding pavement surface and may be adjusted to suit actual site levels.
- Any pipework up to 300mm Ø to be standard strength vitrified clay to BS EN 255 (min crushing strength 400kN/m) or plastic to BS 4660:2000 and BS EN 1401-1:1998 and shall comply with the requirements of Sewers for Adoption 6th Edition.
- All pipework larger than 300mm Ø to be Class 120 precast concrete to BS EN 1916:2002 and shall comply with the requirements of Sewers for Adoption 6th Edition
- Bedding to all pipework to be Class S granular bed & surround in accordance with BS882 or Class Z (see manhole schedule and/or details drawing).
- All backfill above gravel surround in drainage trenches and under building slabs to be Type 1 stone compacted in layers not exceeding 225mm thick.
- Manholes to be precast concrete to BS EN1917: 2002, Type B, in accordance with the requirements of Sewers for Adoption, 6th Edition unless noted otherwise.
- Inspection chambers to be polypropylene, 475mm diameter, Hepworth range or similar & approved. Opening restricted to max 350mm where depth of chamber exceeds 1.2m.
- All manholes covers and gully gratings located in trafficked areas to be ductile iron class D400. Covers located in not trafficked areas to be min class B125 unless noted otherwise on the drainage layout or manhole schedule.
- Any external recessed cover required or internal manhole covers to be specified by the Architect.
- Proprietary attenuation systems, cellular soakaways and petrol/oli interceptors to be installed in accordance with the manufacturers details and recommendations, including bedding and surround, membranes, protection and backfill requirements.
- Position and details of rainwater pipes, and foul connections to be confirmed by Architect.
- For above ground and internal drainage, vents, fittings and access points refer to Architects and/or M&E details
- Cover levels of private drainage chambers may be adjusted to suit actual site levels.
- The contractor is responsible for applying to Yorkshire Water for a Section 106 sewer connection.
- The contractor is responsible for identifying and locating all existing services and ensuring that the levels do not conflict with the proposed drainage system. If there are any such conflicts then the Engineer must be made aware immediately.
- All existing redundant drainage systems are to be abandoned and grubbed up including redundant manholes and pipework. The voids are to be backfilled with as dug material or suitable fill material and compacted in layers.
- Any live sewer connections found in any sewers that are to be abandoned are to be picked up and diverted.
- The Contractor shall undertake a CCTV survey of the as constructed site drainage system on completion of the works. A copy shall be made available to Mason Kark Associates.

P2	Amended position of attenuation.	AP	29.09.2017
P1	Preliminary - Initial Issue	AP	28.09.2017
Rev	Details	By	Date
 Unit E, Millshaw Business Living Global Avenue, Beeston, Leeds, LS11 8PR Tel: +44 (0) 113 277 9542 Fax: +44 (0) 113 277 4738			
masonclarkassociates civil and structural engineering consultants			
Client.			
CAS Behavioural Health			
Project.			
Mulberry Lodge			
Title.			
Schematic Drainage Layout			
Drawing: AP		Checked:	
Scale @ A1: 1:200		Date: Sept 2017	
Drawing No: 15682-H-DR-202		Rev: P2	



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CIVIL ENGINEERING Bridge design, maintenance and construction Wharfs, jetties and marine structures Highway design and maintenance Retaining wall and slope stability solutions Land remediation advice Road and sewer design to adoptable standards Section 38 and 104 Agreements Sewer requisitions and diversions Section 98 and 185 Agreements Flood Risk Assessments Coastal erosion flood breach analysis Flood risk management / prevention schemes Underground drainage design Stormwater attenuation SUDS Ponds, lakes and balancing ponds PROJECT MANAGEMENT BUILDING SURVEYS Building Surveys Design, Remedial Repair / Improvement Schemes Contract Administration & Contract advice Professional Opinion Reports Schedules of Condition Condition Surveys Measured Surveys Dilapidation Claims CDM Services Party Wall etc. Act representation Disabled adaptations		STRUCTURAL ENGINEERING Residential and commercial building structures Education and healthcare facilities Heavy industrial development Feasibility studies for development sites Building Regulations and Planning Applications Access and maintenance gantries Modular building design Blast design Subsidence management and resolution Temporary works design and specification Site and soils investigation Sulphate attack specialists Confined spaces assessments CONSERVATION ENGINEERING Engineer Accredited in Building Conservation CARE Registered Engineer Heritage and conservation engineering Listed Building refurbishment Historic Parks and Gardens Scheduled Ancient Monuments Monitoring and investigations Liaison with Local Conservation Officers Buildings at Risk and Managed Ruins EXPERT WITNESS SERVICES Civil & Structural engineering disputes Project Disputes Building Surveying Health and Safety Regulations