LANMOR Consulting

Civil Engineers & Transport Planners

# 38-42 Hampton Road, Teddington

# Drainage Strategy

October 2019

191213/DS/JR/RS/01

LANMOR Consulting

Civil Engineers & Transport Planners

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**DOCUMENT STATUS**

| | |
|---|---|
| Project: | 38-42 Hampton Road, Teddington |
| Title: | Drainage Strategy |
| Client: | Howarth Homes |
| Reference: | 191213/DS/JR/RS/01 |

| | | | | |
|---|---|---|---|---|
| Produced by: | JR | ..... | Date: | ..... |
| Checked by: | RS | ..... | Date: | ..... |
| Approved by: | KBL | ..... | Date: | ..... |

| Issue/revision | Date | Status | Issued by |
|---|---|---|---|
| First | 21/10/2019 | For Approval | JR |

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# 1 INTRODUCTION

## 1.1 Scope

1.1.1 Lanmor Consulting Ltd has been appointed by Howarth Homes to prepare a Drainage Strategy report in support of a planning application for the proposed residential development at 38-42 Hampton Road, Teddington TW11 0EN.

1.1.2 This report has been commissioned to advice on the technical feasibility of providing foul and surface water drainage for the proposed development.

1.1.3 This report will consider the proposed drainage regime for the site, it will assess the site's current Greenfield and Brownfield runoff rates, suitable methods of discharging the runoff from the development and set the drainage strategy for the proposed development including discharge rates and any requirements for attenuation.

1.1.4 The information and details within this report will be refined, modified and updated as the detailed design is progressed, post planning. The scope of works for this Drainage Strategy report is outlined below:

- Review available data relating to existing on-site drainage and other drainage networks in the vicinity of the site.
- Review of the sites ground conditions for suitability of SuDS.
- Consider the use of Sustainable Drainage Systems as an option for disposal of surface water runoff from the proposed development in accordance with the Sustainable Drainage Hierarchy.
- Undertake drainage assessments of proposed buildings to establish discharge rates and attenuation requirements to deal with any increased surface water runoff.

# 2 BASELINE PARAMETRES

## 2.1 Existing Site

2.1.1 The proposed site is located to west of Teddington, between Hampton Road and Anlaby Road. The site is approximately 0.16ha in size and comprises of open green space. The site is located within a residential area with low rise dwellings and apartments located in all directions. Millwood house to the east is currently under development for new residential apartments.

2.1.2 The nearest watercourse to the site is the River Thames. The river is located to the east of the site approximately 1.45km away.

2.1.3 Figure 2.1 below shows the location of the site.


**Figure 2.1 – Site Location Plan**

## 2.2 Geology

2.2.1 The British Geological Survey records indicates the site is over a sedimentary bedrock formation of London Clay Formation, formed approximately 48 to 56 million years ago in the Palaeogene Period. The bedrock consists of clay and silt.

2.2.2 The records also state that the bedrock is overlaid by superficial deposits of Taplow Gravel Formation, a mixture of sand and gravel formed 2 million years ago during the Quaternary Period.

## 2.3 Proposed Development

2.3.1 The proposed development will seek to provide a total of 14 residential units in a single block across 3 storeys.

2.3.2 As well as a new residential block, car parking will also be provided with a total of 14 spaces. A cycle store will also be constructed to the front of the site. Drawing L1000 in Appendix A shows the proposed development layout.

# 3 EXISTING DRAINAGE REGIME

## 3.1 Existing Foul Drainage

3.1.1 As part of the investigation, Thames Water sewer records were obtained. The records indicate that there are both foul and surface water sewers located within the vicinity of the site.

3.1.2 According to the records there are foul sewers passing along both Hampton Road and Anlaby Road. The sewer along Hampton road is a 300mmØ pipe falling from west to east, whilst the sewer along Anlaby Road consists of a 225mmØ pipe which connects to the sewer in Hampton Road.

3.1.3 The nearest manhole to the site is located beneath the T junction located to the southwest of the site. The manhole is listed as 0103, however there is no information regarding the cover level or invert level.

## 3.2 Existing Surface Water Drainage

3.2.1 Similar to the existing foul records, there is a surface water sewer located along both Hampton Road and Anlaby Road. The surface water sewer along Hampton Road consist of a 300mmØ pipe falling from west to east, whilst the sewer along Anlaby Road consists of a 225mmØ pipe falling from north to south.

3.2.2 The manhole nearest the site is located to the south west and is listed as 0104, however no details regarding the cover level or invert level have been provided.

3.2.3 The Thames Water Asset records can be found in Appendix B of this report.

# 4 PROPOSED DRAINAGE REGIME

## 4.1 Proposed Foul Drainage

4.1.1 The proposed foul drainage will consist of several pipes and manholes to collect foul discharge from the site, before flowing to the existing foul sewer located on Hampton Road to the south.

## 4.2 Proposed Surface Water Drainage

4.2.1 Sustainable Drainage Systems (SuDS) were considered as part of this assessment for the disposal of surface water runoff from the development.

4.2.2 Rainwater harvesting was considered to reuse surface water runoff within the development. These systems require a separate network of pipes in the building along with tanks and pumps to store the rainwater and distribute it throughout the residential units.

4.2.3 Since a large portion of the site is to be impermeable, the capacity required to store the predicted volume of surface water runoff would require the rainwater harvestings tanks to be excessively large. Therefore, due to inadequate space, multiple occupancies in the property and the high additional costs to run such a system, the use of rainwater harvesting has been discounted.

4.2.4 Next on the sustainable drainage hierarchy, is the use of ground infiltration techniques such as soakaways and infiltration basins. Space on site is limited for locating soakaways the minimum of 5m from buildings as required by Building Regulations. The only area available for soakaways is to the front of the site under the parking area, again this is restricted by existing trees and root protection zones. The British Geological Survey records indicate that the ground conditions to consist mainly of clay, silt and sand with superficial deposits of sand and gravel. Given the anticipated infiltration rate of the ground conditions and the lack of space, the soakaways are not expected to be able to half empty within 24 hours, therefore infiltration techniques have been discounted.

4.2.5 Discharge to a watercourse is next on the sustainable hierarchy. There are no known watercourses within close proximity of the site and therefore this method of discharge has been discounted.

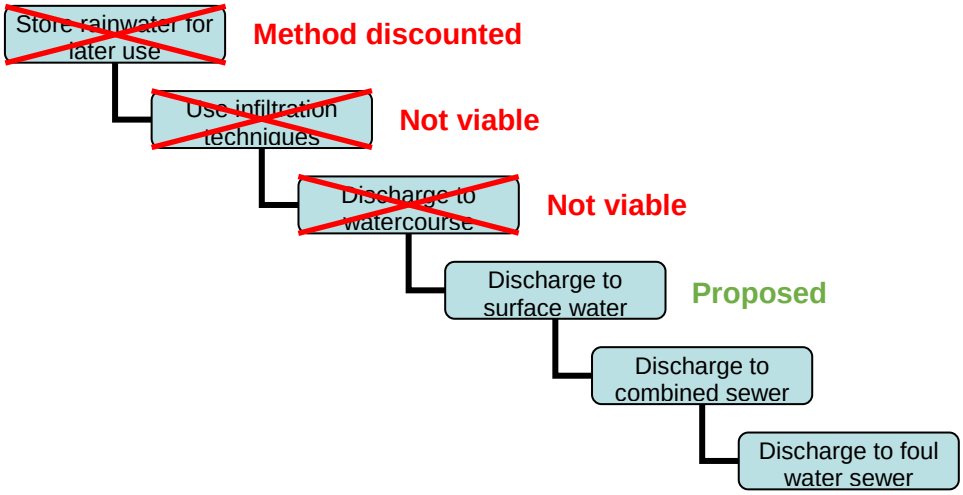



**Figure 4.1 – Sustainable Drainage Hierarchy**

4.2.6 Therefore, in accordance with the SuDS hierarchy, surface water runoff will discharge to the existing public surface water sewer that passes the front of the site via an attenuation tank restricted by a HydroBrake.

4.2.7 Calculations have been undertaken to determine the existing Greenfield and Brownfield discharge rates for the site, to set the maximum discharge rate from the proposed development. These are tabulated below in Table 4.1.

| Return Period | Greenfield Run-off | Brownfield Run-off | Proposed Discharge | % Reduction |
|---|---|---|---|---|
| $Q_{BAR}$ | 0.2 l/s | - | 2.0 l/s | - |
| 1 in 1 | 0.2 l/s | 13.5 l/s | 2.0 l/s | 85.0 % |
| 1 in 30 | 0.6 l/s | 32.3 l/s | 2.0 l/s | 93.8 % |
| 1 in 100 | 0.8 l/s | 42.8 l/s | 2.0 l/s | 95.3 % |
| 1 in 100 +40% CC | - | 59.9 l/s | 2.0 l/s | 96.6 % |

**Table 4.1 – Existing and Proposed Discharge Rates**

4.2.8 As you can see from the table above, the 1 in 1 year Greenfield runoff rate has been calculated 0.2 l/s. It is not possible to restrict the discharge from the site to such a low rate as recommended by the manufacture as this risks blockages in the system leading to flooding occurring on site.

4.2.9 The proposed buildings will drain via rainwater pipes to a series of manholes and pipes, before flowing to the proposed attenuation tank located beneath the car park to the south. The access road and car park will discharge to the attenuation tank via gullies.

4.2.10 The tank has been designed to cater for all storm return periods up to and including the 1 in 100 year storm plus 40% climate change allowance. It will be sized at 4m x 14m x 0.8m to provide storage of up to 44.8m$^3$. The attenuation tank will take the form of an underground crate systems with catchpits on the inlet and outlet to collect silt and pollutants in the runoff. A typical layout for the attenuation tank is provided below.

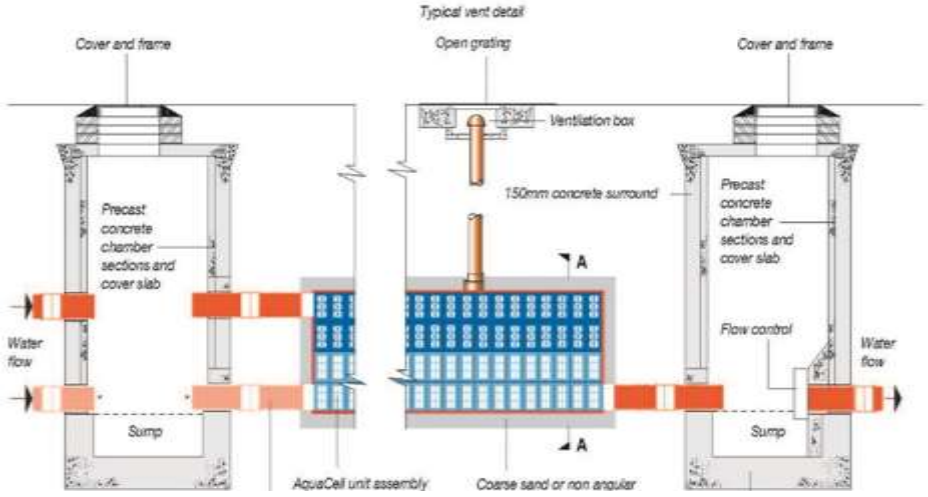



**Figure 4.2 – Aquacell Attenuation Tank**

4.2.11 An indicative drainage layout for the proposed development has been prepared and is included in Appendix C as drawing 191213/DS/01. MicroDrainage has been used to design the attenuation tank system and a copy of these calculations are included in Appendix D.

# 5 MANAGING POLLUTION RISK FROM SURFACE WATER

5.1.1 As part of the CIRIA SuDS Manual C753, Section 26.7 provides information regarding methods for managing pollution risks from surface water runoff.

5.1.2 Part of the assessment is to determine which land use classification the proposed development falls under. Since the development will consist of a residential block of flats, it has been concluded that the site should be classed within the section shown in Table 45.1 below.

**TABLE 26.2 Pollution hazard indices for different land use classifications**

| Land use | Pollution hazard level | Total suspended solids (TSS) | Metals | Hydro-carbons |
|---|---|---|---|---|
| Residential roofs | Very low | 0.2 | 0.2 | 0.05 |
| Other roofs (typically commercial/ industrial roofs) | Low | 0.3 | 0.2 (up to 0.8 where there is potential for metals to leach from the roof) | 0.05 |
| Individual property driveways, residential car parks, low traffic roads (eg cul de sacs, homezones and general access roads) and non-residential car parking with infrequent change (eg schools, offices) ie < 300 traffic movements/day | Low | 0.5 | 0.4 | 0.4 |
| Commercial yard and delivery areas, non-residential car parking with frequent change (eg hospitals, retail), all roads except low traffic roads and trunk roads/motorways[1] | Medium | 0.7 | 0.6 | 0.7 |
| Sites with heavy pollution (eg haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites), sites where chemicals and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured; industrial sites; trunk roads and motorways[1] | High | 0.8[2] | 0.8[2] | 0.9[2] |

**Table 5.1 – Extract from CIRIA SuDS Manual c753 (Land use classifications)**

5.1.3 Suitable treatment measures offered by SuDS features are set out in CIRA report, the results have been cross referenced with Table 5.2 below of the CIRA C753 report.

**TABLE 26.3 Indicative SuDS mitigation indices for discharges to surface waters**

| Type of SuDS component | Mitigation indices[1] | | |
|---|---|---|---|
| | TSS | Metals | Hydrocarbons |
| Filter strip | 0.4 | 0.4 | 0.5 |
| Filter drain | 0.4[2] | 0.4 | 0.4 |
| Swale | 0.5 | 0.6 | 0.6 |
| Bioretention system | 0.8 | 0.8 | 0.8 |
| Permeable pavement | 0.7 | 0.6 | 0.7 |
| Detention basin | 0.5 | 0.5 | 0.6 |
| Pond[4] | 0.7[3] | 0.7 | 0.5 |
| Wetland | 0.8[3] | 0.8 | 0.8 |
| Proprietary treatment systems[5,6] | These must demonstrate that they can address each of the contaminant types to acceptable levels for frequent events up to approximately the 1 in 1 year return period event, for inflow concentrations relevant to the contributing drainage area. | | |

**Table 5.2 – Extract from CIRIA SuDS Manual c753 (mitigation indices)**

5.1.4 The expected levels of pollution which are shown in Table 4.1, cannot be mitigated by basic SuDS components such as filter strips or filter drains as they are not viable for the site. The only remaining option would be to adopt a proprietary treatment system which can be incorporated into the drainage network.

5.1.5 Since this Drainage Strategy is part of planning application the detailed design has not yet been completed. However, for the benefit of this report, a proprietary treatment system that could be specified in this instance would be a Downstream Defender from Hydro International.

5.1.6 This product provides mitigation indices which will comply with the indices set out in Table 4.1 above. The defender provides mitigation for suspended solids of 0.5, for metals of 0.4 and for hydrocarbons of 0.8.

# 6 SURFACE WATER/SUDS MAINTENANCE

6.1.1 Regularly inspection of the surface water drainage network for blockages and clearing unwanted debris / silt from the system should improve the performance of the surface water network and decrease the need for future repairs. In the event of blockages, high pressure water jets can be used to clear the gullies and pipes to ensure they are functioning correctly, this should be undertaken by certified trained professionals.

6.1.2 The level and frequency of maintenance required on site is dependent on the type of facility. The type of maintenance will fall into one of three categories “regular maintenance”, “occasional maintenance” and “remedial maintenance”.

6.1.3 Regular maintenance of the drainage and SuDS features will include, inspections, removal of litter / debris and sweeping of the surfaces. Occasional maintenance will include removal of sediment etc. and remedial maintenance may include structural repairs and infiltration reconditioning if required.

6.1.4 The drainage and SuDS elements after an initial inspection following construction should be inspected on a monthly basis for the first 12 months and after large storms, thereafter the following maintenance regime should be applied and adjusted if the 12-month monitoring process has identified any issues.

6.1.5 Following completion of the development a Management Company will be set up to maintain all the communal areas, including the drainage. It will be their responsibility to maintain the drainage network, including the SuDS elements.

## 6.2 Attenuation Tanks

6.2.1 For the attenuation tanks, the following maintenance is recommended.

| Attenuation Tank Maintenance Schedule | | |
|---|---|---|
| | **Required Action** | **Typical Frequency** |
| **Regular maintenance** | Inspect and identify any areas that are not operating correctly. If required take remedial action | Annually |
| | Remove debris from the catchment surface (where it may cause risk to performance). | Monthly |
| | For systems where rainfall infiltrates in the tank from above, check surface of filter for blockage by sediment, algae or other matter, remove and replace surface infiltration medium as necessary | Annually |
| | Remove sediment from pre-treatment structures. | Annually or as required |
| **Remedial Actions** | Repair/rehabilitate inlets/outlets, overflows and vents. | As required |
| **Monitoring** | Inspect/check all inlets, outlets, vents and overflows to ensure that they are in good condition and operating as designed. | Annually |
| | Survey inside of tanks for sediment build-up and remove if necessary | Every 5 years or as required |

**Table 6.1 – Attenuation Tank Maintenance**

6.2.2 For specialist pieces of equipment, such as the Hydrobrake, maintenance brochures will be provided by the manufacturers. These will set out the frequency of inspections and correct methods of cleaning etc. that should be followed. It is recommended that once installed the facility should be inspected monthly for the first three months and thereafter at six monthly intervals or as advised in the maintenance brochure.

6.2.3 Treatment/inceptors are proposed to treat runoff from the development and the manufacturers recommended maintenance regime is set out in their installation and technical brochures. These will form part of the handover maintenance record for the development.

6.2.4 The above information is only intended as guidance to standard maintenance practise for surface water drainage and SuDS features. The above measures should be reviewed regularly and modified to suit the site conditions.

## 7 SUMMARY AND CONCLUSION

7.1.1 The site is located within the town of Teddington, part of the London Borough of Richmond. The proposed development will include the construction 14 new residential units made up of different tenure. A new car park will also be provided as well as cycle storage spaces.

7.1.2 The site lies upon a bedrock of London Clay, which consists mainly of clay and silt. This therefore excludes the use of infiltration techniques for discharge of surface water. There are also no watercourses located within the immediate vicinity of the site. Therefore, surface water runoff will discharge to the existing Thames Water sewer located beneath Hampton Road to the south.

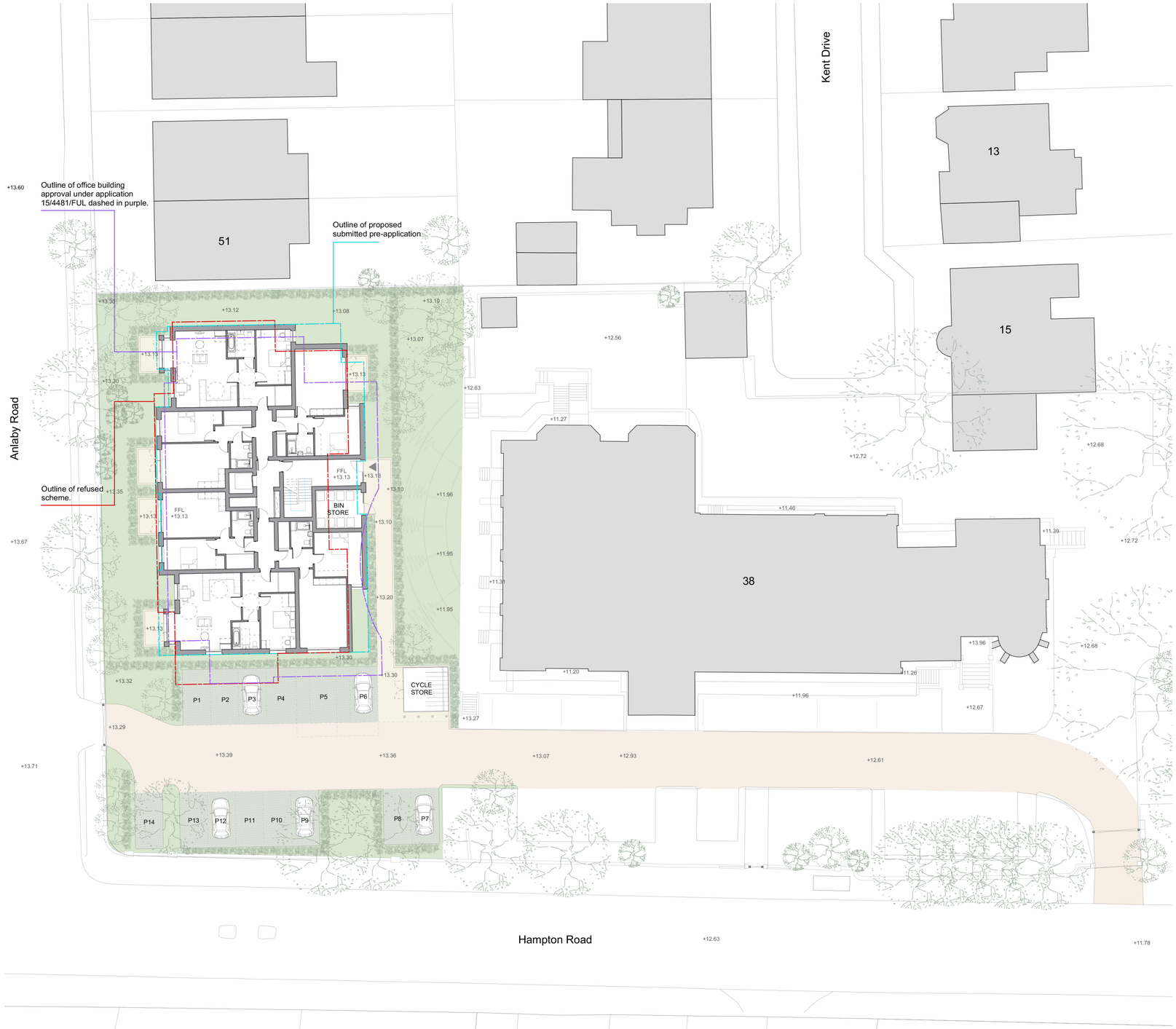
7.1.3 The surface water runoff will discharge to the public sewer via an attenuation tank restricted by a HydroBrake set at 2.0 l/s. This equates to an 85 % reduction in the peak discharge rate compared to the existing Brownfield runoff.

7.1.4 This report has proved that the drainage strategy proposed is within accordance of the Sustainable Drainage Hierarchy. Therefore, suitable foul and surface water drainage can be provided for the proposed development.

7.1.5 For the reasons outlined within this drainage strategy, we see no reason to refuse planning permission on the grounds of there being insufficient capacity to discharge runoff from the development.

# APPENDIX A

L1000 – Proposed Development Plan




1 Proposed Site Plan
Scale: 1:200

0 5 25 M


2 Proposed Block Plan
Scale: 1:500

0 5 25 M

DISCLAIMER

Do not scale from this drawing.
Drawings based on survey information provided by others.
Verify all dimensions on site.
Drawing should be read in conjunction with information from all other design consultants and contractors.
All drawings in digital format are for reference only, paper copies are available on request.


| Rev | Date | Reason for Issue | Chk |
|---|---|---|---|
| | | | |
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| Rev | Date | Reason for Issue | Chk |
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PROGRESS PLANNING
Land & Development
Progress Planning
Waterside House 20 Riverside Way
Uxbridge UB8 2YF

Project Title
38-42 Hampton Rd, Teddington TW11 0JE

Project Number
022

Date
June 2019

Drawing Title
Proposed Site Plan & Block Plan

Drawing Number
L1000

Revision
-

Drawing Status
Preliminary

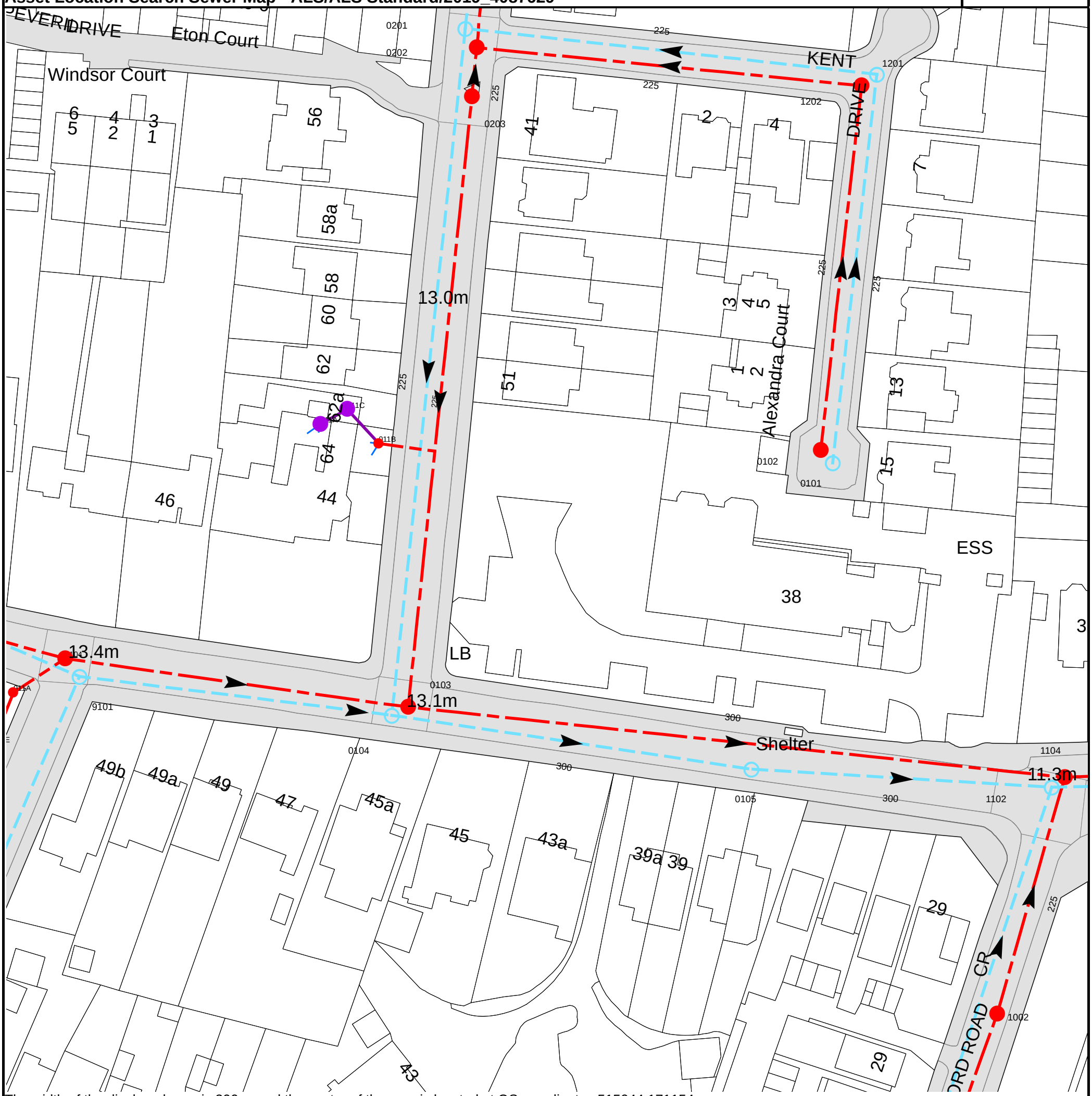
Scale / North Point
1:200 @ A1 / 1:400 @ A3
1:500 @ A1 / 1:1000 @ A3

N

# APPENDIX B

Thames Water Asset Mapping

**Asset Location Search Sewer Map - ALS/ALS Standard/2019_4087629**




The width of the displayed area is 200 m and the centre of the map is located at OS coordinates 515044,171154

**The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.**

NB. Levels quoted in metres Ordnance Newlyn Datum. The value -9999.00 indicates that no survey information is available

| Manhole Reference | Manhole Cover Level | Manhole Invert Level |
|---|---|---|
| 1002 | n/a | n/a |
| 1102 | n/a | n/a |
| 1104 | n/a | n/a |
| 0105 | n/a | n/a |
| 0101 | n/a | n/a |
| 0102 | n/a | n/a |
| 0203 | n/a | n/a |
| 1202 | n/a | n/a |
| 1201 | n/a | n/a |
| 0202 | n/a | n/a |
| 0201 | n/a | n/a |
| 011A | 10.25 | 9.55 |
| 011C | 10.22 | 9.42 |
| 0104 | n/a | n/a |
| 0103 | n/a | n/a |
| 911A | n/a | n/a |
| 9101 | n/a | n/a |
| 9104 | n/a | n/a |
| 011B | 10.48 | 8.86 |

**The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.**

# ALS Sewer Map Key

## Public Sewer Types (Operated & Maintained by Thames Water)

**Foul:** A sewer designed to convey waste water from domestic and industrial sources to a treatment works.

**Surface Water:** A sewer designed to convey surface water (e.g. rain water from roofs, yards and car parks) to rivers or watercourses.

**Combined:** A sewer designed to convey both waste water and surface water from domestic and industrial sources to a treatment works.

Trunk Surface Water

Trunk Foul

Storm Relief

Trunk Combined

Vent Pipe

Bio-solids (Sludge)

Proposed Thames Surface Water Sewer

Proposed Thames Water Foul Sewer

Gallery

Foul Rising Main

Surface Water Rising Main

Combined Rising Main

Sludge Rising Main

Proposed Thames Water Rising Main

Vacuum

## Sewer Fittings

A feature in a sewer that does not affect the flow in the pipe. Example: a vent is a fitting as the function of a vent is to release excess gas.

Air Valve

Dam Chase

Fitting

Meter

Vent Column

## Operational Controls

A feature in a sewer that changes or diverts the flow in the sewer. Example: A hydrobrake limits the flow passing downstream.

Control Valve

Drop Pipe

Ancillary

Weir

## End Items

End symbols appear at the start or end of a sewer pipe. Examples: an Undefined End at the start of a sewer indicates that Thames Water has no knowledge of the position of the sewer upstream of that symbol, Outfall on a surface water sewer indicates that the pipe discharges into a stream or river.

Outfall

Undefined End

Inlet

## Other Symbols

Symbols used on maps which do not fall under other general categories

Public/Private Pumping Station

Change of characteristic indicator (C.O.C.I.)

Invert Level

Summit

**Areas**

Lines denoting areas of underground surveys, etc.

Agreement

Operational Site

Chamber

Tunnel

Conduit Bridge

## Other Sewer Types (Not Operated or Maintained by Thames Water)

Foul Sewer

Surface Water Sewer

Combined Sewer

Gulley

Culverted Watercourse

Proposed

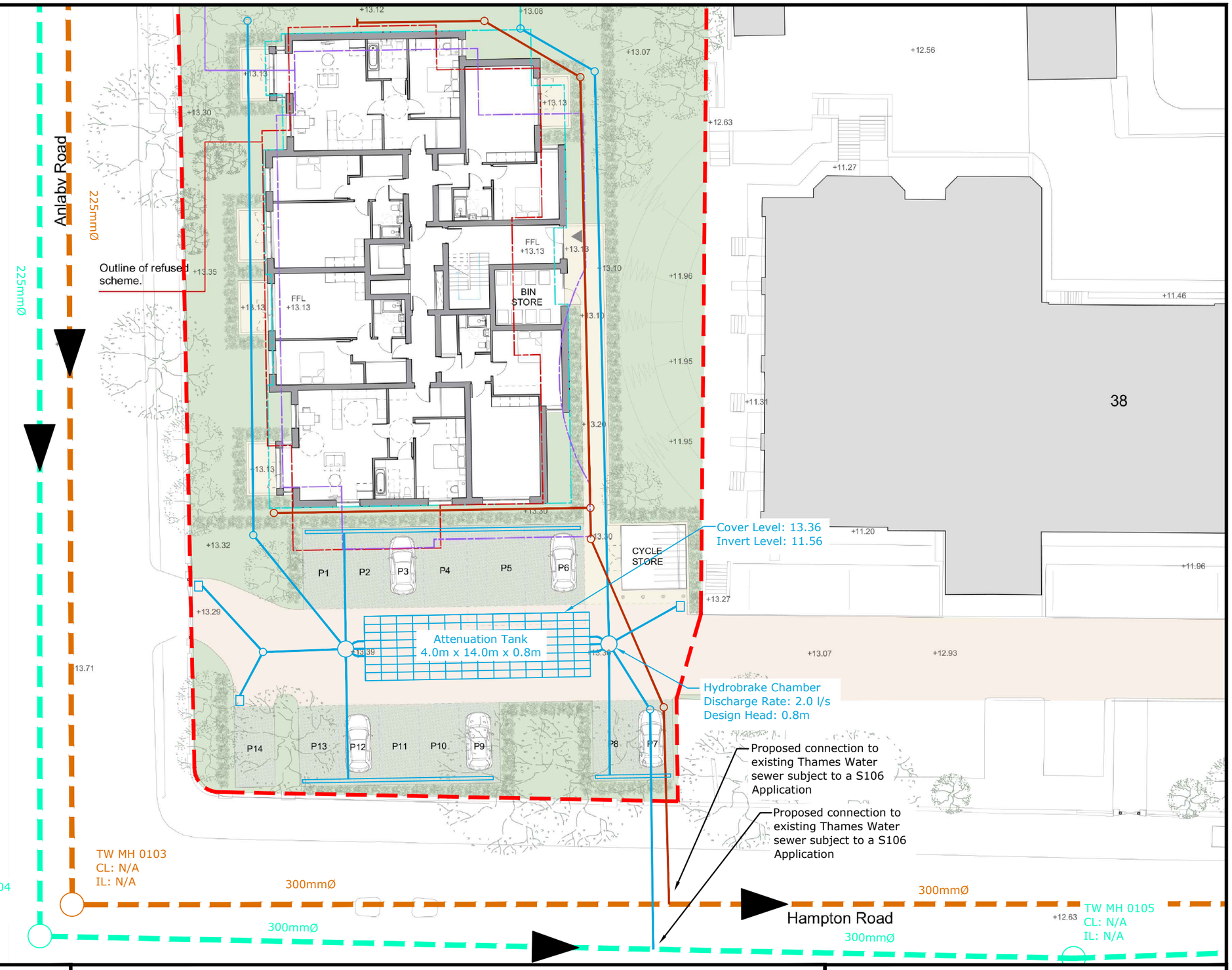
Abandoned Sewer

**Notes:**

1) All levels associated with the plans are to Ordnance Datum Newlyn.
2) All measurements on the plans are metric.
3) Arrows (on gravity fed sewers) or flecks (on rising mains) indicate direction of flow.
4) Most private pipes are not shown on our plans, as in the past, this information has not been recorded.
5) 'na' or '0' on a manhole level indicates that data is unavailable.
6) The text appearing alongside a sewer line indicates the internal diameter of the pipe in milimetres. Text next to a manhole indicates the manhole reference number and should not be taken as a measurement. If you are unsure about any text or symbology present on the plan, please contact a member of Property Insight on 0845 070 9148.

# APPENDIX C

191213/DS/01 – Proposed Drainage Strategy




Howarth Homes

38-42 Hampton Road
Teddington

Drainage Strategy
Site Plan

| SCALE | DRAWN BY | PRJ No. | DWG No. |
|---|---|---|---|
| 1:250 | JR | 191213 | 191213/DS/01 |

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# APPENDIX D

Greenfield Calculations

## ICP SUDS Mean Annual Flood

Input

| | | | |
|---|---|---|---|
| Return Period (years) | 100 | Soil | 0.300 |
| Area (ha) | 0.161 | Urban | 0.000 |
| SAAR (mm) | 600 | Region Number | Region 6 |

**Results l/s**

| | |
|---|---|
| QBAR Rural | 0.2 |
| QBAR Urban | 0.2 |
| Q100 years | 0.8 |
| Q1 year | 0.2 |
| Q30 years | 0.6 |
| Q100 years | 0.8 |

Attenuation Tank Calculations

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

| Storm Event | Max Level (m) | Max Depth (m) | Max Control (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|
| 15 min Summer | 12.025 | 0.425 | 2.0 | 23.8 | O K |
| 30 min Summer | 12.144 | 0.544 | 2.0 | 30.4 | O K |
| 60 min Summer | 12.242 | 0.642 | 2.0 | 36.0 | O K |
| 120 min Summer | 12.295 | 0.695 | 2.0 | 38.9 | O K |
| 180 min Summer | 12.290 | 0.690 | 2.0 | 38.6 | O K |
| 240 min Summer | 12.274 | 0.674 | 2.0 | 37.7 | O K |
| 360 min Summer | 12.237 | 0.637 | 2.0 | 35.7 | O K |
| 480 min Summer | 12.200 | 0.600 | 2.0 | 33.6 | O K |
| 600 min Summer | 12.164 | 0.564 | 2.0 | 31.6 | O K |
| 720 min Summer | 12.126 | 0.526 | 2.0 | 29.5 | O K |
| 960 min Summer | 12.043 | 0.443 | 2.0 | 24.8 | O K |
| 1440 min Summer | 11.913 | 0.313 | 2.0 | 17.5 | O K |
| 2160 min Summer | 11.788 | 0.188 | 2.0 | 10.5 | O K |
| 2880 min Summer | 11.724 | 0.124 | 1.8 | 6.9 | O K |
| 4320 min Summer | 11.680 | 0.080 | 1.5 | 4.5 | O K |
| 5760 min Summer | 11.664 | 0.064 | 1.2 | 3.6 | O K |
| 7200 min Summer | 11.656 | 0.056 | 1.0 | 3.1 | O K |
| 8640 min Summer | 11.650 | 0.050 | 0.9 | 2.8 | O K |
| 10080 min Summer | 11.646 | 0.046 | 0.8 | 2.6 | O K |
| 15 min Winter | 12.079 | 0.479 | 2.0 | 26.8 | O K |
| 30 min Winter | 12.213 | 0.613 | 2.0 | 34.3 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 15 min Summer | 138.754 | 0.0 | 25.2 | 18 |
| 30 min Summer | 90.906 | 0.0 | 33.0 | 33 |
| 60 min Summer | 56.713 | 0.0 | 41.2 | 62 |
| 120 min Summer | 34.176 | 0.0 | 49.7 | 120 |
| 180 min Summer | 25.072 | 0.0 | 54.7 | 166 |
| 240 min Summer | 20.006 | 0.0 | 58.2 | 194 |
| 360 min Summer | 14.514 | 0.0 | 63.3 | 260 |
| 480 min Summer | 11.557 | 0.0 | 67.2 | 328 |
| 600 min Summer | 9.678 | 0.0 | 70.4 | 398 |
| 720 min Summer | 8.369 | 0.0 | 73.0 | 468 |
| 960 min Summer | 6.648 | 0.0 | 77.3 | 596 |
| 1440 min Summer | 4.799 | 0.0 | 83.7 | 836 |
| 2160 min Summer | 3.459 | 0.0 | 90.6 | 1172 |
| 2880 min Summer | 2.739 | 0.0 | 95.6 | 1504 |
| 4320 min Summer | 1.968 | 0.0 | 103.0 | 2204 |
| 5760 min Summer | 1.556 | 0.0 | 108.6 | 2936 |
| 7200 min Summer | 1.295 | 0.0 | 113.1 | 3656 |
| 8640 min Summer | 1.115 | 0.0 | 116.8 | 4384 |
| 10080 min Summer | 0.982 | 0.0 | 120.0 | 5064 |
| 15 min Winter | 138.754 | 0.0 | 28.2 | 18 |
| 30 min Winter | 90.906 | 0.0 | 36.9 | 32 |

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

| Storm Event | Max Level (m) | Max Depth (m) | Max Control (l/s) | Max Volume (m³) | Status |
|---|---|---|---|---|---|
| 60 min Winter | 12.327 | 0.727 | 2.0 | 40.7 | O K |
| 120 min Winter | 12.396 | 0.796 | 2.0 | 44.6 | O K |
| 180 min Winter | 12.398 | 0.798 | 2.0 | 44.7 | O K |
| 240 min Winter | 12.376 | 0.776 | 2.0 | 43.4 | O K |
| 360 min Winter | 12.329 | 0.729 | 2.0 | 40.8 | O K |
| 480 min Winter | 12.279 | 0.679 | 2.0 | 38.0 | O K |
| 600 min Winter | 12.226 | 0.626 | 2.0 | 35.0 | O K |
| 720 min Winter | 12.172 | 0.572 | 2.0 | 32.0 | O K |
| 960 min Winter | 12.045 | 0.445 | 2.0 | 24.9 | O K |
| 1440 min Winter | 11.855 | 0.255 | 2.0 | 14.3 | O K |
| 2160 min Winter | 11.718 | 0.118 | 1.8 | 6.6 | O K |
| 2880 min Winter | 11.682 | 0.082 | 1.5 | 4.6 | O K |
| 4320 min Winter | 11.660 | 0.060 | 1.1 | 3.3 | O K |
| 5760 min Winter | 11.651 | 0.051 | 0.9 | 2.8 | O K |
| 7200 min Winter | 11.645 | 0.045 | 0.7 | 2.5 | O K |
| 8640 min Winter | 11.641 | 0.041 | 0.6 | 2.3 | O K |
| 10080 min Winter | 11.638 | 0.038 | 0.6 | 2.1 | O K |

| Storm Event | Rain (mm/hr) | Flooded Volume (m³) | Discharge Volume (m³) | Time-Peak (mins) |
|---|---|---|---|---|
| 60 min Winter | 56.713 | 0.0 | 46.2 | 62 |
| 120 min Winter | 34.176 | 0.0 | 55.6 | 118 |
| 180 min Winter | 25.072 | 0.0 | 61.2 | 172 |
| 240 min Winter | 20.006 | 0.0 | 65.2 | 220 |
| 360 min Winter | 14.514 | 0.0 | 70.9 | 276 |
| 480 min Winter | 11.557 | 0.0 | 75.3 | 354 |
| 600 min Winter | 9.678 | 0.0 | 78.8 | 432 |
| 720 min Winter | 8.369 | 0.0 | 81.8 | 506 |
| 960 min Winter | 6.648 | 0.0 | 86.6 | 642 |
| 1440 min Winter | 4.799 | 0.0 | 93.8 | 866 |
| 2160 min Winter | 3.459 | 0.0 | 101.4 | 1172 |
| 2880 min Winter | 2.739 | 0.0 | 107.1 | 1496 |
| 4320 min Winter | 1.968 | 0.0 | 115.4 | 2204 |
| 5760 min Winter | 1.556 | 0.0 | 121.7 | 2928 |
| 7200 min Winter | 1.295 | 0.0 | 126.6 | 3672 |
| 8640 min Winter | 1.115 | 0.0 | 130.8 | 4368 |
| 10080 min Winter | 0.982 | 0.0 | 134.4 | 5080 |

## 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) | 20.000 | Shortest Storm (mins) | 15 |
| Ratio R | 0.405 | Longest Storm (mins) | 10080 |
| Summer Storms | Yes | Climate Change % | +40 |

## Time Area Diagram

Total Area (ha) 0.097

| Time (mins) From: | To: | Area (ha) |
|---|---|---|
| 0 | 4 | 0.097 |

## Model Details

Storage is Online Cover Level (m) 13.400

## Tank or Pond Structure

Invert Level (m) 11.600

| Depth (m) | Area (m²) | Depth (m) | Area (m²) | Depth (m) | Area (m²) |
|---|---|---|---|---|---|
| 0.000 | 56.0 | 0.800 | 56.0 | 0.801 | 0.0 |

## Hydro-Brake Optimum® Outflow Control

| | |
|---|---|
| Unit Reference | MD-SHE-0070-2000-0800-2000 |
| Design Head (m) | 0.800 |
| Design Flow (l/s) | 2.0 |
| Flush-Flo™ | Calculated |
| Objective | Minimise upstream storage |
| Diameter (mm) | 70 |
| Invert Level (m) | 11.600 |
| Minimum Outlet Pipe Diameter (mm) | 100 |
| Suggested Manhole Diameter (mm) | 1200 |

| Control Points | Head (m) | Flow (l/s) |
|---|---|---|
| Design Point (Calculated) | 0.800 | 2.0 |
| Flush-Flo™ | 0.238 | 2.0 |
| Kick-Flo® | 0.502 | 1.6 |
| Mean Flow over Head Range | - | 1.7 |

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 | 1.8 | 1.200 | 2.4 | 3.000 | 3.6 | 7.000 | 5.4 |
| 0.200 | 2.0 | 1.400 | 2.6 | 3.500 | 3.9 | 7.500 | 5.6 |
| 0.300 | 2.0 | 1.600 | 2.7 | 4.000 | 4.2 | 8.000 | 5.8 |
| 0.400 | 1.9 | 1.800 | 2.9 | 4.500 | 4.4 | 8.500 | 5.9 |
| 0.500 | 1.6 | 2.000 | 3.0 | 5.000 | 4.6 | 9.000 | 6.1 |
| 0.600 | 1.7 | 2.200 | 3.2 | 5.500 | 4.8 | 9.500 | 6.3 |
| 0.800 | 2.0 | 2.400 | 3.3 | 6.000 | 5.0 | | |
| 1.000 | 2.2 | 2.600 | 3.4 | 6.500 | 5.2 | | |

Event: 180 min Winter