12-14 Station Road and Nos 13, 19-33 Lower Teddington Road, Hampton Wick, KT1 4EU

NPPF: Flood Risk Assessment

For CIRC Construction Limited

KRS.0232.003.R.001.A

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www.krsenvironmental.com

CONTACT DETAILS

Registered Office:
KRS Environmental Ltd
3 Princes Square
Princes Street
Montgomery
Powys
SY15 6PZ

Tel: 01686 668957
Mob: 07857 264 376

Office also at:
KRS Environmental Ltd
The Media Centre
7 Northumberland Street
Huddersfield
West Yorkshire
HD1 1RL

Tel: 01484 437420
Mob: 07857 264 376

Email: keelan@krsenvironmental.com
Web: www.krsenvironmental.com
LinkedIn: uk.linkedin.com/in/keelanserjeant/

12-14 Station Road and Nos 13 and 19-33 Lower Teddington Road, Hampton Wick, KT1 4EU	
Project	NPPF: Flood Risk Assessment
Client	CIRC Construction Limited
Status	Final
Prepared by	Keelan Serjeant BSc (Hons), MSc, MCIWEM
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EXECUTIVE SUMMARY

An independent senior living extra care development would be expected to remain dry in all but the most extreme conditions. Providing the recommendations made in this FRA are instigated, flood risk from all sources would be minimised, the consequences of flooding are acceptable, and the development would be in accordance with the requirements of the NPPF.

The adoption of a SUDS Strategy for the site will further reduce the risk of flooding to the site and off-site locations. This FRA demonstrates that the proposed development would be operated with minimal risk from flooding, would not increase flood risk elsewhere and is compliant with the requirements of the NPPF. The development should not therefore be precluded on the grounds of flood risk.

1.0 INTRODUCTION

1.1 Background

This Flood Risk Assessment (FRA) has been prepared by KRS Environmental Limited at the request of CIRC Construction Limited to support a planning application for the proposed development at 12-14 Station Road and 13 and 19-33 Lower Teddington Road, Hampton Wick, KT1 4EU. This FRA includes an assessment of the existing and proposed surface water drainage of the site.

A separate Flood Risk Mitigation Strategy) (KRS.0232.003.R.002.A) and Flood Warning & Evacuation Plan (KRS.0232.003.R.003.A) have been written for the site proposals.

This FRA has been carried out in accordance with guidance contained in the National Planning Policy Framework (NPPF)[1] and associated Planning Practice Guidance[2]. This FRA identifies and assesses the risks of all forms of flooding to and from the development and demonstrates how these flood risks will be managed so that the development remains safe throughout the lifetime, taking climate change into account.

It is recognised that developments which are designed without regard to flood risk may endanger lives, damage property, cause disruption to the wider community, damage the environment, be difficult to insure and require additional expense on remedial works. The development design should be such that future users will not have difficulty obtaining insurance or mortgage finance, or in selling all or part of the development, as a result of flood risk issues.

1.2 National Planning Policy Framework (NPPF)

One of the key aims of the NPPF is to ensure that flood risk is taken into account at all stages of the planning process; to avoid inappropriate development in areas at risk of flooding and to direct development away from areas of highest risk.

It advises that where new development is exceptionally necessary in areas of higher risk, this should be safe, without increasing flood risk elsewhere, and where possible, reduce flood risk overall.

A risk based approach is adopted at stages of the planning process, applying a source pathway receptor model to planning and flood risk. To demonstrate this, an FRA is required and should include:

- whether a proposed development is likely to be affected by current or future flooding from all source;
- whether it will increase flood risk elsewhere;
- whether the measures proposed to deal with these effects and risks are appropriate;
- if necessary provide the evidence to the Local Planning Authority (LPA) that the Sequential Test can be applied; and
- whether the development will be safe and pass part c) of the Exception Test if this is appropriate.

1.3 Report Structure

[1] Ministry of Housing, Communities and Local Government (July 2018) National Planning Policy Framework.
[2] Communities and Local Government (2014) Planning Practice Guidance - Flood Risk and Coastal Change.

This FRA has the following report structure:

- Section 2 details the sources of information that have been consulted;
- Section 3 describes the location area and the existing and proposed development;
- Section 4 outlines the flood risk to the existing and proposed development;
- Section 5 details the proposed surface water drainage for the site and assesses the potential impacts of the proposed development on surface water drainage;
- Section 6 outlines mitigation measures to reduce the overall level of flood risk;
- Section 7 details the sequential and exception tests; and
- Section 8 presents a summary and conclusions.

2.0 SOURCES OF INFORMATION

2.1 Discussion with Regulators

Consultation and discussions with the relevant regulators have been undertaken during this FRA including the Environment Agency, the Local Planning Authority (LPA), the Lead Local Flood Authority (LLFA) and Sewerage Undertakers.

2.1.1 Environment Agency

The Flood and Water Management Act 2010 gives the Environment Agency a strategic overview role for all forms of flooding and coastal erosion. They also have direct responsibility for the prevention, mitigation and remediation of flood damage for main rivers and coastal areas. The Environment Agency is the statutory consultee with regards to flood risk and planning.

Environment Agency Flood Risk Standing Advice for England, the NPPF and Technical Guidance to the NPPF has been consulted and reviewed during this FRA. This has confirmed the level of FRA required and that a surface water drainage assessment is to be undertaken. Information regarding the current flood risk at the application site and local flood defences has been obtained from the Environment Agency.

2.1.2 London Borough of Richmond upon Thames

The London Borough of Richmond upon Thames is the LPA and the LLFA and has responsibilities for 'local flood risk', which includes surface runoff, groundwater and ordinary watercourses. Planning guidance written by the London Borough of Richmond upon Thames regarding flood risk was consulted to assess the mitigation policies in place.

The London Borough of Richmond upon Thames Strategic Flood Risk Assessment (SFRA) and the London Borough of Richmond upon Thames Preliminary Flood Risk Assessment (PFRA) which cover the site have been reviewed.

2.1.3 Thames Water

Thames Water is responsible for the disposal of waste water and supply of clean water for this area. Information with regards to sewer and water main flooding contained within the London Borough of Richmond upon Thames SFRA and the London Borough of Richmond upon Thames PFRA have been consulted as part of this FRA. All Water Companies have a statutory obligation to maintain a register of properties/areas which are at risk of flooding from the public sewerage system, and this is shown on the DG5 Flood Register.

3.0 LOCATION & DEVELOPMENT DESCRIPTION

3.1 Site Location

The site is located at 12-14 Station Road and Nos 13 and 19-33 Lower Teddington Road, Hampton Wick, KT1 4EU (see Figure 1). The National Grid Reference (NGR) of the site is 517619, 169736.

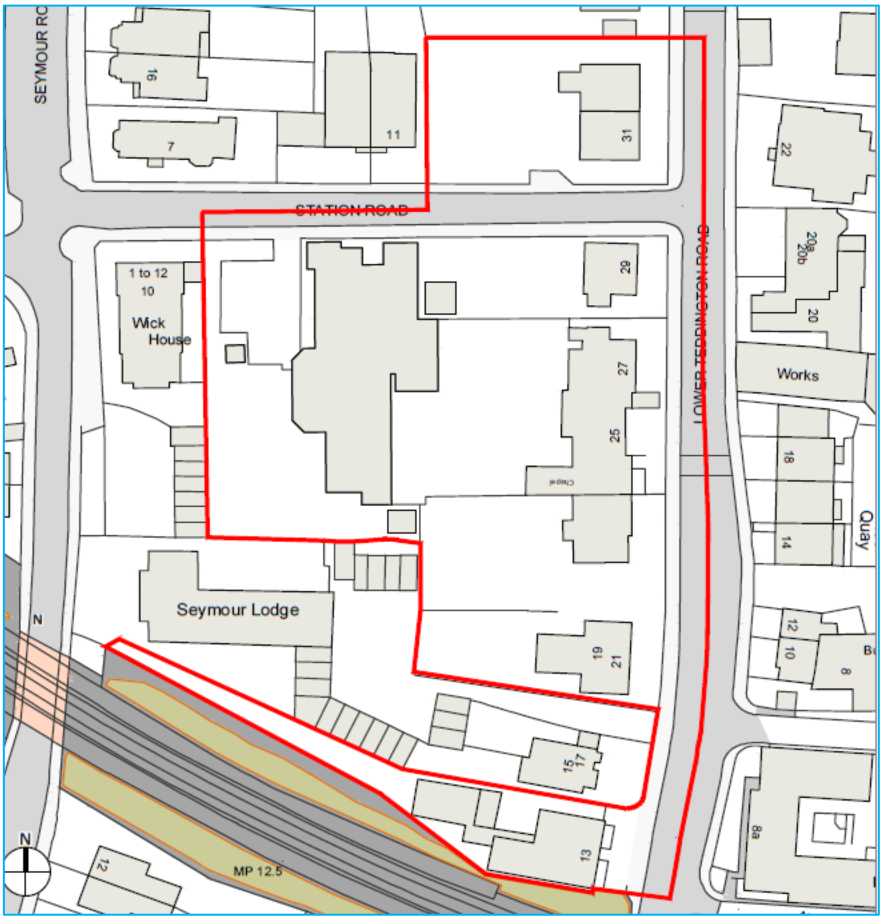


Figure 1 - Site Location

3.2 Existing Development

The current site consists of a redundant care home, office and meeting rooms and residential uses.

3.3 Proposed Development

This planning application is for the demolition of the existing care home and erection of an independent senior living extra care building comprising 28 units (following demolition of the existing care home) at 12-14 Station Road; the refurbishment and renovation of Nos.13 and 23-33 Lower Teddington Road (including the erection of a single storey rear extension to No.23 and the change of use of No.13 from office to residential); the erection of a temporary sales building to the rear of Nos 31-33 Lower Teddington Road; and associated landscape planting and car parking (see Appendix 1). Further details with regard to the proposed development can be found in the accompanying information submitted with the planning application.

3.4 Ground Levels

A topographical survey of the site has recently been undertaken (see Appendix 2). The site rises from south to north and from east to west. The minimum ground levels to the south east of the site is 7.30 metres Above Ordnance Datum (mAOD) with ground levels rising to 8.87mAOD to the north of the site. Lower Teddington Road rises to the north with ground levels rising from 7.15mAOD to 8.22mAOD adjacent to the eastern boundary of the site and Station Road rises to the west with ground levels rising from 8.19mAOD to 8.84mAOD.

3.5 Catchment Hydrology / Drainage

The River Thames is located approximately 100m to the west of the site. There are no other watercourses evident either on, or within the vicinity of the site. Currently the surface and foul water from the site drains to the public sewers.

3.6 Ground Conditions

It is understood that the site is underlain by Made Ground. The British Geological Survey (BGS) Map indicates that the bedrock underlying the site consists of the Claygate Member - sand, silt and clay. The superficial deposits consist of the Taplow Gravel Formation - sand, silt and clay. Information from the National Soil Resource Institute[3] details the site area as being situated on freely draining slightly acid loamy soils.

3.7 Groundwater

The Environment Agency has designated the bedrock deposits as a Secondary A Aquifer - permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.

The superficial deposits are designated as a Principal Aquifer - these are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.

3.8 Source Protection Zone

The site is not located within an Environment Agency Source Protection Zone.

[3] https://www.landis.org.uk/soilscapes/

4.0 FLOOD RISK

4.1 Sources of Flooding

All sources of flooding have been considered, these are; fluvial (river) flooding, tidal (coastal) flooding, groundwater flooding, surface water (pluvial) flooding, sewer flooding and flooding from artificial drainage systems/infrastructure failure.

The key consequences of flooding are death/personal injury, extensive damage to property, properties uninhabitable for long periods, properties cannot be sold, insurance unavailable or too expensive, expense of installing flood resilience measures and business interruptions.

4.2 Historic Flooding

There are no records of anecdotal information of flooding at the site. The Environment Agency has confirmed that the site has not historically flooded. The British Hydrological Society "Chronology of British Hydrological Event[4]" has no information on flooding within the vicinity of the site. No other historical records of flooding for the site have been recorded. Therefore, it has been assumed that the site has not flooded in the recent past (i.e. the last thousand years).

4.3 Existing and Planned Flood Defence Measures

The Environment Agency are currently working on The River Thames Scheme from Datchet to Teddington. The scheme proposes measures to reduce the risk of flooding to the 15,000 properties which are currently at risk from flooding in the area. These measures include the construction of three flood diversion channels, increasing the capacity to Desborough Cut and improvements to Sunbury and Molesey Weirs and Teddington Lock. It also includes community based measures for improving resistance and resilience to flooding for smaller groups of properties and improving mapping information for emergency evacuation plans.

4.4 Environment Agency Flood Zones

A review of the Environment Agency's Flood Zones indicates that the majority of the site is located within Flood Zone 1 with a 'low probability' of flooding as shown in Figure 2, with less than a 1 in 1000 annual probability of river flooding in any year (<0.1%). However, a small proportion of the site, to the south east, is located within Flood Zone 2 with a 'medium probability' of flooding with between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% - 0.1%) in any year. It should be noted that this area of the site is located on the very edge of Flood Zone 2, areas immediately adjacent to the north and west of the site are located within Flood Zone 1 with a 'low probability' of flooding, with less than a 1 in 1000 annual probability of river flooding in any year (<0.1%). This has been confirmed within the London Borough of Richmond upon Thames SFRA (see Appendix 3).

The Flood Zones are the current best information on the extent of the extremes of flooding from rivers or the sea that would occur <u>without the presence of flood defences</u>, because these can be breached, overtopped and may not be in existence for the lifetime of the development. Therefore, Flood Zones show the worst case scenario.

The Environment Agency Flood Zones and acceptable development types are explained in Table 1. Table 1 shows that most development types are generally acceptable in Flood Zones 1 and 2.

[4] http://www.dundee.ac.uk/geography/cbhe/

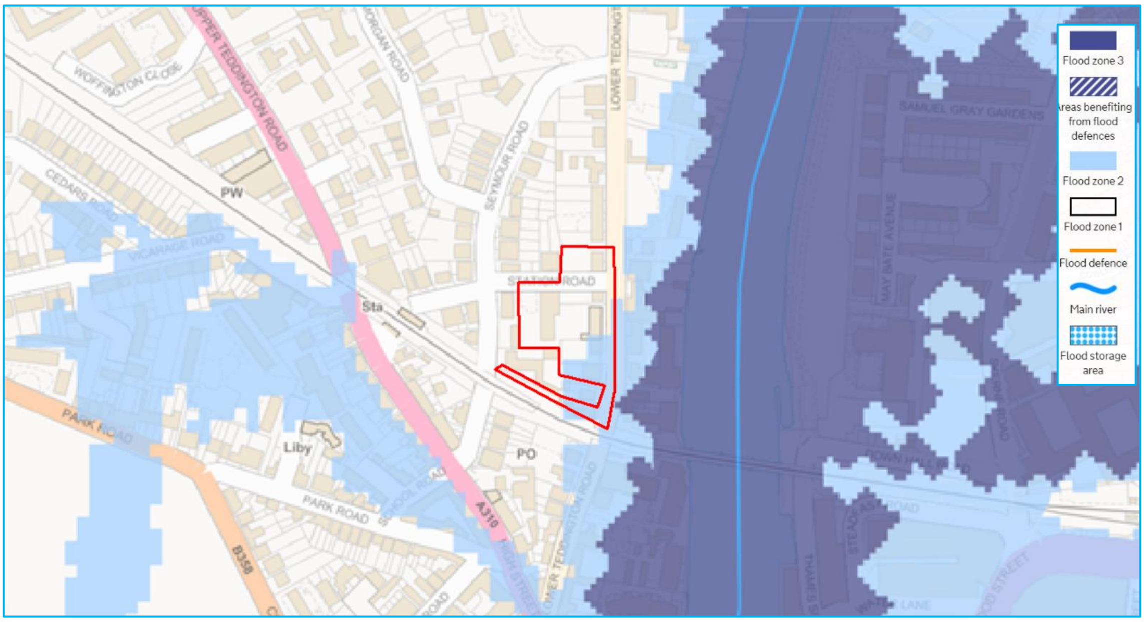


Figure 2 - Environment Agency Reservoir Flood Zones

4.5 Flood Risk Vulnerability

In the Planning Practice Guidance appropriate uses have been identified for the Flood Zones. Applying the Flood Risk Vulnerability Classification in the Planning Practice Guidance, the existing and proposed use of the site is 'more vulnerable'.

The overall number of people accommodated within the site will be reduced from 89 to 69. Therefore, the vulnerability of the site will not change as part of the planning application. The proposals do not constitute a change from to a 'less vulnerable' use to a 'more vulnerable' use. The proposed development will not therefore increase the vulnerability of the development or introduce new development in the Flood Zones.

The proposed development will actually reduce the vulnerability of the site to flooding. The proposed development will improve the sites resilience, resistance to flooding and by using property level protection measures to protect the site from flooding the vulnerability of the site will be improved (see Section 6.0). Tables 1 and 2 of this report and the Planning Practice Guidance state that 'more vulnerable' uses are appropriate within Flood Zones 1 and 2 after the completion of a satisfactory FRA.

Table 1 - Environment Agency Flood Zones and Appropriate Land Use

Flood Zone	Probability	Explanation	Appropriate Land Use
Zone 1	Low	Less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%)	All development types generally acceptable
Zone 2	Medium	Between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% - 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% - 0.1%) in any year	Most development type are generally acceptable
Zone 3a	High	A 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year	Some development types not acceptable
Zone 3b	'Functional Floodplain'	Land where water has to be flow or be stored in times of flood. SFRAs should identify this zone (land which would flood with an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme (0.1% flood, or at another probability to be agreed between the LPA and the Environment Agency, including water conveyance routes)	Some development types not acceptable

Table 2 - Flood Risk Vulnerability and Flood Zone 'Compatibility'

Flood Risk Vulnerability Classification	Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	✓	Exception test required	✓	✓
Zone 3a	Exception test required	✓	×	Exception test required	✓
Zone 3b 'Functional Floodplain'	Exception test required	✓	×	×	×

Key:

✓*: Development is appropriate,* ×*: Development should not be permitted.*

4.6 Climate Change

Projections of future climate change, in the UK, indicate more frequent, short-duration, high intensity rainfall and more frequent periods of long duration rainfall. Guidance included within the NPPF recommends that the effects of climate change are incorporated into FRA. Recommended precautionary sensitivity ranges for peak rainfall intensities and peak river flows are outlined in the associated Planning Practice Guidance to the NPPF[5].

Table 3 show peak river flow allowances by river basin district. The flood risk assessments: climate change allowances guidance recommends that for 'more vulnerable' uses in Flood Zones 1 and 2 that

[5] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#high-allowances.

the higher central allowances are used. Therefore, the 1 in 100 year (+35%) water level has been used as the design flood level.

Table 3 - Peak River Flow Allowances by River Basin District (use 1961 to 1990 baseline)

River basin district	Allowance category	2015 to 2039	2040 to 2059	2060 to 2115
Thames	Upper end	+25%	+35%	+70%
	Higher central	+15%	+25%	+35%
	Central	+10%	+15%	+25%

Using the Environment Agency Thames Area Climate Change Allowance Advice, the proposed development is designated as a minor development therefore, the basic level of assessment is appropriate and an allowance for climate change can be added on to the 1 in 100 year water level, as shown in Table 4.

Table 4 - Allowances for Potential Climate Change Impacts (mm)

Central	Higher central	Upper
500	700	1000

4.7 Fluvial (river) Flooding

The River Thames is located approximately 100m to the west of the site and therefore, poses the primary flood risk to the site. Table 5 shows the Environment Agency modelled water levels for the site. Modelled water levels for the 1 in 5 year, 1 in 20 year, 1 in 100 year, 1 in 100 year (+20%) and 1 in 1000 year events have been provided. Using the most conservative approach the modelled water levels from the node Floodplain 1 has been used to assess the flood risk to the site.

Table 5 - River Thames Water Levels (mAOD)

Node	Return Period (years)				
	5	20	100	100 (+20%)	1000
Floodplain 1	N/A	N/A	N/A	7.19	7.95
Floodplain 2	N/A	N/A	N/A	N/A	7.95
Floodplain 3	N/A	N/A	N/A	N/A	7.95
Floodplain 4	N/A	N/A	N/A	N/A	7.79
Floodplain 5	N/A	N/A	N/A	7.19	7.75
Floodplain 6	N/A	N/A	N/A	N/A	8.21
Floodplain 6	N/A	N/A	N/A	7.49	8.34

A qualified assessment of the impact of climate change has been undertaken. A rating curve of the flow and water levels provide by the Environment Agency for node 063TH01_MN_16.061D has been derived from which a rating equation has been developed. By increasing the flows for the 1 in 100 year event by the climate change allowances it is possible to calculate the corresponding water levels.

The difference in the water level for the 1 in 100 year (+20%) between node 063TH01_MN_16.061D and floodplain node 1 is 0.14m which reflects the reduction in water levels within the floodplain compared to the River Thames. This reduction has been factored into the water levels calculated for node 063TH01_MN_16.061D using the rating equation to calculate the climate change water levels for the site. Table 6 shows the climate change water levels for the site. The modelled water levels have been compared to the ground level of the site and areas within the vicinity of the site to assess the flood risk at the site in detail.

Table 6 - River Thames Climate Change Water Levels

	Return Period (years)			
	100 (+20%)	100 (+25%)	100 (+35%)	100 (+70%)
Water Level (mAOD)	7.19	7.32	7.63	8.69

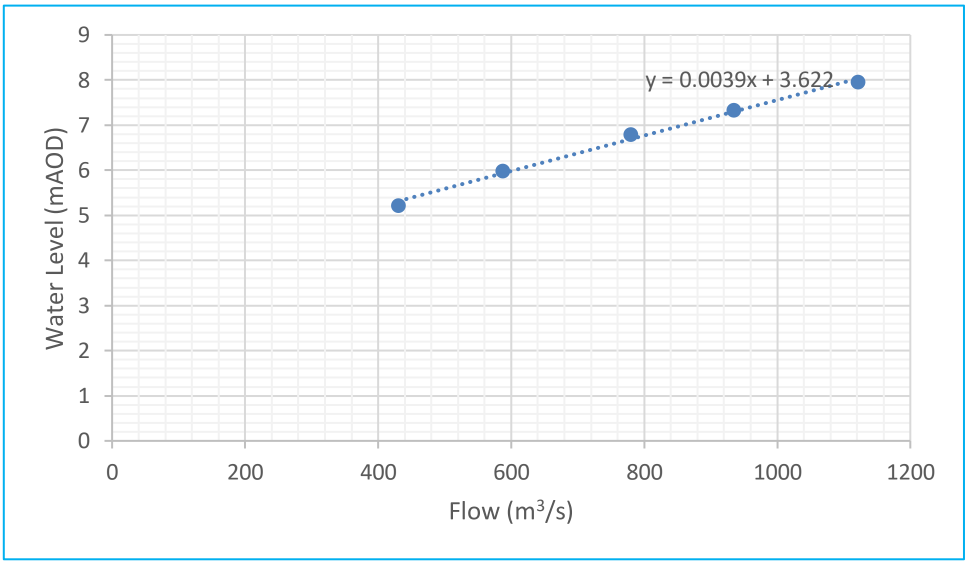


Figure 3 - Rating Curve

The actual risk of flooding caused by overtopping of the river bank during a fluvial flood event on the River Thames will be reduced compared to the extent of flooding shown on the Environment Agency's Flood Zones.

13 Lower Teddington Road

The minimum ground levels within Lower Teddington Road adjacent to 13 Lower Teddington Road are approximately 7.00mAOD. The only way that the floodwater could enter the basement is for it to flow from Lower Teddington Road across the adjacent footway then across the site and into the basement through the lightwell of 13 Lower Teddington Road.

However, the site ground levels are raised above the footway and road, the site falls towards the road (see Figure 4). On the edge of the lightwells is a low up-stand which forms the base to the iron railings with a height of approximately 0.05m. The finished floor level is also raised above the external ground level, with steps at the building entrance.

The concrete boundary wall will restrict the catchment area to direct rainfall, this and the upstand along the front of the lightwell should be sufficient to prevent surface water runoff draining into the front lightwell in all normal circumstances. Therefore, it is unlikely that the basement would be flooded. Externally 13 Lower Teddington Road may be inundated with floodwater to a maximum depth of 0.32m during the 1 in 100 year (+35%) event and 0.95m during the 1 in 1000 year event. This corresponds well with the Flood Zones in Figure 2. In conclusion, it is unlikely that the basement and the ground floor would be flooded.

Figure 4 - 13 Lower Teddington Road

19-21 Lower Teddington Road

The minimum ground levels adjacent to 19-21 Lower Teddington Road are a minimum of 7.33mAOD therefore, 19-21 Lower Teddington Road would not be inundated with floodwater for all events up to and including the 1 in 100 year (+25%) event which has a water level of 7.32mAOD.

The only way that the floodwater could enter the basement is for it to flow from Lower Teddington Road across the adjacent footway then across the site and into the basement through the lightwell of 19-21 Lower Teddington Road. However, on the edge of the 19-21 Lower Teddington Road is a concrete wall a minimum of 0.30m in height with a gated entrance and on the edge of the lightwells is a low up-stand which forms the base to the iron railings with a height of approximately 0.03m and a level of 7.37mAOD (see Figure 5). The site ground levels are raised above the footway and road, the site falls towards the road. The finished floor level is also raised above the external ground level, with steps at the building entrance.

The concrete boundary wall will restrict the catchment to direct rainfall, this and the upstand along the front of the lightwell should be sufficient to prevent surface water runoff draining into the front lightwell in all normal circumstances. Therefore, it is unlikely that the basement would be flooded. Water levels at this cross section have been modelled at 7.63mAOD and 7.95mAOD during the 1 in 100 year (+35%) and 1 in 1000 year events respectively. Therefore, externally 19-21 Lower Teddington Road may be inundated with floodwater to a maximum depth of 0.30m during the 1 in 100 year (+35%) event and 0.62m during the 1 in 1000 year event. This corresponds well with the Flood Zones in Figure 2. In conclusion, it is unlikely that the basement and the ground floor would be flooded.

Figure 5 - 19-21 Lower Teddington Road

23-25 Lower Teddington Road

The minimum ground levels adjacent to 23-25 Lower Teddington Road are a minimum of 7.50mAOD therefore, 19-21 Lower Teddington Road would not be inundated with floodwater for all events up to and including the 1 in 100 year (+25%) event.

The only way that the floodwater could enter the basement is for it to flow from Lower Teddington Road across the adjacent footway then across the site and into the basement through the lightwell of 23-25 Lower Teddington Road. However, on the edge of the 23-25 Lower Teddington Road is concrete wall a minimum of 0.30m with a gated entrance and on the edge of the lightwells is a low up-stand which forms the base to the iron railings with a level of 8.09mAOD (see Figure 6).

The concrete boundary wall will restrict the catchment to direct rainfall, this and the upstand along the front of the lightwell should be sufficient to prevent surface water runoff draining into the front lightwell in all normal circumstances. Therefore, it is unlikely that the basement would be flooded. Water levels at this cross section have been modelled at 7.63mAOD and 7.95mAOD during the 1 in 100 year (+35%) and 1 in 1000 year events respectively. Therefore, externally 19-21 Lower Teddington Road may be inundated with floodwater to a maximum depth of 0.30m during the 1 in 100 year (+35%) event and 0.62m during the 1 in 1000 year event. This corresponds well with the Flood Zones in Figure 2. In conclusion, it is unlikely that the basement and the ground floor would be flooded.

Figure 6 - 23-25 Lower Teddington Road

12-14 House, Station Road, 29-33 Lower Teddington Road

The minimum ground levels adjacent to 12-14 House, Station Road and 29-33 Lower Teddington Road are a minimum of 8.30mAOD therefore, these would not be inundated with floodwater for all events up to and including the 1 in 1000 year event.

Conclusions

The mechanism for flooding from the River Thames is generally prolonged episodes of heavy rainfall, which affords good time for flood warnings to be issued. The likelihood of a rapid river level rise within the River Thames and possible rapid inundation of urban areas posing a risk to life is considered to be minimal. This is primarily due to the large River Thames system and its substantial upper contributing catchment area which allows the Environment Agency, with its current flood warning system, to provide forewarning of two (2) days of a pending flood event.

The site is located within a low risk area where the onset of flooding is very gradual (many hours) as per Flood Risk Assessment Guidance for New Development Phase 2, R&D Technical Report FD2320/TR2. The speed of inundation and rate of floodwater rise would be low. The outputs of the 'Flood Risks to People Methodology' (FD2321/TR11) project indicate that flood depths below 0.25m and velocities below 0.50m/s are generally considered low hazard.

It should be noted that this is the most conservative estimate of flood risk posed by a fluvial flooding as flow would be held in adjacent areas and would enter the road drains. This has been confirmed within the outputs of the 'Flood Risks to People Methodology' (FD2321/TR11) project indicate that flood depths below 0.25m and velocities below 0.50m/s are generally considered low hazard.

The flood risk posed to the site from fluvial sources can be considered to be limited. Any overbank flow would follow the contours of the surrounding area and would flow directly away from the site rather than flowing towards the site. The flood risk can also be considered to be limited due to the difference in elevations. The ground levels of the site are located a minimum of 2.00m above the normal water level of the River Thames. Therefore, the risk of fluvial flooding is considered to be of **low significance**. The risk of fluvial flooding will be further managed and mitigated by using a number of property level protection measures to manage and reduce the overall flood risk at the site (see Section 6.0).

4.8 Tidal (coastal) Flooding

The site is not located within the vicinity of tidal flooding sources and the risk of tidal flooding is considered to be **not significant**. Therefore, flooding from this source has not been considered further within this FRA.

4.9 Groundwater Flooding

Groundwater flooding is defined as the emergence of groundwater at the ground surface or the rising of groundwater into man-made ground under conditions where the normal range of groundwater levels is exceeded.

Groundwater flooding tends to occur sporadically in both location and time. When groundwater flooding does occur, it tends to mostly affect low-lying areas, below surface infrastructure and buildings (for example, tunnels, basements and car parks) underlain by permeable rocks (aquifers).

Site conditions suggest a low probability of groundwater flooding. The risk of flooding from groundwater flooding is considered to be **not significant**. Therefore, flooding from these sources has not been considered further within this FRA.

4.10 Surface Water (pluvial) Flooding

Surface water flooding tends to occur sporadically in both location and time such surface water would tend to be confined to the streets around the development. The site is not situated near to large areas of poor permeability or areas with the geology may result in surface water flooding. The majority of rainfall will infiltrate into the soil substrate and will not runoff as surface water.

The Environment Agency Surface Water flood map shows that the site has a very low risk of surface water flooding (see Figure 7) with a chance of flooding of less than 1 in 1000 (0.1%) years. Surface water flooding poses a very low flood risk to the site. Therefore, the risk of flooding from surface water flooding is considered to be of **low significance.** the risk from this source will be further mitigated by using a number of property level protection measures to manage and reduce the overall flood risk at the site (see Section 6.0).

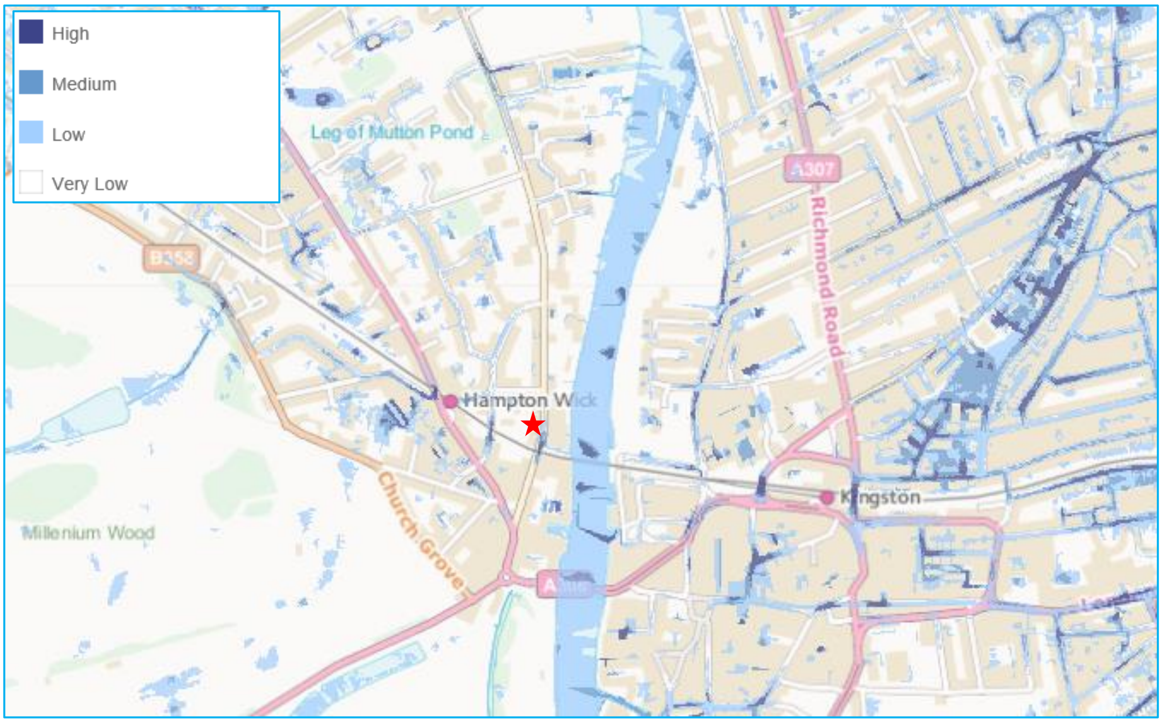


Figure 7 - Environment Agency Surface Water Flood Map

4.11 Sewer Flooding

Sewer flooding occurs when urban drainage networks become overwhelmed and maximum capacity is reached. This can occur if there is a blockage in the network causing water to back up behind it or if the sheer volume of water draining into the system is too great to be handled. Sewer flooding tends to occur sporadically in both location and time such flood flows would tend to be confined to the streets around the development.

It has been assumed that there are existing sewers located within the vicinity of the site and these will inevitably have a limited capacity so in extreme conditions there would be surcharges, which may in turn cause flooding. Flood flows could also be generated by burst water mains, but these would tend to be of a restricted and much lower volume than weather generated events and so can be discounted for the purposes of this assessment.

Given the design parameters normally used for drainage design in recent times and allowing for some deterioration in the performance of the installed systems, which are likely to have been in place for many years, an appropriate flood risk probability from this source could be assumed to have a return period in the order of 1 in 10 to 1 in 20 years.

There are no reported incidents of sewer flooding within the vicinity of the site. The provision of adequate level difference between the ground floors and adjacent ground level would reduce the annual probability of damage to property from this source to 1 in 100 years or less. The risk of flooding from sewer flooding is considered to be **not significant**. Therefore, flooding from these sources has not been considered further within this FRA.

4.12 Flooding from Artificial Drainage Systems/Infrastructure Failure

The site is located within the vicinity of Thames Water reservoirs there are: Queen Mary and Queen Elizabeth II. Figure 8 shows that the site is at risk of flooding from reservoir failure. This map shows the largest area that might be flooded if a reservoir were to fail and release the water it holds.

The Environment Agency Reservoir flood map has been prepared for emergency planning purposes and for this reason they reflect a worst case scenario. Since this is a prediction of a worst case scenario, it's unlikely that any actual flood would be this large. Reservoir flooding is extremely unlikely; reservoirs in the UK have a very good safety record. There has been no loss of life in the UK from reservoir flooding since 1925. Since then reservoir safety legislation has been introduced to make sure reservoirs are well maintained.

The hazard is well managed through effective legislation and it is unlikely that the impact zone downstream of these reservoirs should not allow the proposed development. Reservoir flooding poses a very low flood risk to the site however, the risk of flooding from reservoir flooding is considered to be **not significant**.

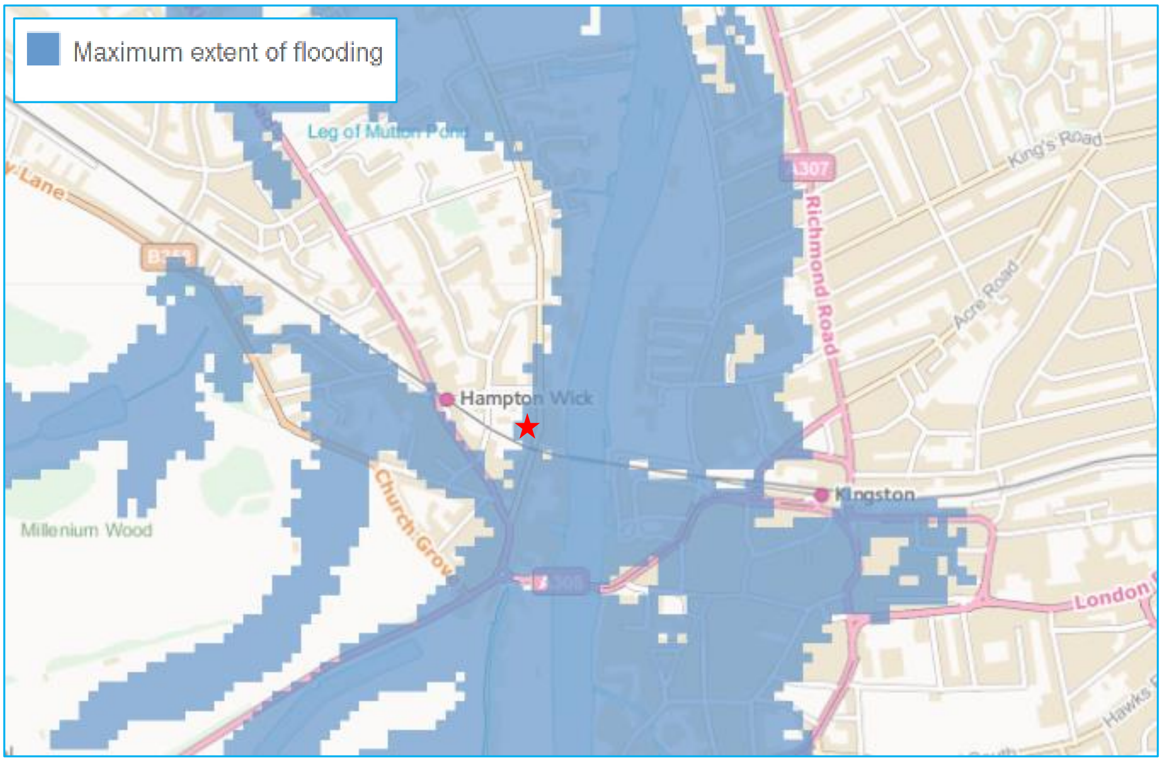


Figure 8 - Environment Agency Reservoir Flood Map

4.13 Site Specific Flood Risk Assessment

A summary of the sources of flooding and a review of the risk posed by each source at the site is shown in Table 7.

Table 7 - Risk Posed by Flooding Sources

Sources of Flooding	Potential Flood Risk	Potential Source	Probability/Significance
Fluvial Flooding	Yes	River Thames	Low
Tidal Flooding	No	None Reported	None
Groundwater Flooding	No	None Reported	None
Surface Water Flooding	Yes	Poor Permeability	Low
Sewer Flooding	Yes	Local Sewers	Low
Flooding from Artificial Drainage Systems/Infrastructure Failure	No	None Reported	None

The site is unlikely to flood except in extreme conditions. The primary, but unlikely, flood risk to the site is from fluvial flooding from the River Thames. The majority of the site is located within Flood Zone 1 with a 'low probability' of flooding, with less than a 1 in 1000 annual probability of river flooding in any year (<0.1%). A small proportion of the site, to the south east, is located within Flood Zone 2 with a 'medium probability' of flooding with between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% - 0.1%) in any year. It should be noted that this area of the site is located on the very edge of Flood Zone 2, areas immediately adjacent to the north and west of the site are located within Flood Zone 1 with a 'low probability' of flooding, with less than a 1 in 1000 annual probability of river flooding in any year (<0.1%). However, the site has no history of flooding

The site would not be inundated with floodwater for all evets up to and including the 1 in 100 year event. The actual flood risk posed to the site is less than 1 in 100 years (1%). During flood events of a higher magnitude, a small proportion of the site, to the south east, may be flooded externally however, it is unlikely that the basement and the ground floor would be flooded due to the layout of the site.

The mechanism for flooding from the River Thames is generally prolonged episodes of heavy rainfall, which affords good time for flood warnings to be issued. The likelihood of a rapid river level rise within the River Thames and possible rapid inundation of urban areas posing a risk to life is considered to be minimal. This is primarily due to the large River Thames system and its substantial upper contributing catchment area which allows the Environment Agency, with its current flood warning system, to provide forewarning of two (2) days of a pending flood event. The speed of inundation and rate of floodwater rise would be low. Therefore, the risk of flooding from the River Thames is considered to be of **low significance:**

A number of secondary flooding sources have been identified which may pose a **low significant** risk to the site. These are:

- Surface Water Flooding
- Sewer Flooding

The flooding sources will only inundate the site to a relatively low water depth and water velocity, will only last a short period of time, in very extreme cases and will not have an impact on the whole of the proposed development site.

The flood risk at the site will be further mitigated by using a number of property level protection measures to manage and reduce the overall flood risk at the site. The existing and proposed development for residential uses is classified as ‘more vulnerable’. ‘More vulnerable’ uses are appropriate within Flood Zones 1 and 2 after the completion of a satisfactory FRA.

The overall number of people accommodated within the site will be reduced from 89 to 69. Therefore, the vulnerability of the site will not change as part of the planning application. The proposals do not constitute a change from to a ‘less vulnerable’ use to a ‘more vulnerable’ use. The proposed development will not therefore increase the vulnerability of the development or introduce new development in the Flood Zones.

5.0 SURFACE WATER DRAINAGE

5.1 Surface Water Management Overview

It is recognised that consideration of flood issues should not be confined to the floodplain. The alteration of natural surface water flow patterns through developments can lead to problems elsewhere in the catchment, particularly flooding downstream. For example, replacing vegetated areas with roofs, roads and other paved areas can increase both the total and the peak flow of surface water runoff from the development site. Changes of land use on previously developed land can also have significant downstream impacts where the existing drainage system may not have sufficient capacity for the additional drainage.

A SUDS Strategy for the site proposals has been developed to manage and reduce the flood risk posed by the surface water runoff from the site. An assessment of the surface water runoff rates has been undertaken, in order to determine the surface water options and attenuation requirements for the site. The assessment considers the impact of the development compared to current conditions. Therefore, the surface water attenuation requirement for the developed site can be determined and reviewed against existing arrangements.

The requirement for managing surface water runoff from developments depends on the pre-developed nature of the site. If it is an undeveloped greenfield site, then the impact of the development will need to be mitigated so that the runoff from the site replicates the natural drainage characteristics of the pre-developed site. In the case of brownfield sites, drainage proposals will be measured against the existing performance of the site, although it is preferable for solutions to provide runoff characteristics that are similar to greenfield behaviour.

The surface water drainage arrangements for any development site should be such that the volumes and peak flow rates of surface water leaving a developed site are no greater than the rates prior to the proposed development, unless specific off-site arrangements are made and result in the same net effect.

It should be acknowledged that the satisfactory collection, control and discharge of surface water runoff are now a principle planning and design consideration. This is reflected in recently implemented guidance as well as the new Defra non-statutory technical standards for SUDS.

5.2 Climate change

Projections of future climate change, in the UK, indicate more frequent, short-duration, high intensity rainfall and more frequent periods of long duration rainfall. Guidance included within the NPPF recommends that the effects of climate change are incorporated into Flood Risk Assessments. Recommended precautionary sensitivity ranges for peak rainfall intensities and peak river flows are outlined in the associated Planning Practice Guidance to the NPPF[6].

The recommended national precautionary sensitivity range for peak rainfall intensity are summarised in Table 8.

[6] Communities and Local Government (2014) Planning Practice Guidance - Flood Risk and Coastal Change.

Table 8 - Peak Rainfall Intensity Allowance in Small and Urban Catchment (use 1961 to 1990 baseline)

Parameter	2010 to 2039	2040 to 2059	2060 to 2115
Upper end	+10%	+20%	+40%
Central	5%	+10%	+20%

5.3 Opportunities for Discharge of Surface Water

There are three possible options to discharge the surface water runoff in accordance with requirement H3 of the Building Regulations, this hierarchy is also promoted within the NPPF. Rainwater shall discharge to one of the following, listed in order of priority:

- an adequate soakaway or some other adequate infiltration system; or, where that is not reasonably practicable,
- a watercourse; or where that is not reasonably practicable,
- a sewer.

It is necessary to identify the most appropriate method of controlling and discharging surface water. The design should seek to improve the local runoff profile by using systems that can either attenuate runoff and reduce peak flow rates or positively impact on the existing surface water runoff.

5.3.1 Soakaway/Infiltration System

The general ground conditions suggest that the permeability and infiltration rate of the site will be low. Whilst this should ideally be confirmed by a site investigation into the hydrogeology of the site, the ground conditions suggest infiltration techniques such as soakaways will not work and will not provide a suitable option at the site.

If an infiltration system is proposed, it is recommended that a series of infiltration/soakaway tests are carried out on site to BRE Digest 365 Guidelines to confirm the assumptions made in the calculations. Such work is beyond the scope of this FRA.

5.3.2 Watercourse

Should infiltration be found to be unsuitable, the next option is discharge to a watercourse. There are no watercourses within the vicinity of the site. Therefore, it would not be possible to discharge surface water runoff from the site into a watercourse.

5.3.3 Sewer

In the event that discharge of surface water via infiltration or discharge to a watercourse is deemed unsuitable, then discharge to a sewer would be possible. The surface water runoff from the existing site currently drains to the public sewers therefore, it is deemed sustainable to continue to discharge surface water runoff to the public sewers. Therefore, it would be possible to discharge to the public sewers, at a point adjacent to the site.

5.4 Surface Water Runoff

An estimation of surface water runoff is required to permit effective site water management and prevent any increase in flood risk to off-site receptors. The SUDS Manual recommends the use of

Institute of Hydrology Report No. 124 (IoH124)[7] for site runoff calculations for sites less than 50ha. In accordance with The SUDS Manual, the Greenfield runoff from the site has been calculated using the IoH124 method. QBAR (rural) has been calculated to be 0.53l/s for the proposed impermeable area of 0.34 hectares (ha), as shown in Table 9 (see Appendix 4).

The method used for calculating the surface water runoff complies with the NPPF, as well as the new Defra non-statutory technical standards for SUDS, and assumes that the excess runoff associated with the proposed development (plus an allowance for future climate change) will need to be managed by the proposed SUDS Strategy.

Table 9 - Greenfield Runoff Rates

Return Period (years)	l/s
1	0.45
QBAR	0.53
30	1.18
100	1.66

5.5 SUDS and Water Quality

Current guidance promotes sustainable water management through the use of SUDS. SUDS measures should be used to control the surface water runoff from the proposed development site therefore, managing the flood risk to the site and surrounding areas from surface water runoff.

A hierarchy of techniques is identified[8]:

1. **Prevention** – the use of good site design and housekeeping measures on individual sites to prevent runoff and pollution (e.g. minimise areas of hard standing).

2. **Source Control** – control of runoff at or very near its source (such as the use of rainwater harvesting, permeable paving, soakaways and/or green roofs).

3. **Site Control** – management of water from several sub-catchments (including routing water from roofs and car parks to one/several large soakaways for the whole site, swales and/or infiltration trenches).

4. **Regional Control** – management of runoff from several sites, typically in a detention pond, basins, tanks and/or wetland.

It is generally accepted that the implementation of SUDS as opposed to conventional drainage systems, provides several benefits by:

- reducing peak flows to watercourses or sewers and potentially reducing the risk of flooding downstream;

- reducing the volumes and frequency of water flowing directly to watercourses or sewers from developed sites;

- improving water quality over conventional surface water sewers by removing pollutants from diffuse pollutant sources;

[7] Institute of Hydrology Report No. 124, Flood Estimation for Small Catchments.
[8] CIRIA (2004) Report C609, Sustainable Drainage Systems – Hydraulic, Structural and Water Quality advice.

- reducing potable water demand through rainwater harvesting;
- improving amenity through the provision of public open spaces and wildlife habitat; and
- replicating natural drainage patterns, including the recharge of groundwater so that base flows are maintained.

The most appropriate attenuation system will need to satisfy three main characteristics, firstly, provide the required volume of storage, secondly, minimise the loss of developable land and thirdly, where possible provide local amenity.

The application of the SUDS Manual requires that the runoff from sites is not only restricted to meet the Greenfield runoff characteristics but also that SUDS systems are utilised to improve the quality of the runoff prior to outfall to watercourses. The SUDS Manual and Environment Agency guidance applies a sustainability hierarchy to the various types of SUDS systems, this is summarised in Table 10.

Table 10 - Sustainability Hierarchy

Most Sustainable	SUDS Technique	Flood Reduction	Pollution Reduction	Landscape & Wildlife
↑	**Living Roofs**	✓	✓	✓
	Basins and ponds - Constructed wetlands - Balancing ponds - Detention basins - Retention ponds	✓	✓	✓
	Filter strips and swales	✓	✓	✓
	Infiltration Devices - Soakaways	✓	✓	✓
↓	**Permeable Surfaces and Filter Drains** - Gravelled areas - Solid paving blocks - Permeable paving	✓	✓	
Least Sustainable	**Tanked systems** - Over-sized pipes/tanks - Cellular storage	✓		

Systems at the top of the hierarchy provide a combination of attenuation, treatment and ecology and are deemed the most sustainable options. There are always specific scenarios where systems are more suitable than others and at this stage it is not possible to guide the development towards a particular strategy.

In addition to the above hierarchy the SUDS Manual identifies the number of treatment trains or SUDS devices through which flow should pass from various point sources of runoff (see Table 11). This is designed to ensure that the receiving environments are not put at risk of pollution by new development therefore; accordingly, one treatment train will be used on this site.

The usual approach is to consider the 'SUDS train' where each of the above options are considered in turn until a suitable solution is found. Thus, source control techniques such as soakaways, rainwater harvesting and/or infiltration trenches, if suitable on a site, are considered preferable to permeable conveyance and passive treatment systems such as tanks or ponds. The various options for the site are considered in outlined in Table 12.

Table 11 - Number of Treatment Train Components (assuming effective pre-treatment is in place)

Runoff Catchment Characteristic	Receiving Watercourse Sensitivity		
	Low	Medium	High
Roof only	1	1	1
Residential roads Parking areas Commercial zones	2	2	3
Refuse collection Industrial areas Loading bays Lorry parks Highways	3	3	4

Table 12 - SUDS Techniques

SUDS Technique	Comments	Suitability for Development
Green / Living Roofs / Living Wall	Can be used on low rise buildings to provide retention, attenuation and treatment of rainwater, and promotes evaporation and local biodiversity.	Not a practical option for the proposed development. A green/living roof/living wall would not provide all of the attenuation storage requirements alone.
Basins / Ponds	Provides storage of runoff and flow attenuation. Vegetated surfaces can be used to support the prevention of runoff from the site for small rainfall events (interception) and improve water quality associated with the removal of sediment and buoyant materials.	Not the required area available, especially given the side slopes need to be 1 in 4 max. Without the space the volume attenuated would be very small to be virtually insignificant.
Filter Strips / Swales	Good removal of urban pollutants, reduces runoff rates and volumes.	May be used as conveyance features and to provide betterment.
Infiltration Devices (e.g. soakaways)	Reduces total runoff volume from the development.	Soakaways are not suitable due to site ground conditions.
Permeable Surfaces and Filter Drains	Permeable surfaces together with their associated substructures are an efficient means of intercepting runoff, reducing the volume and frequency of runoff and providing a treatment medium.	May be used as conveyance features and to provide betterment.
Tanked systems	Ideal for sites with insufficient space for basins etc., provide a volume of below ground storage with a high void ratio.	Potential to be installed under the site.
Flow reduction	Manages and reduces the flood risk to the local surface water sewers and watercourses.	A hydrobrake can be installed downstream of attenuation tanks and control flows to the natural Greenfield run off rates.

5.6 Site Storage Volumes

The provision of suitable storage on site to mitigate the flood risk resulting from the development of the site will be a key factor in the evolution of the site development layout. The provision of large volumes of attenuation, as is likely in this case, can be achieved by a number of methods; however, not all systems can be assessed in direct comparison.

One of the aims of the NPPF is to provide not only flood risk mitigation but also to maximise additional gains such as improvements in runoff quality and provision of amenity and bio-diversity. Systems incorporating these features are often termed SUDS and it is the requirement of NPPF that these are considered as the primary means of collection, control and disposal for storm water as close to source as possible.

The principle applied in the design of storage is to limit the discharge rate of surface water runoff from the developed site for events of similar frequency of occurrence to the same peak rate of runoff as that which takes place from a greenfield site prior to development.

QBAR (rural) has been calculated to be 0.53l/s. Using a control device and practical minimum pipe sizes it is not practical to control the discharge rate to below 5.00l/s. Therefore, a value of 5.00l/s has been used as the limiting discharge rate.

Table 13 shows the volume of storage required for the proposed development estimated within the Masterdrain Drainage Software for the 1 in 100 year event, with a 40% allowance for climate change (increase in peak rainfall) assuming the proposed 0.34ha of impermeable area with 5.00l/s used as the limiting discharge rate before discharge to the public sewers (see Appendix 5). Attenuation storage with a volume of 204m^3 is required before discharge to the public sewers. Additional storage is provided within the manholes, pipes and drainage gullies which will provide betterment over and above the 1 in 100 year (+40%) event.

Table 13 - Required Attenuation Storage Volume

Return Period (years)	Limiting Discharge Rate (l/s)	Volume (m^3)
100 +40%	5.00	204

5.7 Proposed SUDS Strategy

The objective of this SUDS Strategy is to ensure that a sustainable drainage solution can be achieved which reduces the peak discharge rate to manage and reduce the flood risk posed by the surface water runoff from the site. At this stage a detailed surface water drainage design has not been undertaken, however it is necessary to demonstrate that the surface water from the proposed development can be discharged safety and sustainably. The SUDS Strategy takes into account the following principles:

- No increase in the volume or runoff rate of surface water runoff from the site.
- No increase in flooding to people or property off-site as a result of the development.
- No surface water flooding of the site.
- The proposals take into account a 40% increase in rainfall intensity due to climate change during the next 100 years which is the lifetime of the development

In line with adopting a 'management train' it is recommended that water is managed as close to source as possible. This will reduce the size and cost of infrastructure further downstream and also shares the maintenance burden more equitably. The SUDS Strategy will take the form of:

- Oversized pipes/cellular storage/storage tanks with a restricted outfall to the public sewers.
- Any areas of hardstanding areas (car parks, driveways, pathways etc.) within the development shall be constructed of a permeable surface examples include:
  - Using permeable block paving, porous asphalt/concrete.
  - Using gravel or a mainly green, vegetated area.
  - Directing water from an impermeable surface to a border rain garden or permeable surfaces.
- Permeable conveyance features - infiltration trenches, swales, filter strips.
- Downpipes connected to water butts.
- For larger events in other areas such as car parking and landscaping, provided that it will not cause damage or prevent access.

For all development, both the Building Regulations and NPPF promote a hierarchical approach to surface water management. This approach has been adopted within this SUDS Strategy, infiltration and discharge to a watercourse is not possible therefore, discharge will be to the public sewers at a restricted runoff rate of 5.00l/s. Therefore, the surface water runoff from the developed site will be no greater than existing. As a consequence of limiting the rate of discharge from the site, at times of heavy rainfall the volume of water leaving the site will be significantly less than that draining from it. In order to prevent this water backing up in the system and causing flooding, 204m^3 of attenuation storage will be required. Additional storage would be provided within the manholes, pipes and drainage gullies which will provide betterment over and above the 1 in 100 year (+40%) event.

The size of the attenuation storage has been calculated such that the proposed development has the capacity to accommodate the 1 in 100 year rainfall event including a 40% increase in rainfall intensity that is predicted to occur as a result of climate change. Consequently, all areas drained have been designed to accommodate a 100 year (+40% climate change) storm event. The remainder of the site that is not formally drained, i.e. landscaped areas, will be permeable (grass). The majority of rainwater falling on these areas will soak into the ground. Surface water runoff would be directed to the drainage system through drainage gullies located around the perimeter of the buildings and through contouring of the hardstanding areas.

These methods will reduce peak flows, the volume of runoff, and slow down flows and will provide a suitable SUDS solution for this site. These preliminary considerations are based on the outline development scheme provided and hence the design purposes.

The adoption of a SUDS Strategy for the site represents an enhancement from the current conditions as the current surface water runoff from the site is uncontrolled, untreated, unmanaged and unmitigated. In adopting these principles, it has been demonstrated that a scheme can be developed that does not increase the risk of flooding to adjacent properties and development further downstream.

5.8 Designing for Local Drainage System Failure

When considering residual risk, it is necessary to make predictions as to the impacts of a storm event that exceeds the design event, or the impact of a failure of the local drainage system. The SUDS Strategy applies a safe and sustainable approach to discharging rainfall runoff from the site and this reduces the risk of flooding however, it is not possible to completely remove the risk. This section of the FRA is therefore associated with the way the residual risk is managed.

As part of the SUDS Strategy it must be demonstrated that the flooding of property would not occur in the event of local drainage system failure and/or design exceedance. It is not economically viable or sustainable to build a drainage system that can accommodate the most extreme events. Consequently, the capacity of the drainage system may be exceeded on rare occasions, with excess water flowing above ground[9].

The attenuation requirements have been designed to accommodate the 1 in 100 year storm event plus climate change (+40%). The design of the site layout provides an opportunity to manage this local drainage system failure/exceedance flow and ensure that indiscriminate flooding of property does not occur.

There will not be an extensive sewerage network on the proposed development site and therefore any potential exceedance flooding would be from the sewers and lateral drains connecting the buildings to the underground storage areas. It is very unlikely that a catastrophic failure would occur. An exceedance or blockage event of the sewers would not affect the proposed buildings because the finished floor level will be raised above surrounding ground levels, ensuring any exceedance flooding would not affect the buildings. Exceedance flows would be contained within the highways adjacent to the site and within the site and would flow to the lower ground levels where the public open space is located. It is not considered that there is an increased risk to the properties on the site or located adjacent to the site.

In particular, the landscaped areas will include preferential flow paths that convey water away from buildings. Surface water runoff would be directed to the drainage system through drainage gullies located around the perimeter of the buildings and through contouring of the hardstanding areas.

When considering the impacts of a storm event that exceeds the 1 in 100 year (+40%) event, there is safety factor, even under the design event conditions. Consequently, if this event were to be exceeded there is additional capacity with the system to accommodate this (i.e. within the manholes, pipes etc.). If this freeboard was to be exceeded the consequences would be similar, if not less than for the local drainage system failure. Consequently, the impact of an exceedance event is not considered to represent any significant flood hazard.

The above manages and mitigates the flood risk from surface water runoff to the proposed properties from surface water runoff generated by the site development and to offsite locations as well the risk from surface water runoff generated offsite.

[9] CIRIA (2006) Designing for exceedance in urban drainage – good practice.

6.0 RISK MANAGEMENT

6.1 Introduction

The flood risk at this location is considered suitable for 'more vulnerable' developments within the NPPF. In this flood zone, developers and local authorities should seek opportunities to reduce the overall level of flood risk in the area through the layout, form of the development and the use of flood mitigation measures including SUDS techniques.

The flooding sources will be mitigated on the site by using a number of techniques, and mitigation strategies to manage and reduce the overall flood risk at the site. This will ensure the development will be safe and there is:

- Minimal risk to life;
- Minimal disruption to people living and working in the area;
- Minimal potential damage to property;
- Minimal impact of the proposed development on flood risk generally; and;
- Minimal disruption to natural heritage.

The proposed development will improve the sites resilience, resistance to flooding and by using property level protection measures to protect the site from flooding the vulnerability of the site will be improved.

6.2 Finished Floor Levels

Ground floor finished floor levels will be located above the back of footway of the adjacent carriageway to enable the full capacity of any secondary flood conveyance to be utilised. The basement finished floor levels will be located as a minimum at existing ground levels. A combination of resistance (proofing) and resilience measures will be included to provide further protection event. This is discussed below.

6.3 First Floor Accommodation

Accommodation will be located on the first floor and above as well as the ground floor of the buildings. This will allow occupants to retreat to higher floor levels if needed. The levels of the first floor are located well above any floodwater levels.

This provides a 'safe haven' above any floodwater levels. This will enable rapid escape should flooding occur which is unlikely. The upper floors are accessed via internal stairs and are sufficient in size to safely house all occupants of the dwellings. The 'safe haven' will only be required in very extreme events or if a flood warning has not been received.

6.4 Flood Resilience and Resistance

The development of the layout should always consider that the site is potentially at risk from an extreme event and as such the implementation of flood resilience and resistance methods should be assessed.

To make the buildings more resistant to seepage the following measures will be incorporated. Sealant will be used around external doors and windows. All external doors and windows will be constructed from synthetic materials. The walls of the buildings will be thick.

To improve the buildings resilience to flooding the following measures will be incorporated. All electrical wiring, switches, sockets, socket outlets, electrical, and gas meters etc. will be located a minimum of 450mm above the finished floor level.

Upstands along the front of the lightwells should be sufficient to prevent surface water runoff draining into the lightwells in all normal circumstances. The brickwork boundary walls will restrict the catchment to direct rainfall.

6.5 Flood Warning and Evacuation

The site is located in a flood risk area therefore; the site will participate in the Environment Agency flood warning telephone service. The site will register contact details with the Environment Agency' Flood Warnings Service (Floodline 0345 988 1188) in order to receive Flood Warnings for the following Flood Warning area: -

- River Thames at Hampton and Hampton Wick including Hampton Court, properties on the Barge Walk, Hampton Court Palace Golf Club and Hampton Court Road.

The Environment Agency operate a free flood warning service providing alerts by phone, text or email when flooding is anticipated providing an opportunity for home owners to take necessary precautions, giving enough time for the building to be safely evacuated and mitigation measures to be put in place.

All occupants/visitors of the site will be made aware of the Environment Agency Floodline telephone number (Call Floodline on 0345 988 1188 to get more information) and the three Flood Warning Codes and their meaning.

The Environment Agency uses three Flood Warnings Codes. They can be issued in any order, usually ending with an 'all clear'. They are issued by the Environment Agency through their website and Floodline. The flood warning will be passed onto the visitors and occupants of the site verbally, by telephone and/or in person. It will be ensured that everyone receives the flood warnings when required.

6.6 Flood Warning and Evacuation Plan

A Flood Warning and Evacuation Plan outlining the precautions and actions you should take when a flood event is anticipated to help reduce the impact and damage flooding may cause has been developed[10].

6.7 Safe Access and Egress Routes

The NPPF requires that, where required, safe access and escape is available to/from new developments in flood risk areas. Access routes should be such that occupants can safely access and exit their dwellings/buildings in design flood conditions. These routes must also provide the emergency services with access to the development during a flood event and enable flood defence authorities to carry out any necessary duties during the period of flood.

Safe access and egress routes, including emergency access can be maintained for vehicles and/or by foot. The majority of the site is located within Flood Zone 1 with a 'low probability' of flooding as shown in Figure 2, with less than a 1 in 1000 annual probability of river flooding in any year (<0.1%). A small proportion of the site, to the south east, is located within Flood Zone 2 with a 'medium probability' of flooding with between a 1 in 100 and 1 in 1000 annual probability of river flooding (1%

[10] KRS Environmental Ltd, 12-14 Station Road and Nos 13, 19-33 Lower Teddington Road, Hampton Wick, KT1 4EU, Flood Warning and Evacuation Plan, For CIRC Construction Limited, KRS.0232.003.R.003.A, December 2018.

- 0.1%) in any year. It should be noted that this area of the site is located on the very edge of Flood Zone 2, areas immediately adjacent to the north and west of the site are located within Flood Zone 1 with a 'low probability' of flooding, with less than a 1 in 1000 annual probability of river flooding in any year (<0.1%).

The mechanism for flooding from the River Thames is generally prolonged episodes of heavy rainfall, which affords good time for flood warnings to be issued. The likelihood of a rapid river level rise within the River Thames and possible rapid inundation of urban areas posing a risk to life is considered to be minimal. This is primarily due to the large River Thames system and its substantial upper contributing catchment area which allows the Environment Agency, with its current flood warning system, to provide forewarning of two (2) days of a pending flood event. The speed of inundation and rate of floodwater rise would be low.

There are multiple access and egress routes from the buildings themselves, the main entrances, secondary exits from the front of the building and a dedicated exit direct to the outside. These three access and egress routes all allow rapid evacuation from the site. Lower Teddington Road rises to the north with ground levels rising from 7.15mAOD to 8.22mAOD adjacent to the eastern boundary of the site and Station Road rises to the west with ground levels rising from 8.19mAOD to 8.84mAOD. Therefore, safe access and egress can be maintained for all events up to and including the 1 in 100 year (+25%) event in accordance with the NPPF and Environment Agency Guidance.

People should make their way to areas outside of the flood zone once a flood warning has been received using the safe access and egress routes shown in Figure 9. In the event of a Flood Warning, vital belongings, including waterproof clothing, necessary medication and essentials for infants and children will be collected. It should be ensured that all occupiers and visitors to the site are accounted for, and then exit the site.

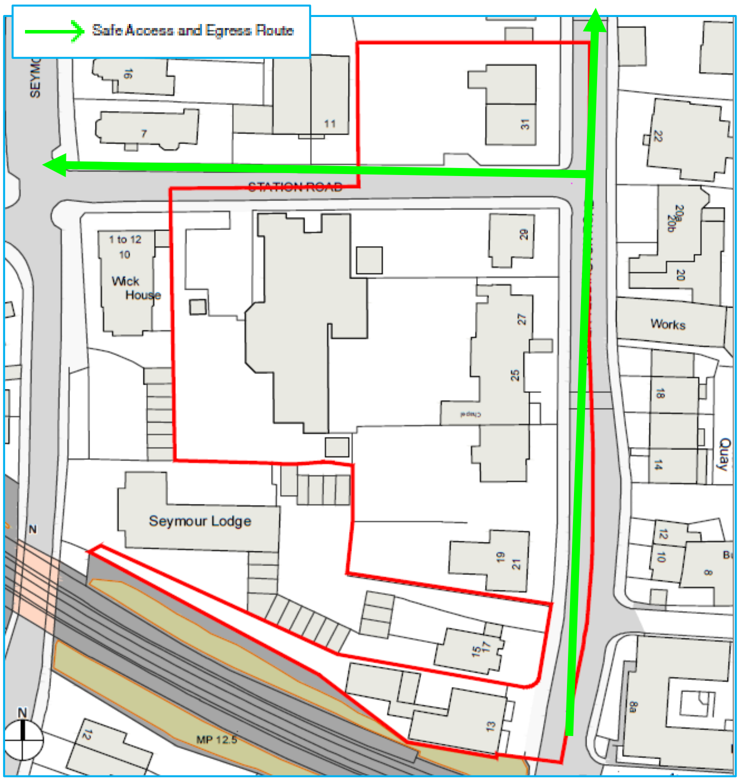


Figure 9 - Safe Access and Egress Routes

6.8 Flooding Consequences

The property level mitigation measures detailed above show that the flood risk can be effectively managed and therefore the consequences of flooding are acceptable. The chance of flooding each year is low each year. This takes into account the effect of any flood defences that may be located within the vicinity of the site as well property level protection measures.

7.0 SEQUENTIAL APPROACH

7.1 Sequential and Exception Tests

The risk-based Sequential Test in accordance with the NPPF aims to steer new development to areas at the lowest probability of flooding (i.e. Flood Zone 1).

Paragraph 104 of the NPPF states that:

> *'Applications for minor development and changes of use should not be subject to the Sequential or Exception Tests[11] but should still meet the requirements for site-specific flood risk assessments'.*

The Planning Practice Guidance to the NPPF confirms that minor developments are:

- Minor non-residential extensions: industrial/commercial/leisure etc. extensions with a footprint less than 250m^2.

- Alterations: development that does not increase the size of buildings e.g. alterations to the external appearance.

- Householder development: e.g. sheds, garages, games rooms etc. within the curtilage of the existing dwelling in addition to physical extensions to the existing dwelling itself. This definition excludes any proposed development that would create a separate dwelling within the curtilage of the existing dwelling e.g. subdivision of houses into flats.

Therefore, the Sequential and Exception Tests will not need to be undertaken as part of this planning application. The development proposals should therefore be considered by the LPA to satisfy the Sequential and Exception Tests as set out in the NPPF.

[11] Except for any proposal involving a change of use to a caravan, camping or chalet site, or to a mobile home or park home site, where the Sequential and Exception Tests should be applied as appropriate.

8.0 SUMMARY AND CONCLUSIONS

8.1 Introduction

This report presents a FRA in accordance with the NPPF for the proposed development at 12-14 Station Road and Nos 13 and 19-33 Lower Teddington Road, Hampton Wick, KT1 4EU.

This FRA identifies and assesses the risks of all forms of flooding to and from the development and demonstrates how these flood risks will be managed so that the development remains safe throughout the lifetime, taking climate change into account.

8.2 Flood Risk

The site is unlikely to flood except in extreme conditions. The primary, but unlikely, flood risk to the site is from fluvial flooding from the River Thames. The majority of the site is located within Flood Zone 1 with a 'low probability' of flooding, with less than a 1 in 1000 annual probability of river flooding in any year (<0.1%). A small proportion of the site, to the south east, is located within Flood Zone 2 with a 'medium probability' of flooding with between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% - 0.1%) in any year. It should be noted that this area of the site is located on the very edge of Flood Zone 2, areas immediately adjacent to the north and west of the site are located within Flood Zone 1 with a 'low probability' of flooding, with less than a 1 in 1000 annual probability of river flooding in any year (<0.1%). However, the site has no history of flooding

The site would not be inundated with floodwater for all events up to and including the 1 in 100 year event. The actual flood risk posed to the site is less than 1 in 100 years (1%). During flood events of a higher magnitude, a small proportion of the site, to the south east, may be flooded externally however, it is unlikely that the basement and the ground floor would be flooded due to the layout of the site.

The mechanism for flooding from the River Thames is generally prolonged episodes of heavy rainfall, which affords good time for flood warnings to be issued. The likelihood of a rapid river level rise within the River Thames and possible rapid inundation of urban areas posing a risk to life is considered to be minimal. This is primarily due to the large River Thames system and its substantial upper contributing catchment area which allows the Environment Agency, with its current flood warning system, to provide forewarning of two (2) days of a pending flood event. The speed of inundation and rate of floodwater rise would be low. Therefore, the risk of flooding from the River Thames is considered to be of **low significance:**

A number of secondary flooding sources have been identified which may pose a **low significant** risk to the site. These are:

- Surface Water Flooding
- Sewer Flooding

The flooding sources will only inundate the site to a relatively low water depth and water velocity, will only last a short period of time, in very extreme cases and will not have an impact on the whole of the proposed development site.

The flood risk at the site will be further mitigated by using a number of property level protection measures to manage and reduce the overall flood risk at the site. The existing and proposed development for residential uses is classified as 'more vulnerable'. 'More vulnerable' uses are appropriate within Flood Zones 1 and 2 after the completion of a satisfactory FRA.

The overall number of people accommodated within the site will be reduced from 89 to 69. Therefore, the vulnerability of the site will not change as part of the planning application. The proposals do not constitute a change from to a 'less vulnerable' use to a 'more vulnerable' use. The proposed development will not therefore increase the vulnerability of the development or introduce new development in the Flood Zones.

8.3 SUDS Strategy

The SUDS Strategy ensures that a sustainable drainage solution can be achieved which reduces the peak discharge rate to manage and reduce the flood risk posed by the surface water runoff from the site. At this stage a detailed surface water drainage design has not been undertaken, however it is necessary to demonstrate that the surface water from the proposed development can be discharged safety and sustainably. The SUDS Strategy takes into account the following principles:

- No increase in the volume or runoff rate of surface water runoff from the site.
- No increase in flooding to people or property off-site as a result of the development.
- No surface water flooding of the site.
- The proposals take into account a 40% increase in rainfall intensity due to climate change during the next 100 years which is the lifetime of the development

In line with adopting a 'management train' it is recommended that water is managed as close to source as possible. This will reduce the size and cost of infrastructure further downstream and also shares the maintenance burden more equitably. The SUDS Strategy will take the form of:

- Oversized pipes/cellular storage/storage tanks with a restricted outfall to the public sewers.
- Any areas of hardstanding areas (car parks, driveways etc.) within the development shall be constructed of a permeable surface examples include:
    - Using permeable block paving, porous asphalt/concrete.
    - Using gravel or a mainly green, vegetated area.
    - Directing water from an impermeable surface to a border rain garden or permeable surfaces.
- Permeable conveyance features - infiltration trenches, swales, filter strips.
- Downpipes connected to water butts.
- For larger events in other areas such as car parking and landscaping, provided that it will not cause damage or prevent access.

For all development, both the Building Regulations and the NPPF promote a hierarchical approach to surface water management. This approach has been adopted within this SUDS Strategy, infiltration and discharge to a watercourse is not possible therefore, discharge will be to the public sewers at a restricted runoff rate of 5.00l/s. Therefore, the surface water runoff from the developed site will be no greater than existing. As a consequence of limiting the rate of discharge from the site, at times of heavy rainfall the volume of water leaving the site will be significantly less than that draining from it. In order to prevent this water backing up in the system and causing flooding, 204m^3 of attenuation storage will be required. Additional storage would be provided within the manholes, pipes and drainage gullies which will provide betterment over and above the 1 in 100 year (+40%) event.

The size of the attenuation storage has been calculated such that the proposed development has the capacity to accommodate the 1 in 100 year rainfall event including a 40% increase in rainfall intensity that is predicted to occur as a result of climate change. Consequently, all areas drained have been designed to accommodate a 100 year (+40% climate change) storm event. The remainder of the site that is not formally drained, i.e. landscaped areas, will be permeable (grass). The majority of rainwater falling on these areas will soak into the ground. Surface water runoff would be directed to the drainage system through drainage gullies located around the perimeter of the buildings and through contouring of the hardstanding areas.

These methods will reduce peak flows, the volume of runoff, and slow down flows and will provide a suitable SUDS solution for this site. These preliminary considerations are based on the outline development scheme provided and hence the design purposes.

The adoption of a SUDS Strategy for the site represents an enhancement from the current conditions as the current surface water runoff from the site is uncontrolled, untreated, unmanaged and unmitigated. In adopting these principles, it has been demonstrated that a scheme can be developed that does not increase the risk of flooding to adjacent properties and development further downstream.

8.4 Risk Management

The flooding sources will be managed and mitigated on the site by using a number of techniques, and mitigation strategies to mitigate and reduce the overall flood risk at the site. This will ensure the development will be safe. Measured used:

Finished Floor Levels: Ground floor finished floor levels will be located above the back of footway of the adjacent carriageway to enable the full capacity of any secondary flood conveyance to be utilised. The basement finished floor levels will be located as a minimum at existing ground levels. A combination of resistance (proofing) and resilience measures will be included to provide further protection event. This is discussed below.

First Floor Accommodation: Accommodation will be located on the first floor and above as well as the ground floor of the buildings. This will allow occupants to retreat to higher floor levels if needed. The levels of the first floor are located well above any floodwater levels.

This provides a ‘safe haven’ above any flood water levels. This will enable rapid escape should flooding occur which is unlikely. The upper floors are accessed via internal stairs and are sufficient in size to safely house all occupants of the dwellings. The ‘safe haven’ will only be required in very extreme events or if a flood warning has not been received.

Flood Resilience and Resistance: To make the buildings more resistant to seepage the following measures will be incorporated. Sealant will be used around external doors and windows. All external doors and windows will be constructed from synthetic materials. The walls of the buildings will be thick.

To improve the buildings resilience to flooding the following measures will be incorporated. All electrical wiring, switches, sockets, socket outlets, electrical, and gas meters etc. will be located a minimum of 450mm above the finished floor level.

Upstands along the front of the lightwells should be sufficient to prevent surface water runoff draining into the lightwells in all normal circumstances. The brickwork boundary walls will restrict the catchment to direct rainfall.

Flood Warning and Evacuation: The site is located in a flood risk area therefore; the site will participate in the Environment Agency flood warning telephone service. The site will register contact details with the Environment Agency' Flood Warnings Service (Floodline 0345 988 1188) in order to receive Flood Warnings.

Flood Warning and Evacuation Plan: A Flood Warning and Evacuation Plan outlining the precautions and actions you should take when a flood event is anticipated to help reduce the impact and damage flooding may cause has been developed.

Safe Access and Egress Routes: Safe access and egress routes, including emergency access can be maintained for vehicles and/or by foot. The majority of the site is located within Flood Zone 1 with a 'low probability' of flooding as shown in Figure 2, with less than a 1 in 1000 annual probability of river flooding in any year (<0.1%). A small proportion of the site, to the south east, is located within Flood Zone 2 with a 'medium probability' of flooding with between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% - 0.1%) in any year. It should be noted that this area of the site is located on the very edge of Flood Zone 2, areas immediately adjacent to the north and west of the site are located within Flood Zone 1 with a 'low probability' of flooding, with less than a 1 in 1000 annual probability of river flooding in any year (<0.1%).

The mechanism for flooding from the River Thames is generally prolonged episodes of heavy rainfall, which affords good time for flood warnings to be issued. The likelihood of a rapid river level rise within the River Thames and possible rapid inundation of urban areas posing a risk to life is considered to be minimal. This is primarily due to the large River Thames system and its substantial upper contributing catchment area which allows the Environment Agency, with its current flood warning system, to provide forewarning of two (2) days of a pending flood event. The speed of inundation and rate of floodwater rise would be low.

There are multiple access and egress routes from the buildings themselves, the main entrances, secondary exits from the front of the building and a dedicated exit direct to the outside. These three access and egress routes all allow rapid evacuation from the site. Lower Teddington Road rises to the north with ground levels rising from 7.15mAOD to 8.22mAOD adjacent to the eastern boundary of the site and Station Road rises to the west with ground levels rising from 8.19mAOD to 8.84mAOD. Therefore, safe access and egress can be maintained for all events up to and including the 1 in 100 year (+25%) event in accordance with the NPPF and Environment Agency Guidance.

People should make their way to areas outside of the flood zone once a flood warning has been received using the safe access and egress routes. In the event of a Flood Warning, vital belongings, including waterproof clothing, necessary medication and essentials for infants and children will be collected. It should be ensured that all occupiers and visitors to the site are accounted for, and then exit the site.

8.5 Sequential Approach

The Sequential and Exception Tests will not need to be undertaken as set out in the NPPF.

8.6 Conclusion

Table 14 summarises the probability and consequence of flooding for the site with and without mitigation measures.

An independent senior living extra care development would be expected to remain dry in all but the most extreme conditions. Providing the recommendations made in this FRA are instigated, flood risk from all sources would be minimised, the consequences of flooding are acceptable, and the development would be in accordance with the requirements of the NPPF.

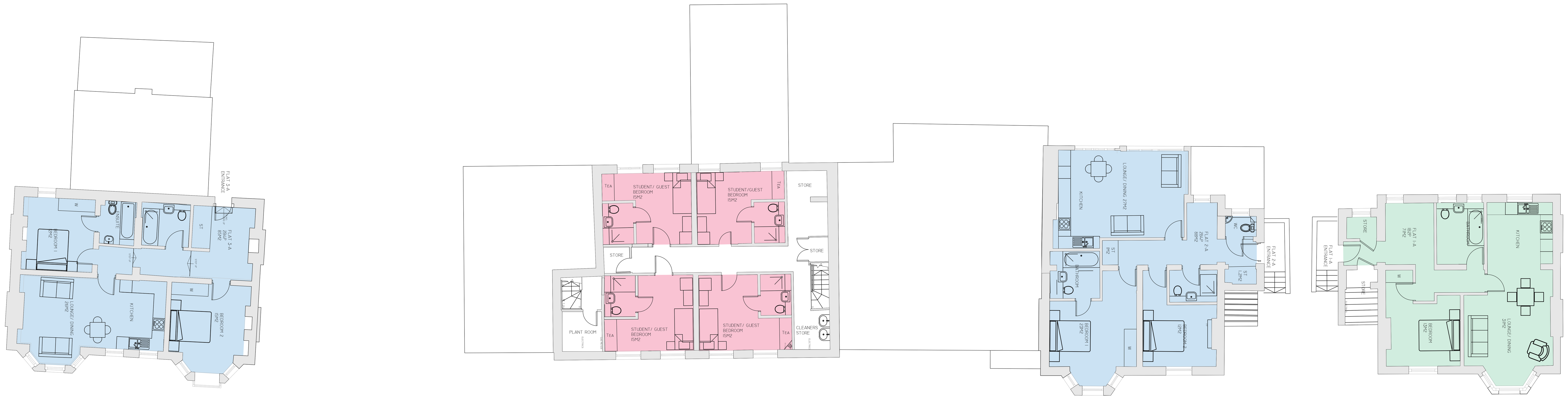
The adoption of a SUDS Strategy for the site will further reduce the risk of flooding to the site and off-site locations. This FRA demonstrates that the proposed development would be operated with minimal risk from flooding, would not increase flood risk elsewhere and is compliant with the requirements of the NPPF. The development should not therefore be precluded on the grounds of flood risk.

Table 14 - Probability and Consequences of all Sources of Flooding

Sources of Flooding	Potential Source	Probability	Consequence & Impact Without Mitigation	Consequence & Impact with Mitigation	Comment
Fluvial Flooding	River Thames	Low	Low	Low	Mitigation measures used
Tidal Flooding	None Reported	None	Negligible	Negligible	None
Groundwater Flooding	None Reported	None	Negligible	Negligible	None
Surface Water Flooding	Poor Permeability	Low	Low	Low	Mitigation measures used
Sewer Flooding	Local Sewers	Low	Low	Low	Mitigation measures used
Flooding from Artificial Drainage Systems/Infrastructure Failure	None Reported	None	Negligible	Negligible	None

APPENDIX 1 – Proposed Site Layout

Revisions:	Drawn/Chkd: Date:



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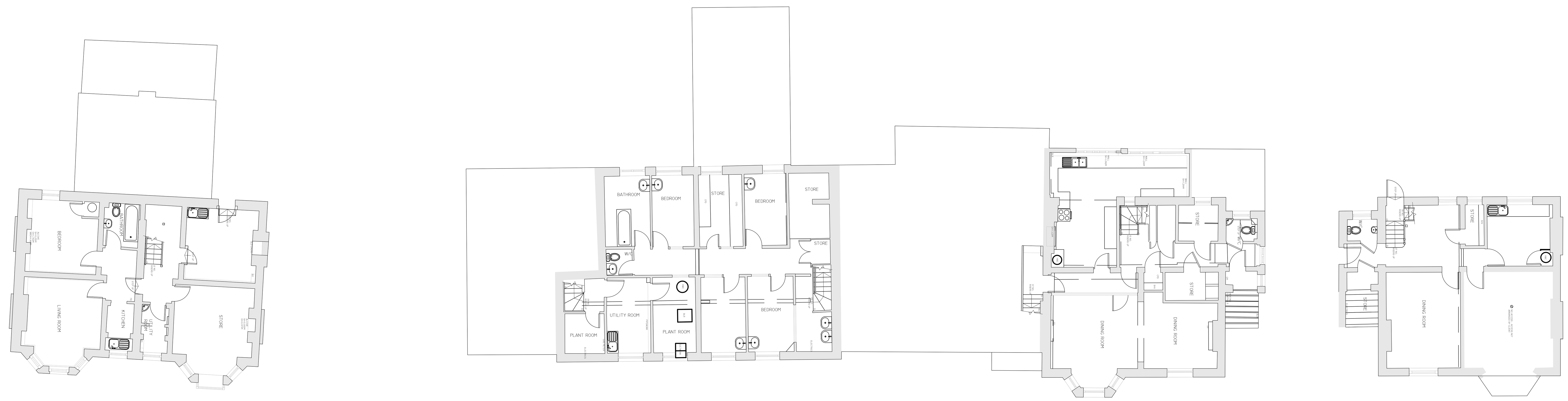

Basement - Existing

KEY:

- COMMUNAL AREA
- STUDENT / GUEST
- PRIEST BEDROOM
- 1 BED APARTMENT
- 2 BED APARTMENT
- 3 BED APARTMENT

Client:
CIRC Management LLP

Project:
Lower Teddington Road
Hampton Wick

Drawing Title:
19-29 Lower Teddington Road
Basement
Existing & Proposed

Scale @ A0 :	Checked by :	Date :
1:100	PR	Aug 2018

Job No:	Stage :	Drawing No : Rev :
10901	FE	210

Issue Status:
- [ ] Construction
- [x] Preliminary
- [x] Information
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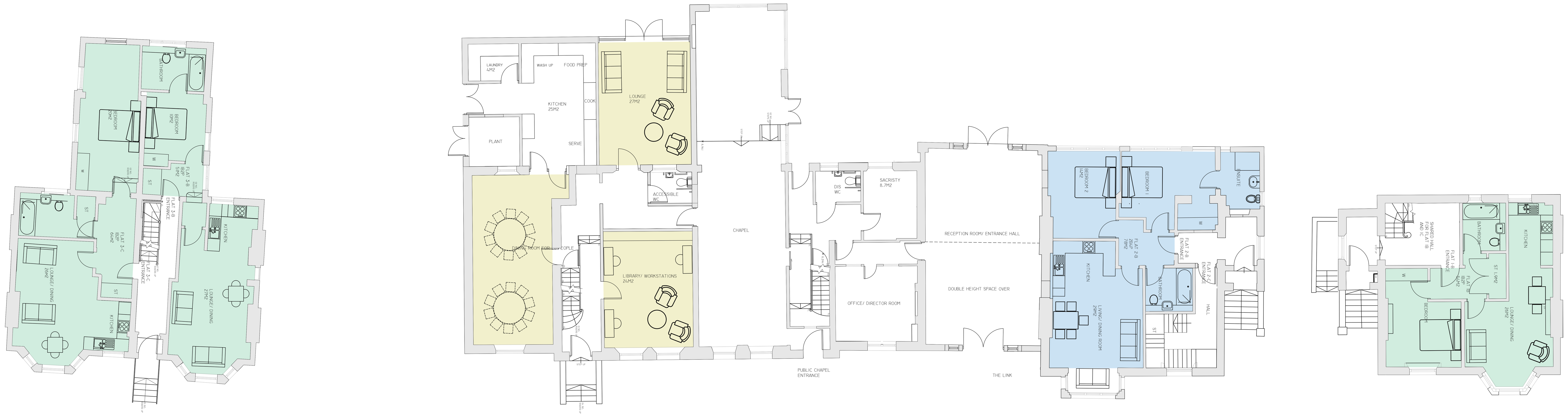
Figured dimensions only are to be used. All dimensions to be checked onsite. Differences between drawings and between drawings and specification or bills of quantities to be reported to the PRC Group.

Revisions: Drawn/Chkd: Date:



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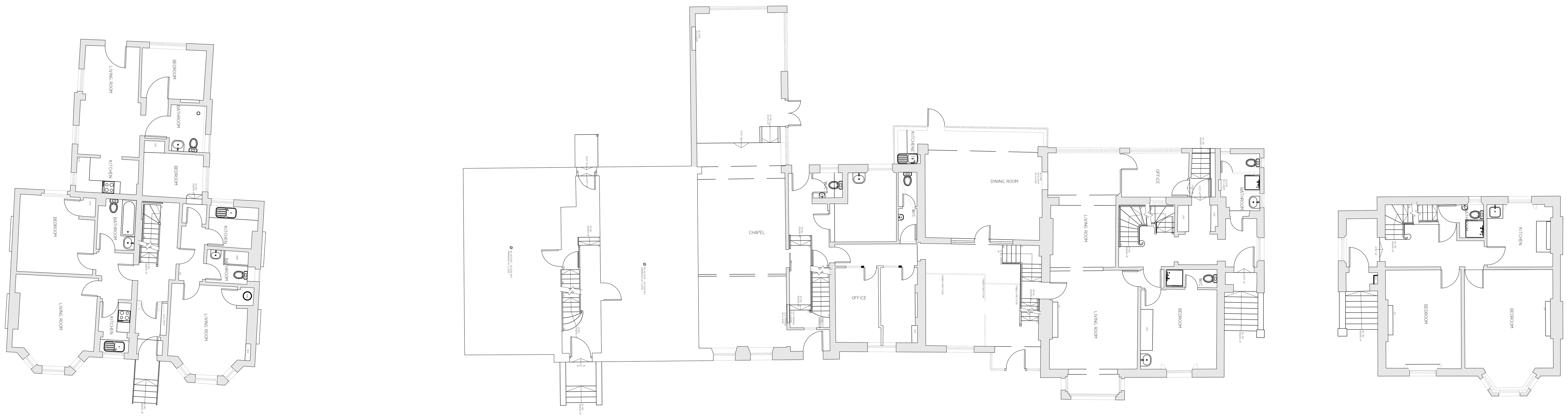

Ground Floor - Existing

KEY:

- COMMUNAL AREA
- STUDENT / GUEST
- PRIEST BEDROOM
- 1 BED APARTMENT
- 2 BED APARTMENT
- 3 BED APARTMENT

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Project:
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Drawing Title:
19-29 Lower Teddington Road
Ground Floor
Existing & Proposed

Scale @ A0: 1:100
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Date: Aug 2018

Job No: 10901
Stage: FE
Drawing No: Rev: 211

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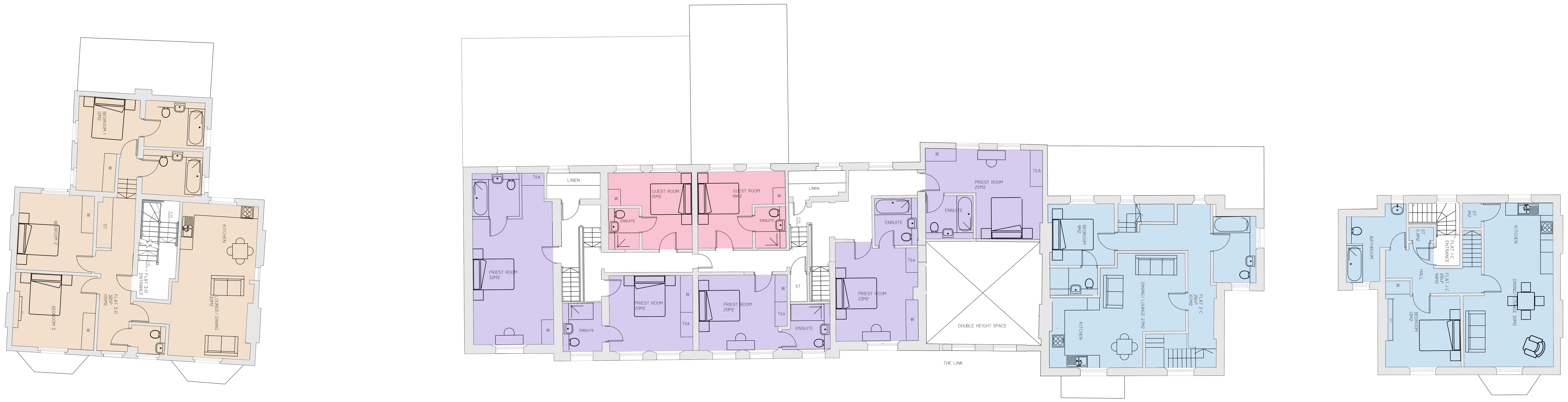
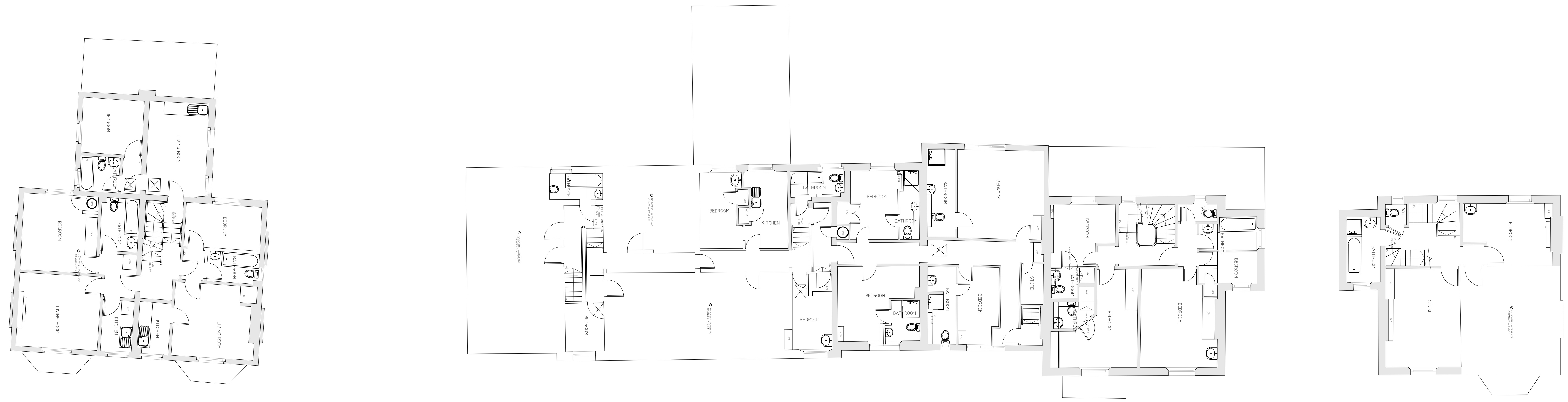
Revisions: Drawn/Chkd: Date:



First Floor - Proposed



First Floor - Existing

KEY:

- COMMUNAL AREA
- STUDENT / GUEST
- PRIEST BEDROOM
- 1 BED APARTMENT
- 2 BED APARTMENT
- 3 BED APARTMENT

Client:
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Project:
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Drawing Title:
19-29 Lower Teddington Road
First Floor
Existing & Proposed

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10901	FE	212

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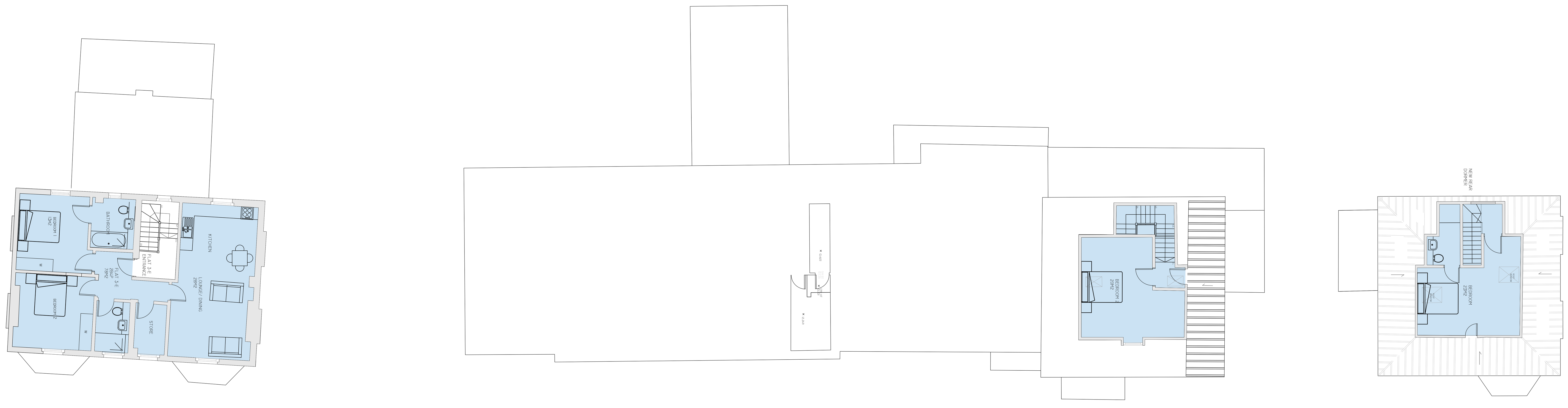

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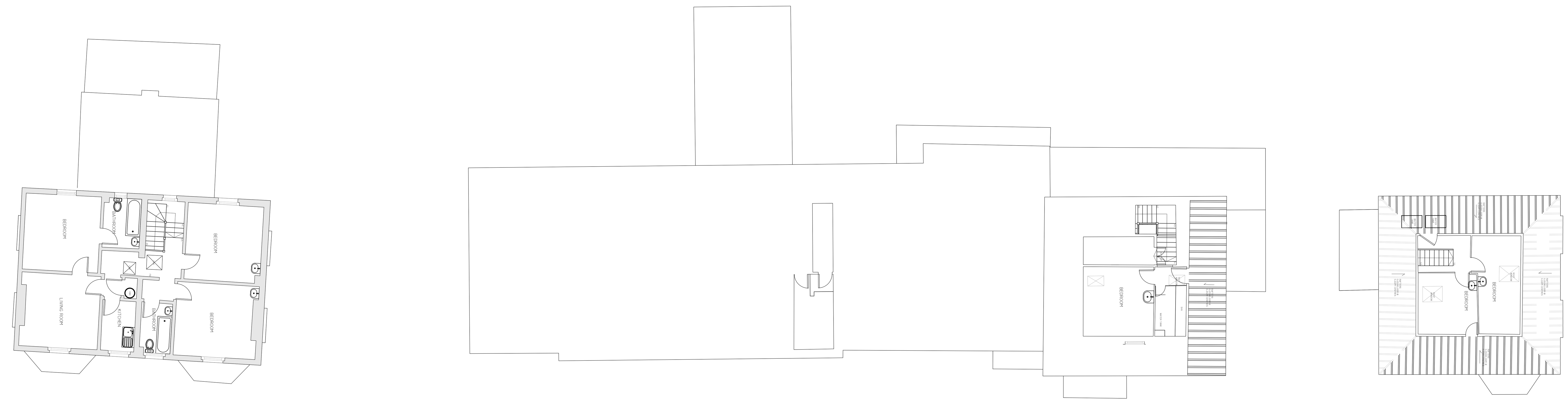

Second Floor - Existing

KEY:

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10901	FE	213

Issue Status:
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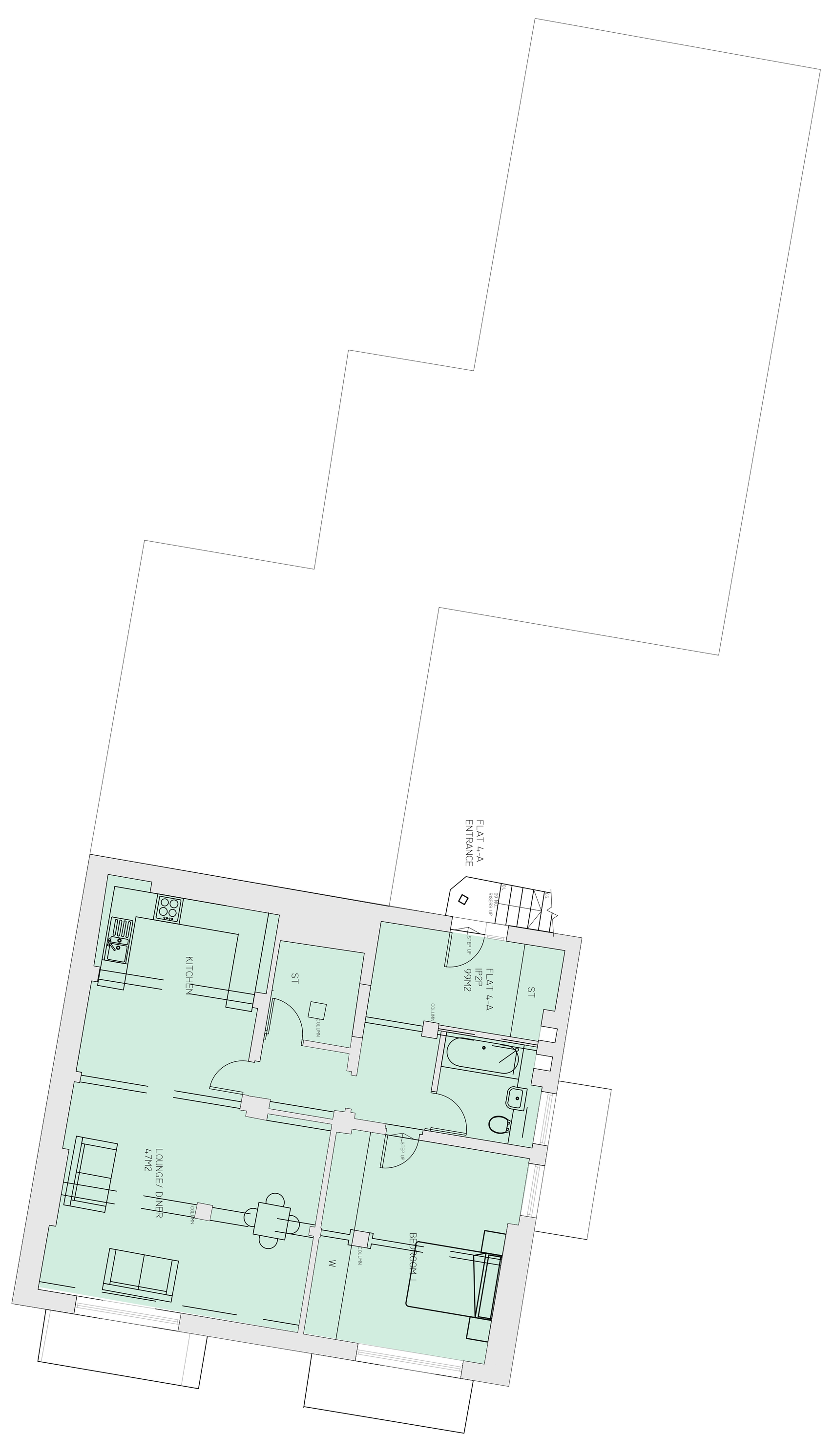

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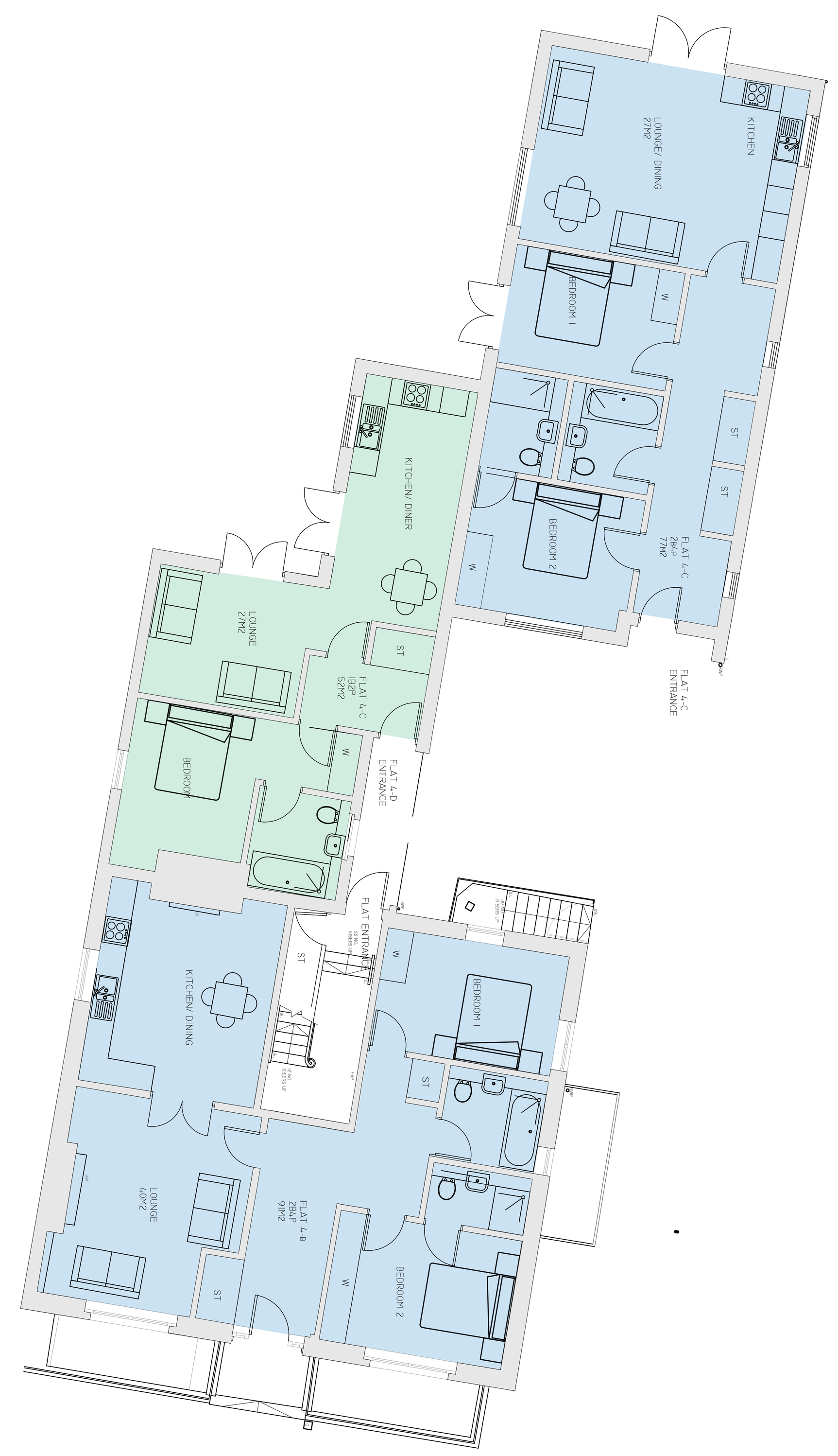
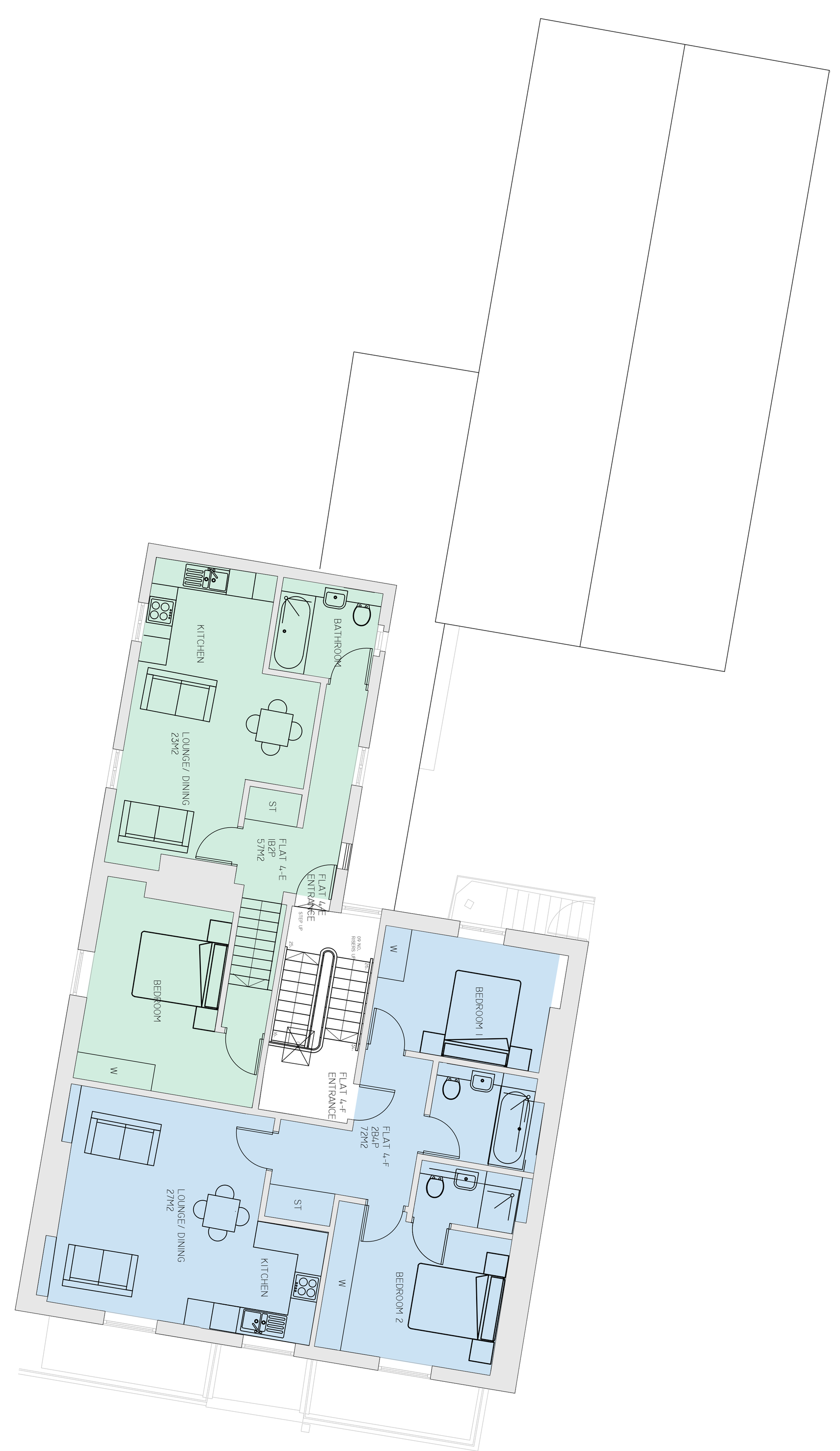
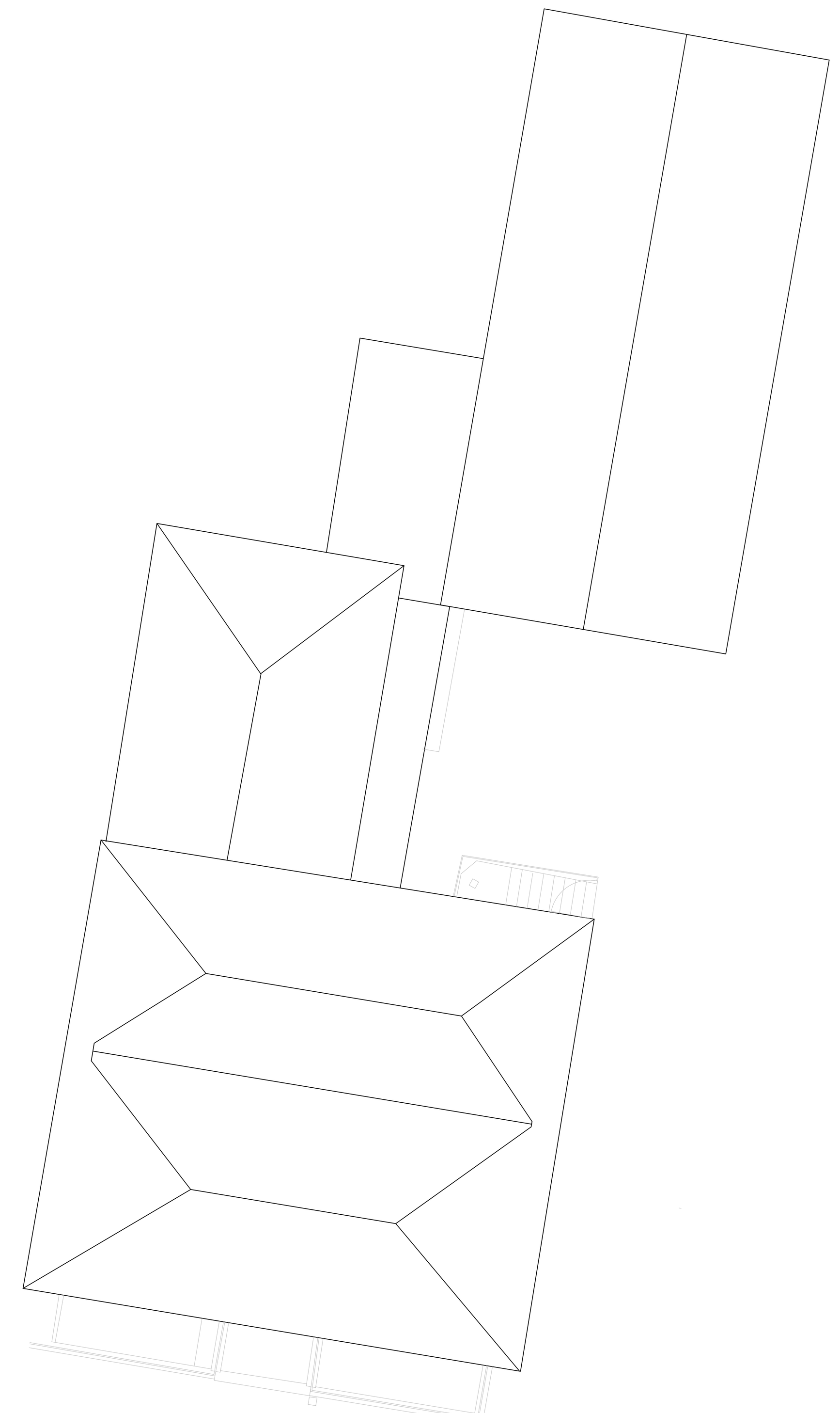


Ground Floor - Proposed



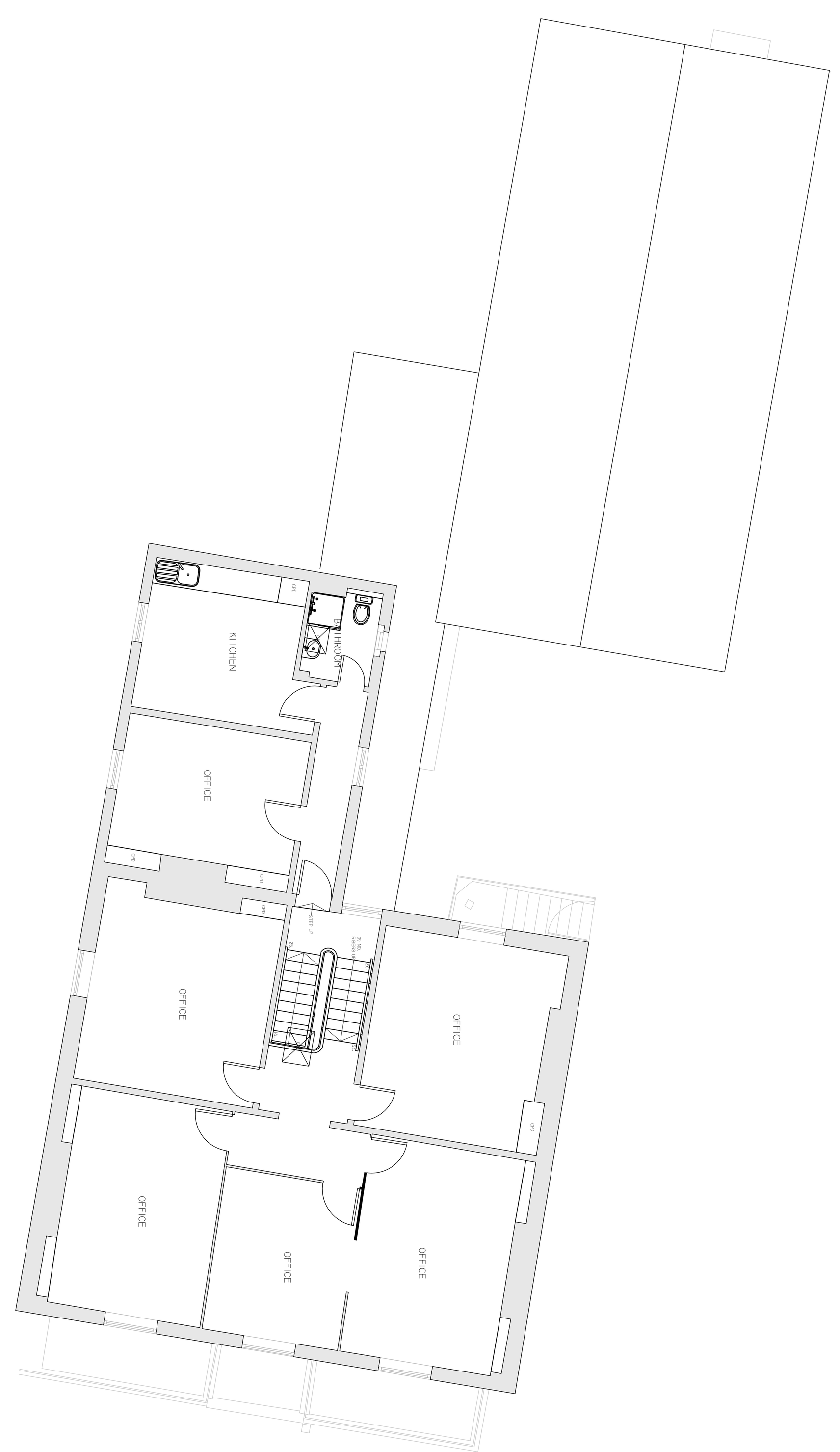
First Floor - Proposed



Second Floor - Proposed

Basement - Existing

Ground Floor - Existing



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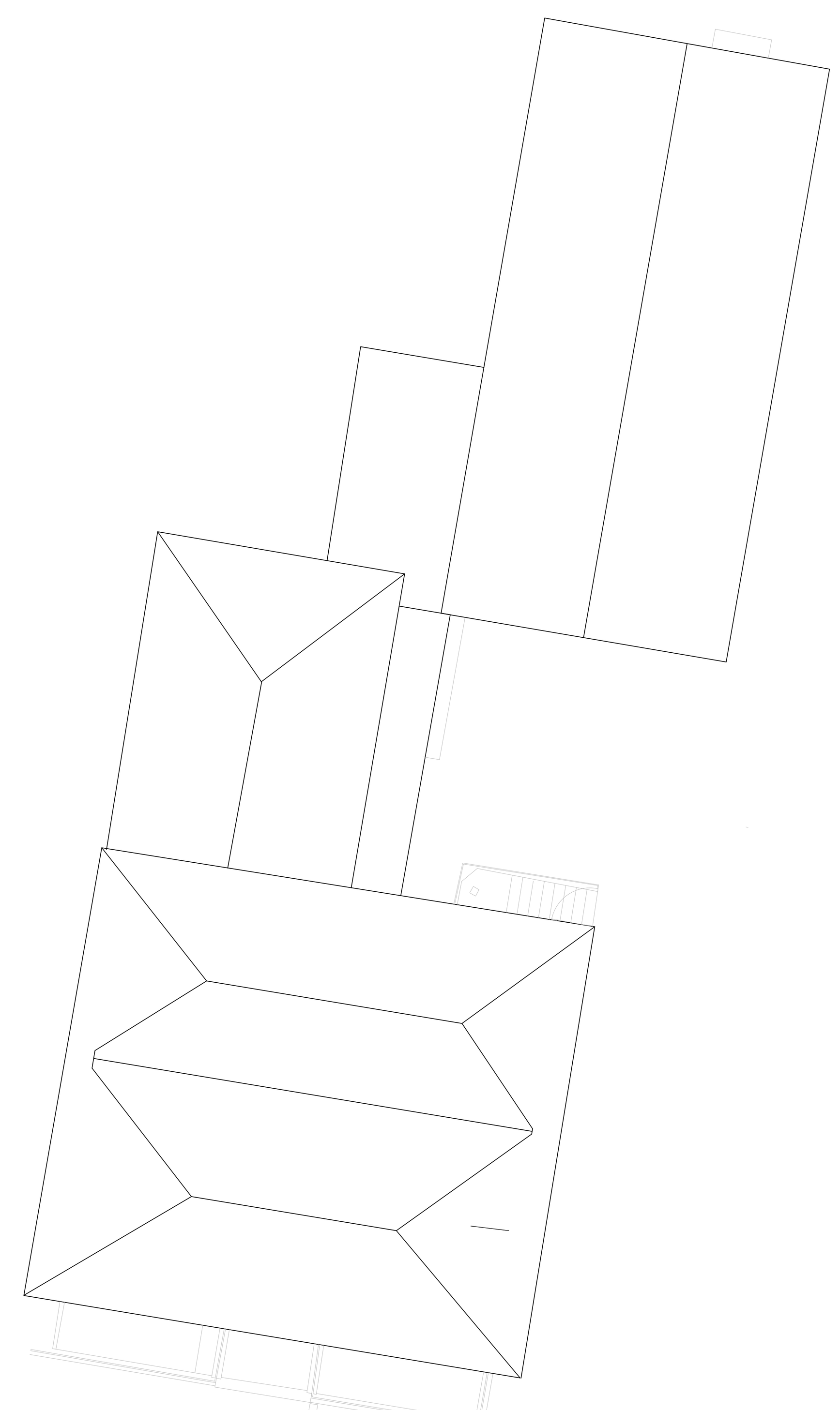

Second Floor - Existing

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Client:
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Project:
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Drawing Title:
13 Lower Teddington Road
Floor Plans
Existing & Proposed

Scale @ A0 :	Checked by :	Date :
1:100	PR	Aug 2018

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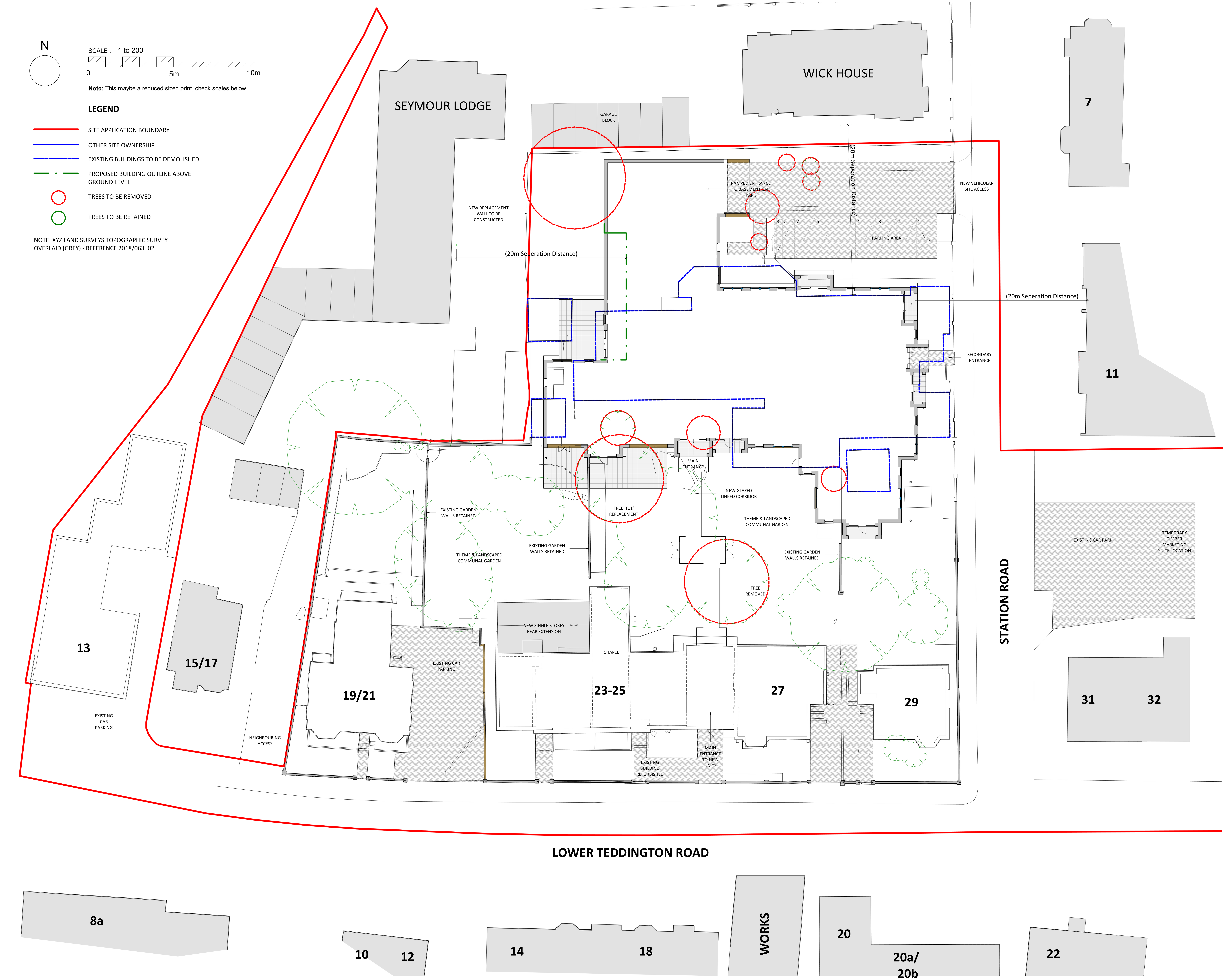

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Revisions:		Drawn / Chkd :	Date :
P1	Preliminary Issue 01	-	29/11/18
P2	Preliminary Issue 02	-	29/11/18
P3	Preliminary Issue 03	-	29/11/18
P4	Updated further to pre-application meeting	MAS	29/11/18

Client:
The Sons of Divine Providence Developments Ltd

PRC

24 Church St. West,
Woking, Surrey,
GU21 6HT

01483 494 350

info@prc-group.com
www.prc-group.com

Project:
12-14 Station Road & 13 & 19-33 Lower Teddington Road Hampton Wick

Drawing Title:
Proposed Site Plan

Scale @ A1 :	Checked by :	Date :
1 : 200	MAS	May 2018

Job No :	Stage _ Drawing No :	Rev :
10901	FE_100	P4

Issue Status :
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- Preliminary ■
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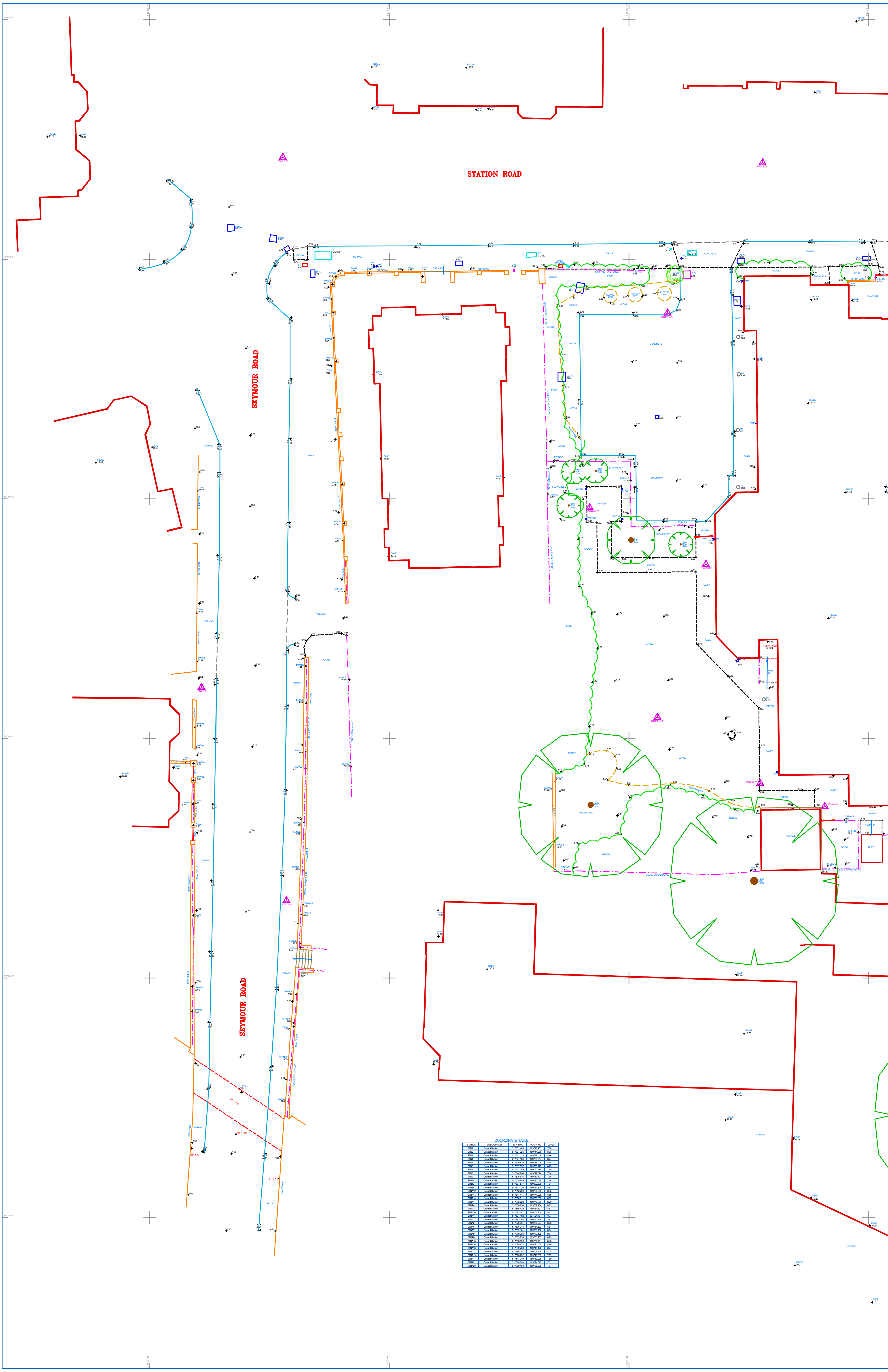
APPENDIX 2 – Topographical Survey



COORDINATE TABLE

STATION	DESCRIPTION	EASTING	NORTHING	LEVEL
STN1	Control Station	517531.409	169726.463	7.66
STN2	Control Station	517524.324	169744.265	8.33
STN3	Control Station	517531.113	169788.516	8.96
STN4	Control Station	517571.156	169788.054	8.74
STN5	Control Station	517610.830	169788.028	8.48
STN6	Control Station	517637.537	169778.173	8.23
STN7	Control Station	517637.749	169762.485	7.95
STN8	Control Station	517640.204	169717.324	7.34
STN9	Control Station	517626.616	169737.771	7.96
STN9A	Control Station	517625.989	169730.090	7.99
STN10	Control Station	517637.577	169692.879	7.01
STN6A	Control Station	517623.220	169767.809	8.53
STNA12	Control Station	517613.209	169765.236	8.45
STNA13	Control Station	517611.411	169771.235	8.69
STNA14	Control Station	517588.911	169778.850	8.62
STNA1	Control Station	517563.228	169775.506	8.79
STNA4	Control Station	517556.730	169759.254	8.85
STNA2	Control Station	517566.429	169754.531	8.67
STNA10	Control Station	517583.287	169754.310	8.67
STNA11	Control Station	517594.192	69752.613	8.77
STNA3	Control Station	517562.380	169741.779	8.81
STNA5	Control Station	517570.961	169736.267	8.63
STNA6	Control Station	517576.343	169734.332	8.61
STNA7	Control Station	517582.161	169733.180	8.64
STNA9	Control Station	517589.766	169737.422	8.84
STNA8	Control Station	517589.795	169733.255	8.79
STNA15	Control Station	517598.890	169727.67	8.43
STNA16	Control Station	517589.412	169721.550	8.80
STNA18	Control Station	517589.723	169715.126	8.24
STNA11	Control Station	517586.001	169706.526	8.14
STNA19	Control Station	517596.732	169710.307	7.82
STNA17	Control Station	517617.749	169719.035	7.60
STNA21	Control Station	517608.603	169714.077	7.51
STNA20	Control Station	517609.130	169705.375	7.37

N

REVISION:

SCALE: 1:100@A0	DATE: MARCH 2018
DRAWING NO: 01	DRAWN BY: PS/SV
SURVEYED BY: PS	CHECKED BY: ME

LEVELS RELATE TO:

GPS DATA

SITE ADDRESS:

ORIONE CARE
LOWER TEDDINGTON RO
HAMPTON WICK
KT1 4HB

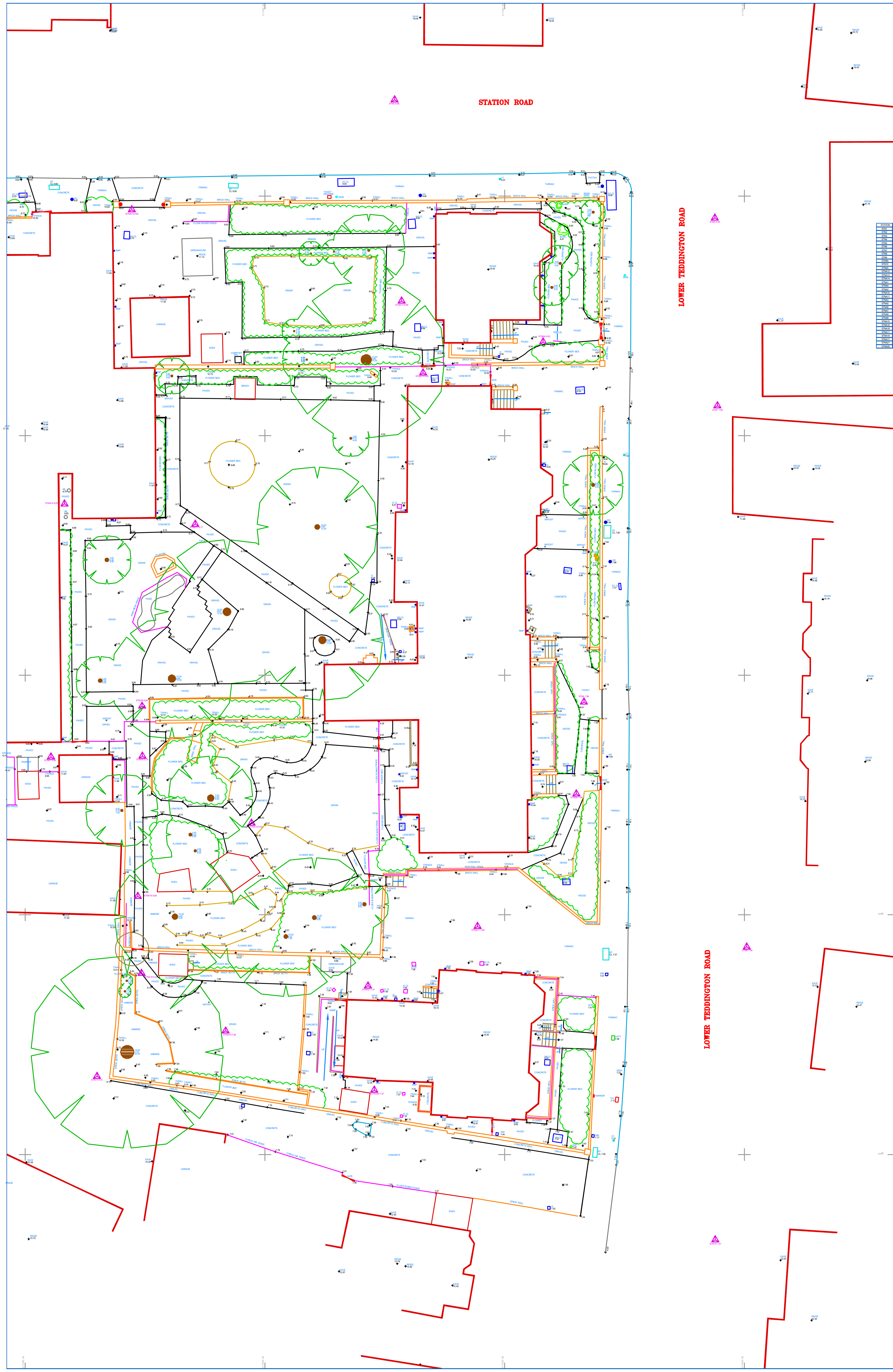
DRAWING TITLE:
SITE SURVEY

JOB NUMBER:
2018/063

CLIENT:
PRC GROUP

XYZ LAND SURVEYS
CHARTERED SURVEYORS
HEAD OFFICE
TRIDENT COURT, UNIT ONE, OAKCROFT R
CHESSINGTON, SURREY, KT9 1BD
TEL 020 8255 4550
E-Mail: surveyors@xyzsurveys.co.uk
Website: www.xyzsurveys.co.uk

CHARTERED SURVEYORS



COORDINATE TABLE

STATION	DESCRIPTION	EASTING	NORTHING	LEVEL
STN1	Control Station	517531.409	169726.463	7.66
STN2	Control Station	517524.324	169744.265	8.33
STN3	Control Station	517531.113	169788.516	8.96
STN4	Control Station	517571.156	169788.054	8.74
STN5	Control Station	517610.830	169788.028	8.48
STN6	Control Station	517637.537	169778.173	8.23
STN7	Control Station	517637.749	169762.485	7.95
STN8	Control Station	517640.204	169717.324	7.34
STN9	Control Station	517626.616	169737.771	7.96
STN9A	Control Station	517625.989	169730.090	7.99
STN10	Control Station	517637.577	169692.879	7.01
STN6A	Control Station	517623.220	169767.809	8.53
STNA12	Control Station	517613.209	169765.236	8.45
STNA13	Control Station	517611.411	169771.235	8.69
STNA14	Control Station	517588.911	169778.850	8.62
STNA1	Control Station	517563.228	169775.506	8.79
STNA4	Control Station	517556.730	169759.254	8.85
STNA2	Control Station	517566.429	169754.531	8.67
STNA10	Control Station	517583.287	169754.310	8.67
STNA11	Control Station	517594.192	69752.613	8.77
STNA3	Control Station	517562.380	169741.779	8.81
STNA5	Control Station	517570.961	169736.267	8.63
STNA6	Control Station	517576.343	169734.332	8.61
STNA7	Control Station	517582.161	169733.180	8.64
STNA9	Control Station	517589.766	169737.422	8.84
STNA8	Control Station	517589.795	169733.255	8.79
STNA15	Control Station	517598.890	169727.67	8.43
STNA16	Control Station	517589.412	169721.550	8.80
STNA18	Control Station	517589.723	169715.126	8.24
STNA11	Control Station	517586.001	169706.526	8.14
STNA19	Control Station	517596.732	169710.307	7.82
STNA17	Control Station	517617.749	169719.035	7.60
STNA21	Control Station	517608.603	169714.077	7.51
STNA20	Control Station	517609.130	169705.375	7.37

N

RICS

QMS

REVISION:

SCALE:	DATE:
1:100@A0	MARCH 2018
DRAWING NO: 02	DRAWN BY: PS/SV
SURVEYED BY: PS	CHECKED BY: ME

LEVELS RELATE TO:

GPS DATA

SITE ADDRESS:

ORIONE CARE
LOWER TEDDINGTON RO
HAMPTON WICK
KT1 4HB

DRAWING TITLE:
SITE SURVEY

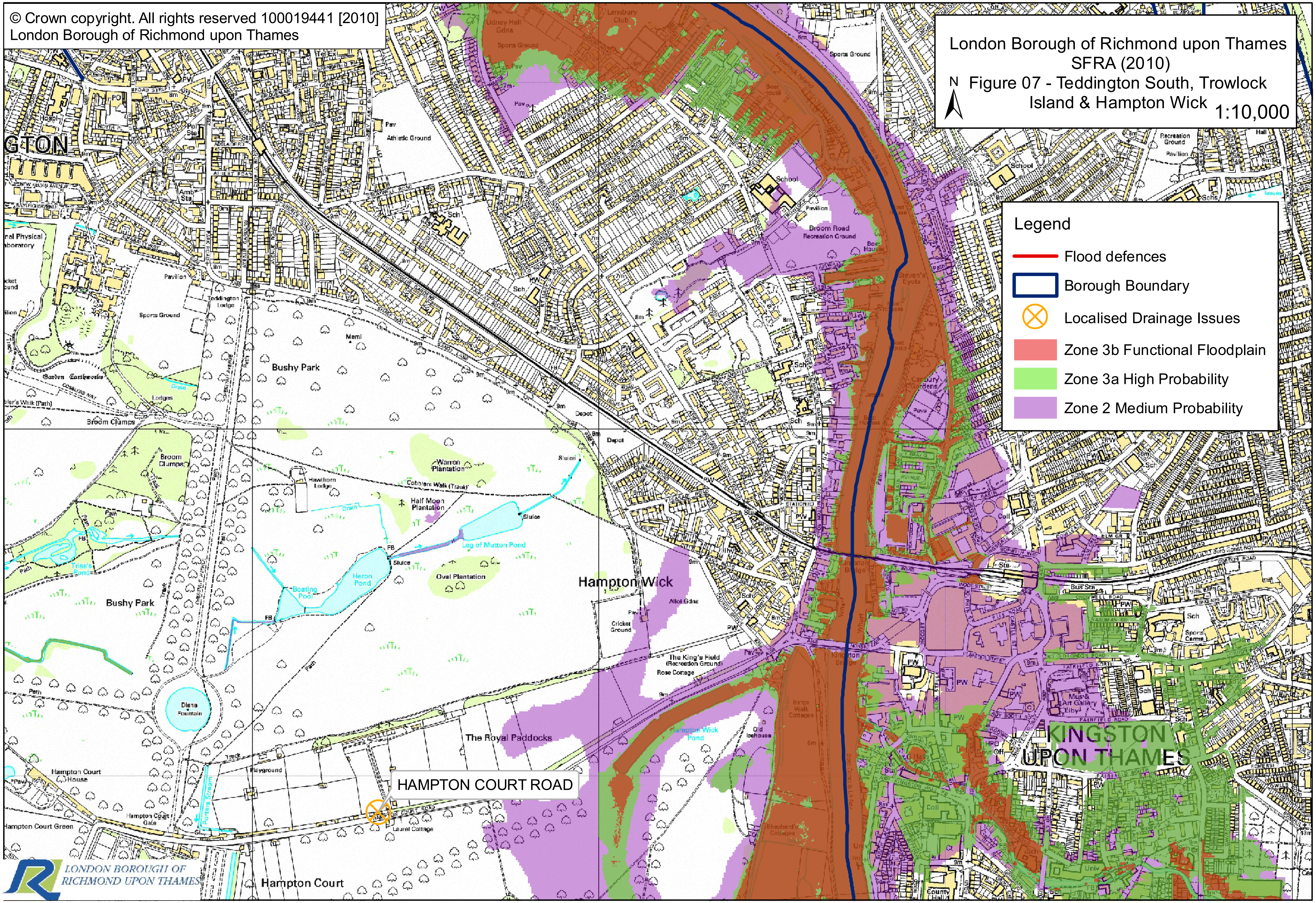
JOB NUMBER:
2018/063

CLIENT:
PRC GROUP

XYZ LAND SURVEYS
CHARTERED SURVEYORS
HEAD OFFICE
TRIDENT COURT, UNIT ONE, OAKCROFT R
CHESSINGTON, SURREY, KT9 1BD
TEL 020 8255 4550
E-Mail: surveyors@xyzsurveys.co.uk
Website: www.xyzsurveys.co.uk

XYZ CHARTERED SURVEYORS

APPENDIX 3 – The London Borough of Richmond upon Thames SFRA Flood Map


London Borough of Richmond upon Thames
SFRA (2010)
Figure 07 - Teddington South, Trowlock Island & Hampton Wick
N
1:10,000
Legend
Flood defences
Borough Boundary
Localised Drainage Issues
Zone 3b Functional Floodplain
Zone 3a High Probability
Zone 2 Medium Probability
HAMPTON COURT ROAD
Bushy Park
Hampton Wick
The Royal Paddocks
Hampton Court
KINGSTON UPON THAMES
LONDON BOROUGH OF RICHMOND UPON THAMES

APPENDIX 4 – IoH 124 Method Calculations

Hydrological Data:-

FSR Hydrology:-

Location = TEDDINGTON
Grid reference = TQ1671
M5-60 (mm) = 19.8
r = 0.42
Soil runoff = 0.30
SAAR (mm/yr) = 610
WRAP = 2
Area = England & Wales
Hydrological area = 6
Hydrological zone = 8

Soil classification for WRAP type 2
i) Very permeable soils with shallow ground water;
ii) Permeable soils over rock or fragipan, commonly on slopes in western Britain associated with smaller areas of less permeable wet soils; (fragipan - a natural subsurface horizon having a higher bulk density than the solum above. Seemingly cemented when dry but showing moderate to weak brittleness when moist. The layer is low in organic matter, mottled and slowly or very slowly permeable to water. It is found in profiles of either cultivated or virgin soils but not in calcareous material).
iii) Moderately permeable soils, some with slowly permeable subsoils.

Design data:-

Area = 0.0034 Km^2 - 0.34 Ha - 3400 m^2

Calculation method:-

Runoff is calculated from:-

$$Q_{BAR(rural)} = 0.00108\ AREA^{0.89}\ .\ SAAR^{1.17}\ .\ SOIL^{2.17}$$

where

AREA = Site area in Km^2
SAAR = Standard Average Annual Rainfall (mm/yr)
SOIL = Soil value derived from Winter Rainfall Acceptance Potential
$Q_{BAR(rural)}$ = Runoff (cumecs)

$Q_{BAR(rural)}$ is then multiplied by a growth factor - GC(T) - for different storm return periods derived from EA publication W5-074/A.

Calculated data:-

For areas less than 50Ha, a modified calculation which multiplies the 50Ha runoff value by the ratio of the site area to 50Ha is used
Reducing factor used for these calculations is 0.007

Mean Annual Peak Flow $Q_{BAR(rural)}$ = 0.53 l/s

Values for $Q_{BAR(rural)}$

Ret. per.	m³/hr	l/s	l/s/ha	Ret. per.	m³/hr	l/s	l/s/ha
1yr	1.614	0.448	1.319	100yr	5.982	1.662	4.887
2yr	1.671	0.464	1.365	100yr+20%	7.178	1.994	5.864
5yr	2.431	0.675	1.986	100yr+30%	7.776	2.160	6.353
10yr	3.076	0.855	2.513	200yr	7.026	1.952	5.740
30yr	4.235	1.176	3.460	200yr + 30%	9.134	2.537	7.462
50yr	4.975	1.382	4.065	500yr	8.526	2.368	6.966
				1000yr	9.798	2.722	8.005

Growth factors -

1yr	2yr	5yr	10yr	30yr	50yr	100yr	200yr	500yr	1000yr
0.85	0.88	1.28	1.62	2.23	2.62	3.15	3.70	4.49	5.16

The above is based on the Institute of Hydrology Report 124
to which you are referred for further details (see Sect 7).
Note that the 200 and above year growth curves were taken from W5-074.

APPENDIX 5 – Attenuation Storage Calculations

MasterDrain SW	**KRS Environmental Limited.** www.krsenvironmental.com	3 Princes Square, Princes Street, Montgomery Powys, SY15 6PZ Tel: 01686 668957 Mob: 07857 264 376 email: keelan@krsenvironmental.com	Job No.		
			Sheet no. 1		
			Date 08/01/19		
	Project Lower Teddington Road, Hampton Wick, KT1 4EU		By	Checked	Reviewed
	Title Attenuation Storage Calculations				

Data:-

Location = TEDDINGTON
M5-60 (mm) = 19.8
Soil index = 0.30
Return period = 100
UCWI = 0.0

Grid reference = TQ1671
r = 0.42
SAAR (mm/yr) = 610
WRAP = 2
Climate change = 40%

i) Very permeable soils with shallow ground water;
ii) Permeable soils over rock or fragipan, commonly on slopes in western Britain associated with smaller areas of less permeable wet soils; The layer is low in organic matter, mottled and (fragipan - a natural subsurface horizon having a higher bulk density than the solum above. Seemingly cemented when dry but showing moderate to weak brittleness when moist. Slowly or very slowly permeable to water. It is found in profiles of either cultivated or virgin soils but not in calcareous material).
iii) Moderately permeable soils, some with slowly permeable subsoils.

Pipeline storage = 0.0 m³
Offline storage = 0.0 m³

Available MH storage = 0.0 m³

Percentage runoff = 100.0% (manual setting)

Imperv. area = 3400 m²
Total area = 3400 m²
Total runoff = 266.9 m³

Pervious area = 0 m²
Equiv area = 3400 m² (Tot. area x % runoff).
Discharge rate = 5.000 l/s

Storage (m³) = 203.7 m³ (Sum of all balance quantities)

Total rainfall depth = 78.5 mm

Calculations :-

Time (hrs)	%Mean intens	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)	Cumulative (m3)
0.040	20.0	3.9	0.534	0.720	0.000	0.000
0.080	20.0	3.9	0.534	0.720	0.000	0.000
0.120	21.0	4.1	0.561	0.720	0.000	0.000
0.160	21.0	4.1	0.561	0.720	0.000	0.000
0.200	22.0	4.3	0.587	0.720	0.000	0.000
0.240	23.0	4.5	0.614	0.720	0.000	0.000
0.280	24.0	4.7	0.641	0.720	0.000	0.000
0.320	26.0	5.1	0.694	0.720	0.000	0.000
0.360	27.0	5.3	0.721	0.720	0.001	0.001
0.400	29.0	5.7	0.774	0.720	0.054	0.055
0.440	31.0	6.1	0.827	0.720	0.107	0.162
0.480	32.0	6.3	0.854	0.720	0.134	0.296
0.520	33.0	6.5	0.881	0.720	0.161	0.457
0.560	34.0	6.7	0.908	0.720	0.188	0.645
0.600	36.0	7.1	0.961	0.720	0.241	0.885
0.640	38.0	7.5	1.014	0.720	0.294	1.180
0.680	39.0	7.7	1.041	0.720	0.321	1.501
0.720	40.0	7.9	1.068	0.720	0.348	1.848
0.760	42.0	8.2	1.121	0.720	0.401	2.249
0.800	45.0	8.8	1.201	0.720	0.481	2.730
0.840	49.0	9.6	1.308	0.720	0.588	3.318
0.880	53.0	10.4	1.415	0.720	0.695	4.013
0.920	57.0	11.2	1.521	0.720	0.801	4.814
0.960	62.0	12.2	1.655	0.720	0.935	5.749
1.000	66.0	13.0	1.762	0.720	1.042	6.791
1.040	71.0	13.9	1.895	0.720	1.175	7.966
1.080	77.0	15.1	2.055	0.720	1.335	9.301
1.120	84.0	16.5	2.242	0.720	1.522	10.823
1.160	91.0	17.9	2.429	0.720	1.709	12.532
1.200	98.0	19.2	2.616	0.720	1.896	14.428
1.240	105.0	20.6	2.803	0.720	2.083	16.510
1.280	114.0	22.4	3.043	0.720	2.323	18.833
1.320	125.0	24.5	3.336	0.720	2.616	21.450
1.360	135.0	26.5	3.603	0.720	2.883	24.333
1.400	143.0	28.1	3.817	0.720	3.097	27.430
1.440	154.0	30.2	4.110	0.720	3.390	30.820

3 Princes Square, Princes Street, Montgomery
Powys, SY15 6PZ
Tel: 01686 668957 Mob: 07857 264 376
email: keelan@krsenvironmental.com

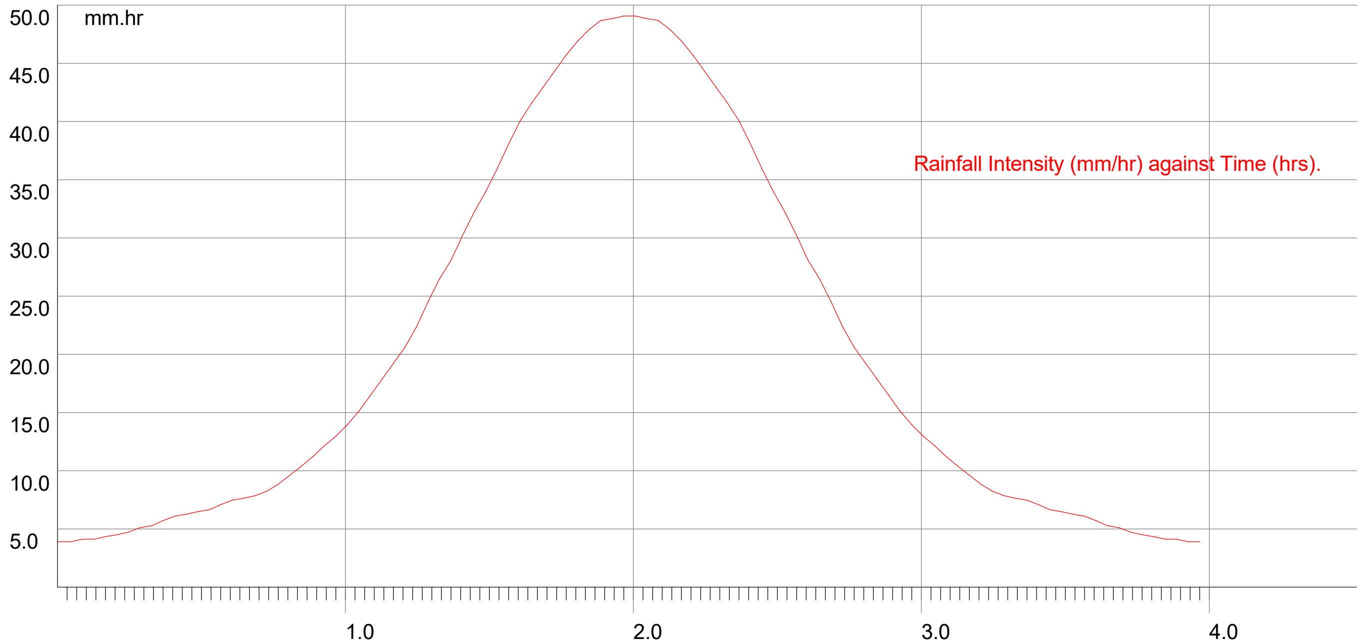
Calculations (cont.) :-

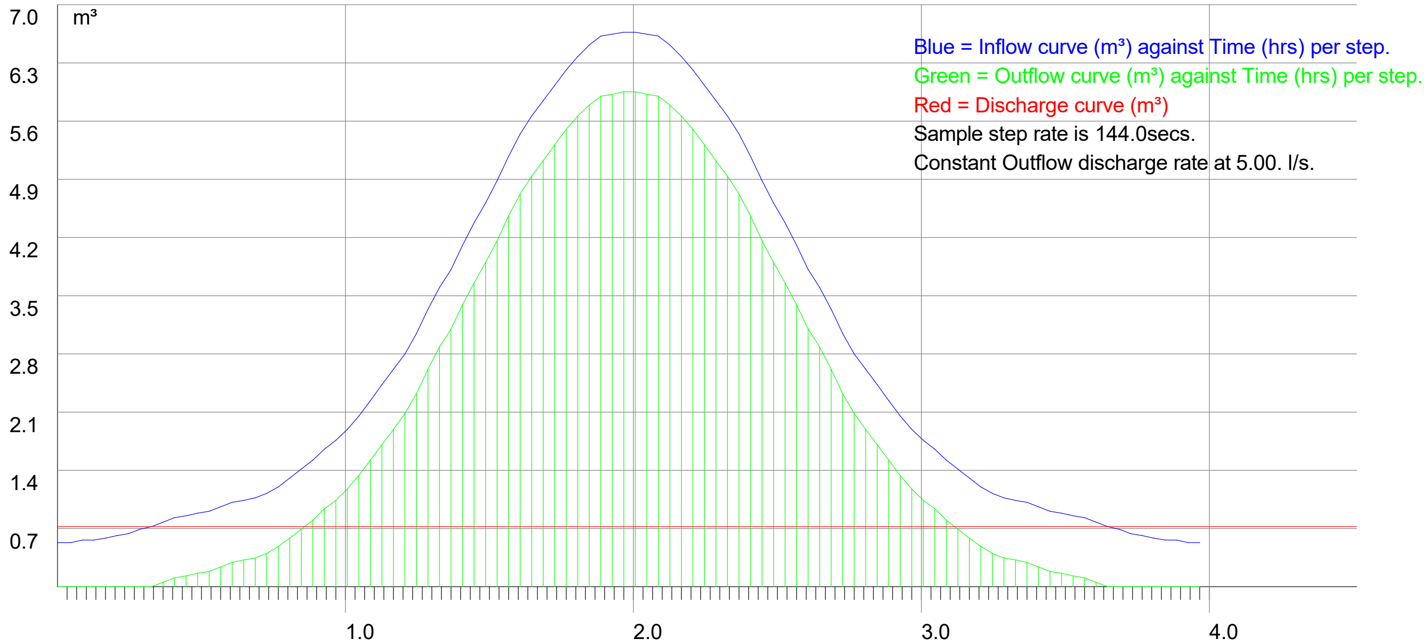
Time (hrs)	%Mean intens	Rain mm/hr	Inflow (m3)	Outflow (m3)	Balance (m3)	Cumulative (m3)
1.640	204.0	40.0	5.445	0.720	4.725	51.723
1.680	212.0	41.6	5.659	0.720	4.939	56.661
1.720	219.0	43.0	5.845	0.720	5.125	61.787
1.760	226.0	44.4	6.032	0.720	5.312	67.099
1.800	233.0	45.7	6.219	0.720	5.499	72.598
1.840	239.0	46.9	6.379	0.720	5.659	78.257
1.880	244.0	47.9	6.513	0.720	5.793	84.050
1.920	248.0	48.7	6.619	0.720	5.899	89.949
1.960	249.0	48.9	6.646	0.720	5.926	95.876
2.000	250.0	49.1	6.673	0.720	5.953	101.828
2.040	250.0	49.1	6.673	0.720	5.953	107.781
2.080	249.0	48.9	6.646	0.720	5.926	113.707
2.120	248.0	48.7	6.619	0.720	5.899	119.607
2.160	244.0	47.9	6.513	0.720	5.793	125.399
2.200	239.0	46.9	6.379	0.720	5.659	131.059
2.240	233.0	45.7	6.219	0.720	5.499	136.558
2.280	226.0	44.4	6.032	0.720	5.312	141.870
2.320	219.0	43.0	5.845	0.720	5.125	146.995
2.360	212.0	41.6	5.659	0.720	4.939	151.934
2.400	204.0	40.0	5.445	0.720	4.725	156.659
2.440	194.0	38.1	5.178	0.720	4.458	161.117
2.480	183.0	35.9	4.884	0.720	4.164	165.281
2.520	173.0	34.0	4.618	0.720	3.898	169.179
2.560	164.0	32.2	4.377	0.720	3.657	172.836
2.600	154.0	30.2	4.110	0.720	3.390	176.227
2.640	143.0	28.1	3.817	0.720	3.097	179.324
2.680	135.0	26.5	3.603	0.720	2.883	182.207
2.720	125.0	24.5	3.336	0.720	2.616	184.823
2.760	114.0	22.4	3.043	0.720	2.323	187.146
2.800	105.0	20.6	2.803	0.720	2.083	189.229
2.840	98.0	19.2	2.616	0.720	1.896	191.124
2.880	91.0	17.9	2.429	0.720	1.709	192.833
2.920	84.0	16.5	2.242	0.720	1.522	194.355
2.960	77.0	15.1	2.055	0.720	1.335	195.691
3.000	71.0	13.9	1.895	0.720	1.175	196.866
3.040	66.0	13.0	1.762	0.720	1.042	197.907
3.080	62.0	12.2	1.655	0.720	0.935	198.842
3.120	57.0	11.2	1.521	0.720	0.801	199.644
3.160	53.0	10.4	1.415	0.720	0.695	200.338
3.200	49.0	9.6	1.308	0.720	0.588	200.926
3.240	45.0	8.8	1.201	0.720	0.481	201.407
3.280	42.0	8.2	1.121	0.720	0.401	201.808
3.320	40.0	7.9	1.068	0.720	0.348	202.156
3.360	39.0	7.7	1.041	0.720	0.321	202.477
3.400	38.0	7.5	1.014	0.720	0.294	202.771
3.440	36.0	7.1	0.961	0.720	0.241	203.012
3.480	34.0	6.7	0.908	0.720	0.188	203.200
3.520	33.0	6.5	0.881	0.720	0.161	203.360
3.560	32.0	6.3	0.854	0.720	0.134	203.495
3.600	31.0	6.1	0.827	0.720	0.107	203.602
3.640	29.0	5.7	0.774	0.720	0.054	203.656
3.680	27.0	5.3	0.721	0.720	0.001	203.657
3.720	26.0	5.1	0.694	0.720	0.000	203.631
3.760	24.0	4.7	0.641	0.720	0.000	203.551
3.800	23.0	4.5	0.614	0.720	0.000	203.445
3.840	22.0	4.3	0.587	0.720	0.000	203.312
3.880	21.0	4.1	0.561	0.720	0.000	203.153
3.920	21.0	4.1	0.561	0.720	0.000	202.993
3.960	20.0	3.9	0.534	0.720	0.000	202.807
4.000	20.0	3.9	0.534	0.720	0.000	202.621

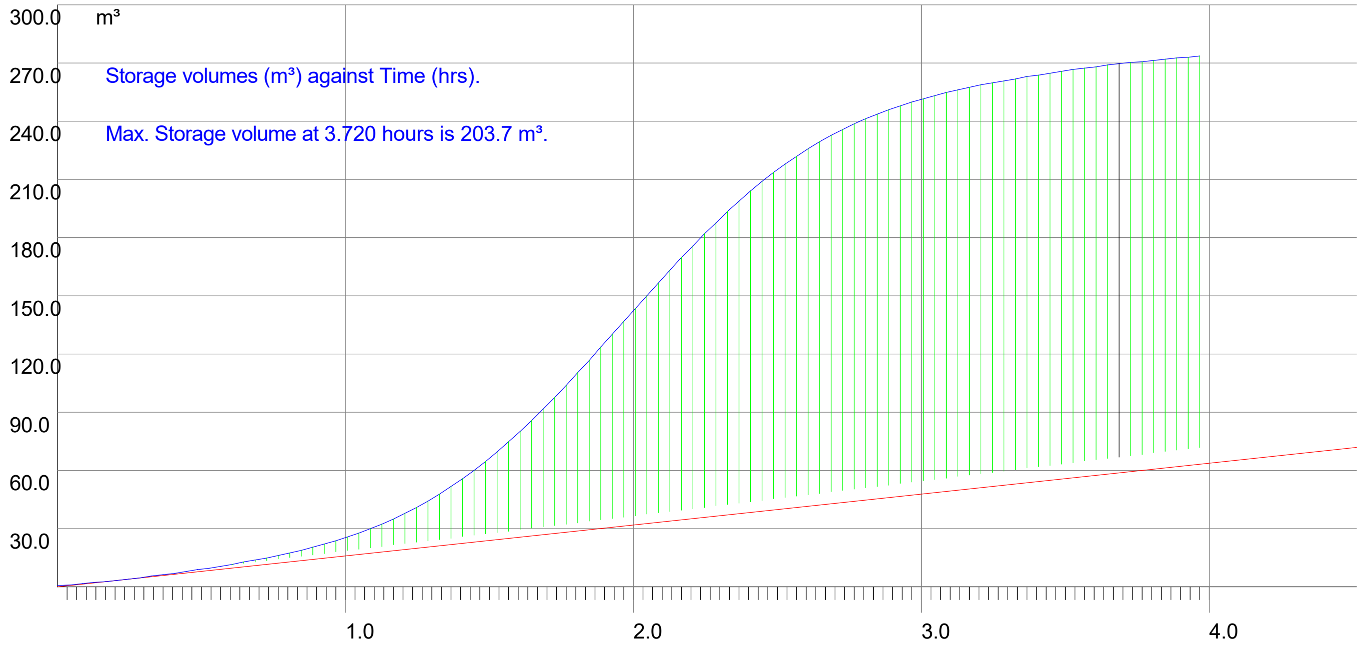
Storage volume (m^3) = 203.7 m^3 (Sum of all balance quantities)

MasterDrain SW

KRS Environmental Limited. www.krsenvironmental.com	3 Princes Square, Princes Street, Montgomery Powys, SY15 6PZ Tel: 01686 668957 Mob: 07857 264 376 email: keelan@krsenvironmental.com	Job No.		
		Sheet no. 3		
		Date 08/01/19		
Project **Lower Teddington Road, Hampton Wick, KT1 4EU**		By	Checked	Reviewed
Title **Attenuation Storage Calculations**				







3 Princes Square, Princes Street, Montgomery
Powys, SY15 6PZ
Tel: 01686 668957 Mob: 07857 264 376
email: keelan@krsenvironmental.com

Maximum storage volumes for varying duration storms.

Storm length (hrs)	Max. Vol (m^3)	Max. Vol time	Mean intens (mm/hr)	Step time. (mins)	Peak found
0.25	116.59	0.25	138.99	0.2	
0.5	148.72	0.50	90.52	0.3	
1	177.61	1.00	56.13	0.6	
2	198.51	2.00	33.65	1.2	
3	203.66	3.00	24.63	1.8	
4	203.66	4.00	19.63	2.4	Peak found
5	200.95	---	16.41	3.0	
6	197.91	---	14.18	3.6	
7	194.54	---	12.54	4.2	
8	190.87	---	11.27	4.8	
9	186.79	---	10.26	5.4	
10	182.45	---	9.42	6.0	
12	173.30	---	8.14	7.2	
15	159.18	---	6.80	9.0	
18	144.84	---	5.87	10.8	
20	135.37	---	5.39	12.0	
24	117.02	---	4.65	14.4	
30	90.78	---	3.87	18.0	
36	66.90	---	3.34	21.6	
42	45.68	---	2.94	25.2	
48	27.43	---	2.64	28.8	
54	12.57	---	2.40	32.4	
60	2.49	---	2.20	36.0	
66	0.00	---	2.03	39.6	
72	0.00	---	1.89	43.2	
84	0.00	---	1.67	50.4	
96	0.00	---	1.49	57.6	
120	0.00	---	1.24	72.0	
150	0.00	---	1.03	90.0	
175	0.00	---	0.91	105.0	
200	0.00	---	0.81	120.0	
250	0.00	---	0.68	150.0	
300	0.00	---	0.58	180.0	
375	0.00	---	0.48	225.0	
500	0.00	---	0.38	300.0	
750	0.00	---	0.27	450.0	
1000	0.00	---	0.21	600.0	
1250	0.00	---	0.18	750.0	
1500	0.00	---	0.15	900.0	
1570	0.00	---	0.15	942.0	
2000	0.00	---	0.12	1200.0	
2500	0.00	---	0.10	1500.0	
3000	0.00	---	0.09	1800.0	
3500	0.00	---	0.08	2100.0	
4000	0.00	---	0.07	2400.0	

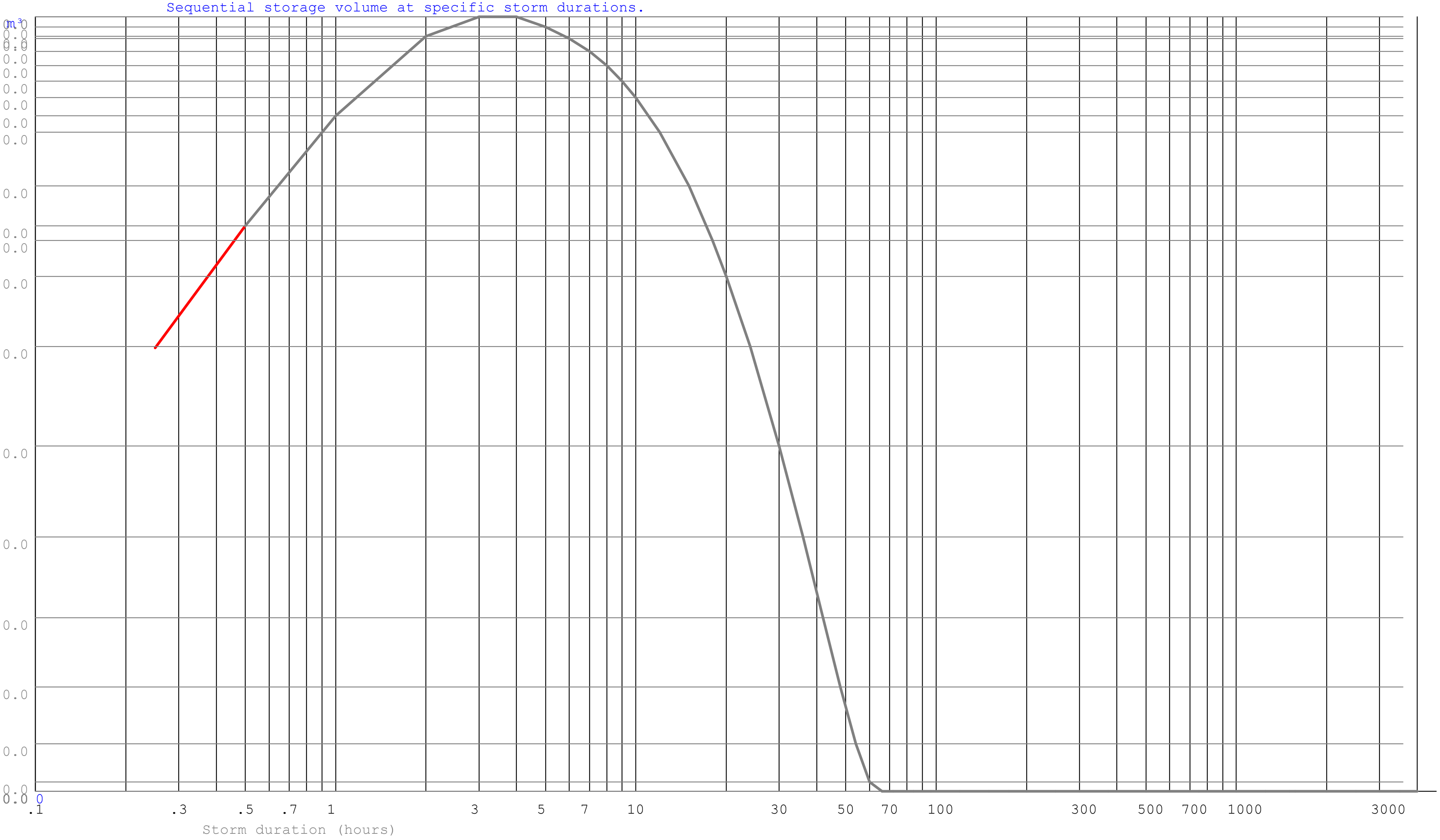
MasterDrain SW

KRS Environmental Limited.
www.krsenvironmental.com
3 Princes Square, Princes Street, Montgomery
Powys, SY15 6PZ
Tel: 01686 668957 Mob: 07857 264 376
email: keelan@krsenvironmental.com

Job No.	
Sheet no.	5
Date	08/01/19
By	
Checked	
Reviewed	

Project **Lower Teddington Road, Hampton Wick, KT1 4EU**

Title **Attenuation Storage Calculations**



Explanatory notes for Peak Flow Storage

1) This system uses the rainfall intensity/ duration curve calculated using either the Wallingford or FEH method as selected.
2) The balance is calculated from the inflow minus the outflow.
3) The storage volume is the maximum value of the balance curve.
4) This method was described by Davis (1963) - see Butler & Davies, 2nd edition, p294
5) References to 'storm duration' relate only to the hydrograph method (qv).
6) There are always 600 steps in the calculation process, thus a 'run' time of 10 hours will be sampled every minute,

Explanatory notes for Hydrograph Storage

1) The user has the choice of Summer or Winter curves
2) The mean intensity varies with the duration of the storm curve
3) There are always 120 steps in the calculation process, irrespective of storm duration.
4) The balance is calculated from the inflow minus the outflow.
5) The storage volume is the sum of the balance values for each step.
6) Varying durations should be tried to find the maximum storage value - this can be narrowed down very closely.

*Modelling using the flow characteristics of the restrictor is available using Vortex Control modelling function.
Please be aware that this function needs the full design data file to function.

Why do the two methods give different results?

The rainfall characteristics for each method are very different.

The Peak flow (using the Intensity/Duration/Frequency curve) does not model the actual rainfall. This curve is joined points which represent the mean intensity of a storm at a given duration i.e. a value of 19.5 mm/hr for a 60 minute storm indicates that over the sixty minute period, the mean intensity was 19.5 mm/hr. The calculation method samples the IDF curve for a given location and frequency (Return Period) and calculates the storage for that rate and duration less the outflow volume. The maximum value is displayed as the 'worst case' storage.

The hydrograph method uses a standard curve for either Winter or Summer storms. Traditionally these are symmetrical about the central peak. UK rainfall does not fit into this convenient curve, so the calculations are dealing with a stylised set of data. The mean intensity for the storm is calculated from the IDF curve and applied to the curve data, calculating the storage for that step less the outflow volume. The final storage volume is the sum of the storage for all the steps.

It can be seen that these two methods are very different, and the user may have the choice of which result to use. This is not an exact science, though is often treated as such by those that do not understand the principles of the calculations.

KRS Environmental Ltd

Mob: 07857 264 376

Tel: 01686 668957

Tel: 01484 437420

Email: keelan@krsenvironmental.com

Web: www.krsenvironmental.com