also. Refer to Appendix 3 for the full calculation details. The existing run off rates are shown in the table below:

Storm Return Period	Run off Rate (l/s)	50% Betterment (l/s)
1 year	22.0	11.0
30 year	50.3	25.2
100 year	65.0	32.5
100 year + 40% climate change	91.0	**45.5**

Table 4 Refurbished area existing surface water run off rate

For the proposed redeveloped site area of 0.255ha, complying with the guidance from LBC and providing a 50% betterment on existing, this gives a proposed discharge rate equal to **45.5l/s**.

Through further hydraulic modelling in MicroDrainage and using the IH124 method, the greenfield run off rate for the new builds area of the plot has been calculated. Refer to Appendix 3 for the full calculation details. The existing run off rates are shown in the table below:

IH124 Site Area (ha)	Qbar (l/s/50ha)	Qbar (l/s/ha)	New Build Site Area (ha)	Qbar (l/s)
50	183.4	3.7	0.724	**2.7**

Table 5 New build greenfield run off rate

The total proposed discharge rate for the site is calculated from the cumulative discharge of the retained buildings with 50% betterment and the greenfield run-off rate for the new build. Therefore, the total proposed discharge rate for the site once fully redeveloped is **48.2 l/s.** This discharge rate was presented to Camden Council drainage officer and received general agreement. Refer to Appendix 6 for correspondence and meeting minutes during the Camden Council pre-application meetings. This proposed discharge rate remains unchanged from the previous planning application.

The Thames Water asset maps indicate a large combined sewer flowing in the north-west direction along Grays Inn Road. This sewer is denoted as 1143 x 762. In consultation with Thames Water, a new connection from the site into the large combined sewer has been proposed and accepted in principle. A pre-development enquiry has been submitted to Thames Water, and the discharge rate calculated above has been accepted. Refer to Appendix 6 for the Thames Water response letter.

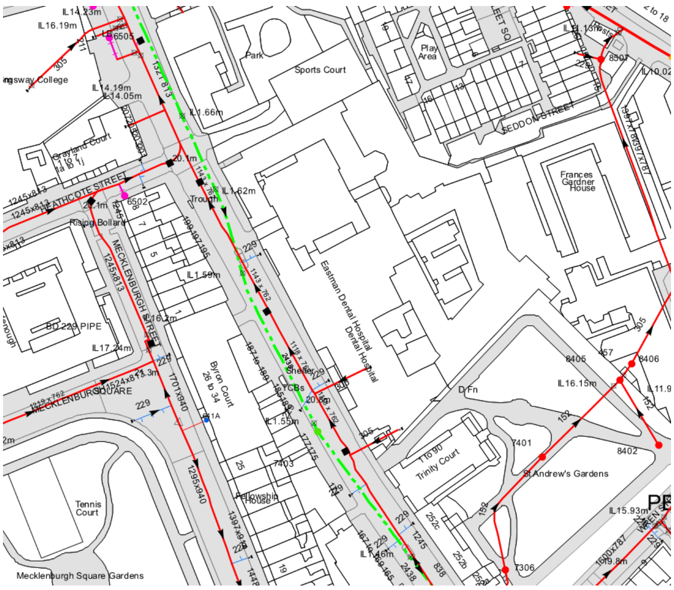

Figure 4 Thames Water asset map extract

4.2 Surface water drainage strategy

4.2.1 Site wide SuDS implementation

Developers must ensure that surface water run-off is controlled and managed effectively. The Sustainable Drainage hierarchy advocates the management of surface water close to its source.

Sustainable Drainage Systems generally mimic the natural drainage patterns of the undeveloped site allowing infiltration into the ground/attenuation, improving water quality and controlling outflow rates from the development. The implementation of SuDS measures are advocated within the LBC Council Guidance and are encouraged to form a requisite consideration within development planning.

The type of drainage systems considered suitable for the site are driven, by the physical characteristics of the site, the local ground conditions, the density of development and site specific constraints such as existing trees, allowable discharge rates and outfall invert levels. Techniques which form part of a good practice approach and were considered for the site, include:

- Detention basins;
- Filter drains;
- Swales;
- Rain gardens/bio-retention areas;
- Blue/green/brown roofs;
- Ponds;
- Permeable paving;
- Rain water harvesting;
- Rills;
- Below ground storage tanks;

The chosen (suitable) systems, which form part of the proposed drainage design, are described below with reference to the proposed development site. The choice of which systems to be used in each location has been based on their suitability, coordination with the landscape proposals, the proposed ground levels and proximity to grade listed buildings.

4.2.2 Green / brown / blue roof

Utilisation of a blue or green roof provides a number of additional benefits beyond storm-water interception, attenuation and reduction of overall runoff through evapotranspiration. Green roofs can improve air quality, storm-water quality and provide supplementary amenity.
In terms of attenuation, a standard blue roof typically consists of 150mm thick interlinked geo-cellular crate structures, laid above a waterproofed zero fall roof, providing approximately 0.143 m^3 of storage per m^2 (assuming 95% voids ratio). This means just over 7 m^2 of (150mm thick) blue roof is required per m^3 of attenuation to be provided. Flow restricted outlets allow the build-up of water, not exceeding the designed hydraulic head, within the crate structures at roof level. The outlets are installed with an overflow feature to ensure the designed hydraulic head (depth of the system) is not surpassed during extreme storm events or if a blockage occurs.
Blue and green roof systems can provide the following benefits:

- Controlled storage and release of storm water in line with SuDS best practice / legislation.
- Reduction in roof penetrations and rain water outlets required.
- Overall time and cost savings versus traditional methods, e.g. ponds and tanks.
- Reduction in excavated material.
- Less disruption on site.
- Reduced requirement to install underground attenuation tanks.

- Reduced carbon footprint.
- Zero falls at roof level; no need to screed to fall.
- Compliant with SuDS schemes and hierarchy; provides source control.
- Contributes to the BREEAM rating.
- Improves quality of discharged storm water
- Removes airborne contaminants such as heavy metals, volatile organic compounds and other pollutant particles

Figure 5 shows a section through an Alumasc green/blue roof showing the typical build-up. From top to bottom the layers include; grass, soil, filter membrane, attenuation crate and associated membranes, insulation and waterproofing layers.

Due to the tight landscape constraints, a blue roof has been proposed in order to reduce the pressure on the landscape in terms of the area available for attenuation, but also in terms of providing an additional treatment method as a part of the pollution prevention strategy. The current site wide proposal provides 127.6m^3 of blue roof surface water attenuation storage across Plot 1 and Plot 3.

Figure 5 Alumasc typical green roof build-up

4.2.3 Underground Storage Tank

The underground storage tank would consist of a geocellular system to control and manage rainwater surface water runoff as a storage tank, refer to Figure 6. The modular/honeycomb nature of geocellular systems means that they can be tailored to suit the specific requirements of the site. There are however constraints when dealing with planting and soft landscaping. Limitations:

- Deep excavation depth and possible large area required to form the below ground storage structure;
- Constraints on location of landscaping and planting;
- Constraints on foundations and sub structures;
- Constraints on service routes.

There is very limited below ground storage area available around Plot 1 and Plot 3, due to the basements extending out further than the above ground building footprint. However, there is available area identified in the proposed public square between Plot 3 and the Eastman Dental

Clinic (Plot 2). The tank is proposed to be located within a fold in the top of the basement slab above the Plot 3 basement lecture theatre.

Figure 6 Below ground geo-cellular attenuation tank

4.2.4 Permeable Paving

Permeable paving with below-ground sub-base attenuation can be used to help manage surface water run-off. In addition to storm-water attenuation, permeable paving also provides pollution control and has been shown to reduce concentrations of contaminants such as oil, heavy metals and sediments. Water quality treatment is provided to the surface water runoff through the following methods as detailed in the CIRIA 753 SuDs manual (CIRIA, 2015):

- Filtration and settlement - removal of silt or suspended solids (with associated pollutants);
- Biodegradation – chemical dissolution of organic contaminants such as oil, petrol and diesel by bacteria, fungi or other biological means within the pavement layers;
- Adsorption – adhesion of contaminant particles to sand and gravel material surfaces within the pavement build-up. Dependent on factors such as aggregate type, structure, texture and moisture content.

The permeable surface can be lined with an impermeable liner, thus utilising the voids within the sub-base to provide attenuation. Perforated drainage pipes will convey water from the storage zone within the subgrade to the surface water drainage system.

In order to capture surface water that falls on the public realm at ground level, a permeable paving arrangement has been proposed to provide additional surface water attenuation. The external landscaping has been developed with an arrangement of a sub-surface storage crate and a granular sub-base to suit site levels and create the necessary drainage falls.

4.2.5 Site wide surface water strategy

To meet the discharge criteria set out above, the proposed surface water network has been modelled in the Windes MicroDrainage hydraulic modelling software to more accurately refine the required attenuation volumes required. Refer to Appendix 2 for Ramboll proposed drainage layouts.

As a result, the proposed surface water drainage solution maximises SuDS opportunities across all three plots in order to provide 295.4m^3 of attenuation and produce no flooding for the site. The blue roofs and permeable paving provide 127.6m^3 and 44.7m^3 of attenuation respectively.

The remaining 123.1m^3 is to be provided using a below-ground tank. Attenuation volumes are summarised in Table 6 below.

Attenuation feature	Volume
Permeable Paving	44.7m^3
Below-ground cellular tank	123.1m^3
Blue roofs	127.6m^3*
Total attenuation	295.4m^3
* Blue roof volume to be designed by specialist supplier, based on performance criteria shown on below-ground drainage drawings.	

Table 6 Proposed attenuation volumes

4.2.6 Pollution hazard indices

In line with CIRIA C753 The SuDS Manual Section 26.7 the land uses for the development and corresponding pollution hazard indices are shown in Table 7 below (reproduced from CIRIA C753 Table 26.2):

Land Use	Pollution hazard level	Total Suspended Solids	Metals	Hydro-carbons
Roofs and footpaths – Other roofs (Typically commercial / industrial roofs)	Low	0.3	0.2	0.05
Access Road – Commercial yard and delivery areas, non-residential car parking with frequent change (e.g. hospitals, retail), all roads except low traffic roads and trunk roads/motorways	Medium	0.7	0.6	0.7

Table 7 Pollution Hazard Indices

The pollution hazard for the majority of the site is low, however, the risk of pollution from the deliveries yard is higher. The sustainable drainage system proposed mitigates pollution discharging to the surface water system. Each sustainable drainage feature has associated pollution mitigation indices, as shown in the below table (reproduced from CIRIA C753 Table 26.3):

Land Use	Total Suspended Solids	Metals	Hydro-carbons
Filter Drain / Green Roof	0.4	0.4	0.4
Permeable Paving	0.7	0.6	0.7
Proprietary treatment systems – petrol interceptor	Removal of sediments and hydro-carbons		

Table 8 SuDS Mitigation Indices

As per CIRIA C753, a sufficient SuDS mitigation index should be provided to eliminate pollutants across all pollutant categories.

The traffic flow on the new access between Plot 1 and Plot 2 is be used for limited movements associated with patient drop off and emergency vehicles. However, there is a requirement for maintenance and plant replacement which will require heavy vehicles including very large mobile cranes to use this route. This requirement reduces the viability of permeable paving as a concrete sub-base is required to support the loads. A petrol interceptor is proposed in the loading bay of B1 due to the risk of spills. To calculate the mitigation index for two or more components, the following formula is used:

Total SuDS mitigation index = mitigation index$_1$ + 0.5(mitigation index$_2$)
Where Mitigation index$_n$ = mitigation index for component n

Land Use	Treatment Techniques	Total Suspended Solids	Metals	Hydro-carbons
Roof	Filter Strip	Exceeding requirements	Exceeding requirements	Exceeding requirements
Access Road	Permeable paving	Meeting requirements	Meeting requirements	Meeting requirements

Table 9 SuDS Pollution Prevention Status

4.3 SuDS management and maintenance

4.3.1 Management and maintenance

Maintenance of the proposed SuDS features will be the responsibility of UCL along with the maintenance of the remaining landscaped areas. A SuDS management and maintenance regime has been compiled and is included in Appendix 7 of this report. The regime details maintenance actions and the relevant frequency required for each.

The maintenance strategy for specific SuDS proposed at the site will be dependent upon the products used within the installation of the systems and is therefore subject to manufacturer's guidance.

The maintenance regime of the SuDS on site can be divided into three categories: regular maintenance, occasional tasks and remedial works. The frequency of regular maintenance will usually be monthly, the occasional tasks and remedial works should be conducted as required.

4.3.2 End of life maintenance

As part of their normal function many SuDS features are intended to act as a repository for potential pollutants such as sediment, hydrocarbons and heavy metals, thus improving the water quality of run-off. Certain pollutants, such as hydrocarbons, can be broken down via biodegradation. However, other pollutants, namely the particulate or sediment type, such as heavy metals, remain trapped within elements of the sustainable drainage feature.

Current evidence does not conclude to what extent pollution entrapment within SuDS will occur or whether this can lead to the site becoming contaminated and therefore hazardous to human wellbeing. Furthermore, it is not yet known if certain sustainable drainage systems (or elements of them) will be classified as hazardous waste at the time of their disposal. For these reasons, it is proposed that at end-of-life, all SuDS are disposed of in accordance with the relevant rules, regulations and available guidance at the time. If required, at redevelopment stage, consultation with the Environment Agency should be sought and testing of materials and ground, for contamination, should be carried out.

4.4 Site wide foul and lab water strategy

4.4.1 Proposed Discharge Rate

The estimated unrestricted foul water discharge rates for each of the plots, provided by the MEP engineers are given below.

Table 10: Plot 1 Foul and lab water peak discharge rates

	Foul water	Sump (Foul)	Lab water	Sump (Lab)
Flows (l/s)	4.2	4.8	8.0	16.1
Total (l/s)	6.4		18.0	
Combined flow* (l/s)	19.1			

**combined flow rates are not calculated through straight addition, there is a specific formula.*

Table 11: Plot 2 Foul water peak discharge rates

	Foul water
Flows (l/s)	4.6

Table 12: Plot 3 Foul water peak discharge rates

	Foul water	Sump (Foul)
Flows (l/s)	4.9	2.3
Combined flow* (l/s)	5.4	

**combined flow rates are not calculated through straight addition, there is a specific formula.*

The total proposed unrestricted peak foul discharge rate for the site is calculated to be **20.4l/s**. Final flow rate pending confirmation on architectural layout and flow rate data from Hoare Lea.

4.4.2 Foul and Lab Water Strategy

The proposed site foul network utilises both an unrestricted network that discharges via gravity and a restricted discharge via a pump chamber. Refer to Appendix 2 for Ramboll proposed drainage layouts.

Unrestricted Discharge Via Gravity

The strategy routes all foul water from ground floor and above at a higher level (i.e. not taken down into the basement) and discharges into the on-plot network via gravity. Foul water is discharged off site via gravity to the adjoining sewer network using a proposed single connection point. The foul discharge will be unrestricted and therefore an increase in allowable foul water discharge rate will be required to implement this solution without compromising the capacity of the existing foul drainage network. Most of the foul network is to discharge at ground level via gravity.

Restricted Discharge Via Pump Chamber

A pump will be required in order to discharge the foul water and lab drainage from the two deep basement levels. Foul water is discharged off site via a pump chamber to the adjoining sewer network. The on-plot foul water would be conveyed via gravity to the pump chamber which would be located close to the site perimeter. The rising main from the pump chamber would then outfall to a demarcation chamber prior to discharging via gravity to the adjoining off site infrastructure manhole.

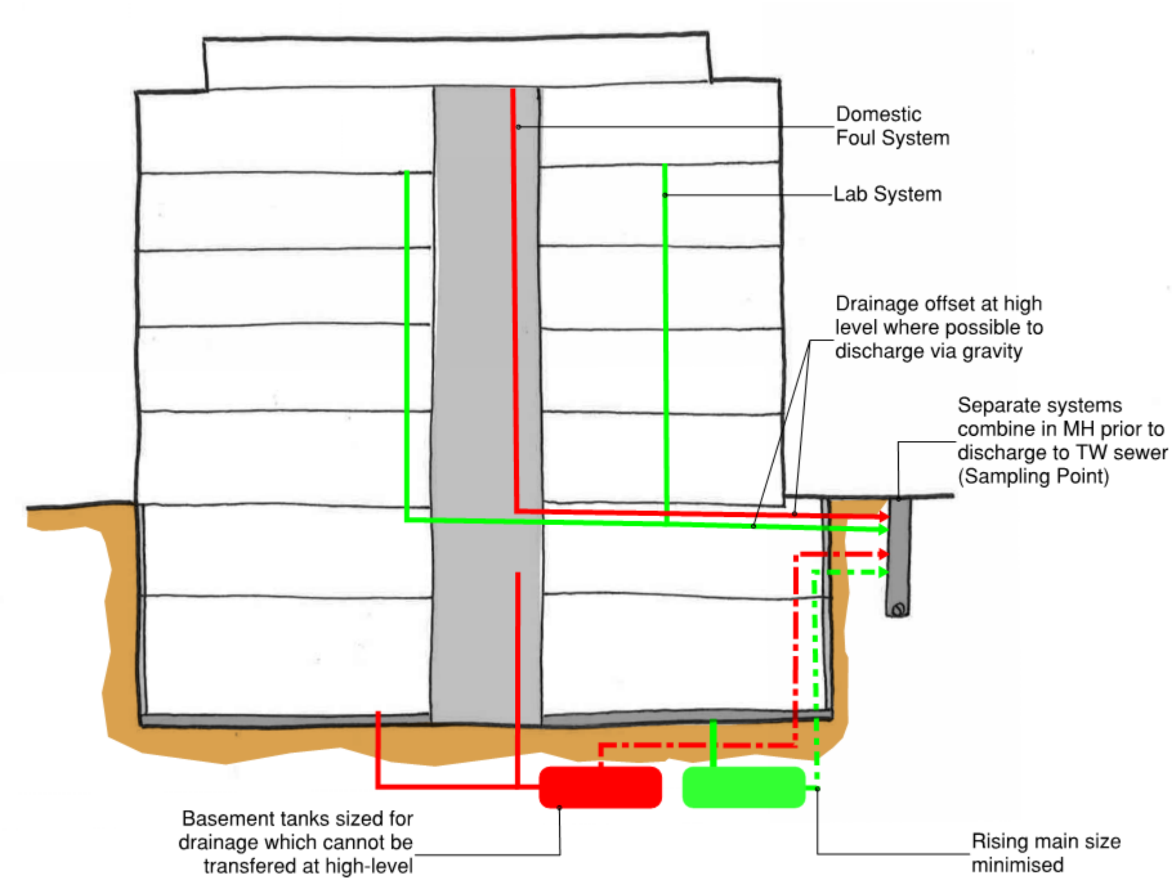

Figure 7 Schematic proposed drainage network

Figure 7 indicates schematically where foul water drainage from the new buildings is to be pumped, the effluent receiving chamber should be sized for storage should there be a disruption in service. Building Regulations Approved Document Part H requires a foul water pump chamber to provide capacity for 24-hour inflow storage for disruption of service.

Consultation and discussions with the client and Building Control will explore whether the required storage volume can be reduced from the regulatory 24-hour through inclusion of appropriate measures to mitigate the risk involved. Storage volumes have been estimated based on the real expected flows over a 24-hour period and provided by the MEP engineers. The storage tanks are proposed to be cast into the basement raft slab and utilise an internal GRP tank lining.

The estimated volume of foul storage is listed in the table below:

Table 13: Estimated foul and lab water storage volumes

Storage required*	Foul Water (m^3)	Lab water (m^3)
Plot 1	54	42
Plot 3	24	N/A
*Volumes based on expected litres per day received from Hoare Lea		

A reduction in storage volumes is considered a derogation from Building Regulations Part H requirements and thus requires an approval from both Building Control and the client. Risks in reducing the storage volume will be mitigated through the following measures:

Design Measures:

- The required pumping station will include dual pumps in a duty/standby arrangement to ensure the foul/lab water effluent can continue to be discharged from the site in the event of a single pump failure;
- A segregated and independent back-up power supply will be provided to ensure the pumping station can continue to operate in the event of service disruption due to power failure;
- The pumping stations will be fully-monitored and linked to the Building Management System (BMS) to provide an early warning in the event of service disruption/ blockages/ high water levels within the tank using level indicator plus high-level alarm;
- Dry suction chambers to provide a spur connection for tankers

Building management measures:

- A dedicated operations and maintenance team will either be present on site or on call to provide essential maintenance in the event of service disruption;
- In the event of emergency, a number of facilities can be closed down to reduce inflow.

4.4.3 Trade Effluent Requirements

A trade effluent licence will be required from Thames Water for the proposed building to provide consent to discharge the laboratory process drainage into the public network. Consent will be achieved through submission of an application form to Thames Water with details on the chemical composition and flow rates. Dedicated sampling chambers have been proposed as required by Thames Water at the manhole prior to discharge into the domestic foul network. Due to the function of the building and potential for corrosive or high temperature effluent discharge the material of the pipes and chambers has been specified to provide adequate resistance to degradation and shock.

5. CONCLUSIONS AND NEXT STEPS

The drainage related design criteria for the refurbishment and redevelopment of 256 Grays Inn Road have been determined through review of the London Borough of Camden policy documents and pre-planning meetings with the drainage officer. The approach to the surface water run-off reduction across the mix of existing building refurbishment and new buildings has been developed and agreed in principle with Camden. This document sets out the philosophy which has been adopted into the design to meet the requirements, both technically from the usages of the buildings as well as local and national planning policy.

The planning submission drainage design has been produced in accordance with the strategy outlined in this document. The strategy and principles will set the framework for the detailed design phased with the following next steps planned;

- Continued co-ordination of the finished level design with the developing architectural and landscape proposals, tie in levels for SuDS features with the surrounding landscape, and refine the hydraulic analysis of the network;

- Confirmation of foul and lab flow rates from Hoare Lea, and consequently pipe and tank sizes;

- Confirm level of proposed outfall connection and proceed with S106 Thames Water application for a new sewer connection;

- Develop a phasing strategy across all plots for the installation and construction of the below-ground drainage. This will be dependent on the overall phasing strategy for Plots 2 and 3 and whether an interim condition is required.

- Continued co-ordination to ensure surface water treatment and attenuation is considered with development of vehicle access routes;

- Receive confirmation from Camden Council as the LLFA, that the unchanged the surface water drainage strategy proposal is still accepted as presented in the previous planning application;

- Detailed design of Frances Gardner House diverted drainage;

- Explore whether any of the proposed landscaping improvements to Frances Gardner House can offer water quality or run-off rate improvements to the existing drainage system.

- A building specific Trade Effluent Licence (TEL) is expected to be required. This will be subject to agreement with Thames Water and developed with UCL facilities management;

- Develop blue roof proposal in co-ordination with the specialist designer.

- Further details to be developed following further stages of design development as per condition 36 attached to the previous planning permission.

APPENDIX 1
FLOOD RISK ASSESSMENT