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1.0 Introduction

This note has been prepared to summarise the principles of the surface water drainage strategy for the proposed redevelopment of the O2 Finchley Road site (The Site), in Camden.

Whilst some of the following text can be used as a response to comments raised as part of the planning consultation, it is intended to summarise the current position and the revised proposals for discussion prior to updating any planning documentation.

2.0 Existing Arrangement

The existing site is made up of predominantly impermeable surfaces which generate surface water run-off in any rainfall event. This runoff is captured by drainage infrastructure such as highway gullies and drainage channels. The existing development does not include any sustainable drainage features and limited areas of landscaping.

Currently the site benefits from several connections to the existing public combined sewerage system which crosses the site. These connections are uncontrolled, and surface water discharges to the network in peak storm events may contribute to flooding events downstream of the development site, or on the development site itself. An estimate for peak discharge rates generate by a range of rainfall events on the existing site can be summarised in Table 1.

Return Period (Years)	Runoff Rate (l/s)
1	520
QBar (equivalent to 2 Year)	647
30	1240
100	1337

Table 1 – Existing runoff rates

The proposed development aims to reduce the amount of impermeable surfacing through introduction of large landscaping areas and permeable surfaces and provide a restriction on the rate at which surface water runoff can leave The Site. This will contribute towards reducing the impact of the surface water drainage arrangements by controlling surface water run-off discharged back to the wider sewerage system.

To restrict surface water discharges from the site, surface water must be stored on site in times of high intensity rainfall. This storage can be provided in a number of different features such as below- ground tanks or within landscape features such as ponds or swales. All proposed storage, be it below ground tanks or landscape led sustainable drainage system, will need to be co-ordinated with all existing and proposed below ground infrastructure.

3.0 Greenfield Runoff

The surface water drainage strategy submitted for planning September 2022 was based on a flow restriction equivalent to circa 3 time the greenfield run-off rate for the development catchment. Greenfield run off is defined as the peak rate of runoff for a specific rainfall event falling on undeveloped land. As it has been noted previously the existing site is predominantly impermeable and therefore not in a greenfield condition. Therefore, the proposed reduction to 3 times the greenfield runoff rate can be considered to be a significant reduction in peak flow rates, which has been quantified in Table 3 below.

Equivalent greenfield runoff rates for the site in the same rainfall events are summarised in Table 2 below. The greenfield runoff rates have been calculated in accordance with best practice criteria.

Return Period (Years)	Runoff Rate (l/s)
1	21.2
QBar (equivalent to 2 Year)	24.9
30	57.2
100	79.3

Table 2 – Greenfield runoff rates

Based on Table 2 the greenfield runoff rate for the site can be presented as 4.35 litres / per second / per hectare, based on an overall site area of 5.72 ha.

QBar is defined as the mean annual maximum flow rate and is typically used to define the greenfield run-off rate controls for proposed developments. Using a rate of 3 times greenfield runoff the percentage reduction in the above rainfall events is summarised in Table 3 below.

Return Period (Years)	Existing Runoff Rate (l/s)	Proposed Runoff Rate (l/s)	Reduction (%)
1	520	74.7	85.6%
2	647		88.5%
30	1240		94.0%
100	1337		94.4%

Table 3 – Proposed runoff reduction at 3 x greenfield runoff rate

4.0 Surface Water Drainage Strategy

To reduced discharge rates from the proposed development, a large amount of attenuation must be provided on the site. This can be provided in a number of ways, some of which are summarised below

- Large landscape features such as ponds and swales.
- Discrete landscape features such as rain gardens, shallow swales, and filter strips etc.
- Below ground geocellular tank systems.
- Blue/green roof/podium infrastructure.
- Permeable paving; and
- Below ground pipe networks

Landscape features are preferable for surface water attenuation as they also provide a level of treatment of runoff due to their vegetated nature. Whilst there is a large amount of public realm being provided on the

proposed development, there is limited scope to provide large scale attenuation features such as ponds or swales, without significantly impacting the public open space and amount of play space provided on the site.

It is however feasible to introduce more discrete landscape features such as rain gardens and shallow swales, which can have a significant impact on the quality of runoff discharged from a proposed development. However, as seen across London given the smaller scale of these features it is unlikely that they will provide significant volumes of storage unless enhanced by below ground cellular structures or pipes.

Buried geocellular tanks are commonplace within redevelopment of brownfield developments particularly in London given the efficiency in volume of storage they provide over a given footprint, ensuring maximum public open space and associated amenities can be delivered for public health. However, it is noted that whilst buried structures are efficient at providing storage volumes, they do not necessarily contribute to improving the quality of runoff from a development. It is therefore recommended that they are provided as part of a carefully designed landscape scheme.

Green roofs are structures which are provided at roof level to mimic vegetated land, and significantly contribute toward treatment of surface water runoff and quality. Green roofs provide no storage benefit as they are typically considered to be saturated when considered in drainage design, but they can be supplemented with geocellular structures to provide that storage function. These combined structures are known as blue roofs.

Whilst a blue roof system provides some additional storage within the footprint of the building, there are a number of other issues associated with installation of a blue roof that go beyond the considerations of surface water management. Firstly, these structures add additional weight to proposed structures as they are required to be considered full at all times for design conditions. This adds unnecessary loading to the design which in turn increase the requirements for concrete, steel, and carbon and therefore does not align with the reduced carbon ambitions of the scheme.

The roof areas in the detailed phases also include an allocation for provision of plant, solar, air source heat pumps, and life overruns required for the building’s operation. This allocation leaves very little room available for blue roof structures and therefore the overall efficiency of any storage that may be provided. It is also difficult to route roof drainage to a bule roof structure with a small footprint, which may result in increased risk of standing water and incurring increased management, maintenance, and risk of defects at roof level.

As such, given the low efficiency of the blue roof structure external surface water storage, the inherent design issues, and impact on embodied carbon required, these are not seen as suitable for this site and indeed many across London.

Permeable paving will be used across the site which provides a good opportunity to improve water quality but is relatively inefficient at providing significant volumes of storage. In addition to granular subbase, it is possible to provide an additional layer of geocellular storage which provides a greater volume of storage, but this will need to be fully co-ordinated with below ground utilities.

Below ground drainage networks are required to convey surface water around the development, to proposed storage structures, and the ultimate discharge from site. Whilst there is minimal benefit to the quality of surface water runoff, the below ground network does provide additional storage in peak rain fall events when the network is likely to become surcharged.

To summarise, for the proposed development it is unlikely that landscape features such as rain gardens, swales, or permeable paving can provide sufficient storage for the development without being supplemented by geocellular storage structures/tanks. As a result, the proposed drainage strategy has been modelled based on all storage being provided within below ground geocellular storage structures design to cater for runoff from each proposed development phase. As the landscape design progresses to a detailed level, it will be possible to offset some of this volume to areas of landscaping in keeping with the current design proposals.

5.0 Proposed Updates to Submitted Strategy

Whilst the proposal of limiting flow to 3 times the greenfield runoff rate provides a significant reduction of surface water runoff when compared to the existing site, the strategy has been updated to further reduce overall flow rates from the proposed development. In order to achieve the reduction in discharge rates we have considered the detailed application and the outline application separately. The revised approach to each application is set out below.

5.1 Detailed Application Update

The detailed application for the development covers phase 1 which is presented as 1a, 1b, and 1c in the Surface Water Drainage Strategy drawing 104878-PEF-ZZ-XX-DR-D-100010. In order to satisfy comments raised by the planning authority, the overall discharge rate has been reduced to a rate equivalent to greenfield runoff rate for the phase 1 development area. Revised calculations and hydraulic modelling results will be provided as part of the updated Surface Water Drainage Strategy report 104878-PEF-ZZ-ZZ-RP-D-100017-S4, and will show no flooding for the 1-, 30-, and 100-year (plus 40% climate change allowance) probability rainfall events.

To achieve this reduction in discharge rate, the quantum of surface water storage has increased significantly. Whilst this increase is significant, the current masterplan for Phase 1 includes sufficient public realm area to accommodate the storage. It should however be noted that given the timescales associated with the application, there is insufficient time available to update the landscape strategy based on the revised tank extents. However, this will be undertaken in the next stage of design and submitted via the detailed design landscaping conditions expected in such an application. It may be the case that landscape, and public realm proposals, change to take account of the revised strategy.

The revised proposals for Phase 1 can be found on drawing 104878-PEF-ZZ-XX-DR-D-100010, and are summarised in Table 4 below. Based on a greenfield runoff rate of 4.35 l/s/ha, we have a maximum greenfield discharge rate of 7.6 l/s for Phase 1 of the proposed development.

Phase	Net Developable Area (ha)	Impermeable Area (ha)	Discharge Rate (l/s)	Volume of Attenuation (m^3)
1A	0.34	0.180	1.5	234
1B	0.65	0.525	2.8	521
1C	0.76	0.623	3.3	576
Total	**1.75**	**1.328**	**7.6**	**1,331**

Table 4 – Detailed Application Attenuation

5.2 Outline Application Update

The outline application for the development covers phases 2 and 3 which are presented as 2a, 2b, 3a, and 3b in the Surface Water Drainage Strategy drawing 104878-PEF-ZZ-XX-DR-D-100010. To satisfy comments

raised by the planning authority, the discharge rate has been reduced, but it is not possible to reduce the overall discharge rate to an equivalent greenfield runoff rate. A revised proposal has been prepared based on a restricted discharge which is equivalent to 2 times that of the estimated greenfield runoff rate.

Given the outline nature of the development proposals in Phases 2 & 3, there are a number of variables that limit any commitment to restrict runoff rates below 2 times greenfield runoff rate.

The outline proposals for buildings only specify a maximum parameter for buildings, and therefore the final footprint, height, and access arrangements for any buildings within these phases is not known. A commitment to attenuation volumes based on greenfield runoff rates as part of the outline application may impact on future building proposals and have a fundamental impact on viability of the scheme.

Furthermore, it is likely that any additional increase in attenuation volumes will further encroach on landscape and public realm proposals, affecting the overall viability of the scheme. Whilst every effort would be made to maximise all opportunities to provide attenuation in landscape features, an increase in attenuation volumes will result in significant limitations being imposed on locations of trees and other landscape features. This would mean that public realm areas will become desolate open spaces with minimal low-lying soft landscaping, and other planning requirements could not be met.

Particularly in Phase 3, the development proposals look to retain a significant quantum of the existing structure and basement slab for sustainability reasons, this will therefore impact ability for storage of rainwater at ground, basement and podium level. Any proposals that come forward will need to balance the attenuation requirements against the impacts of embodied carbon, and need for delivery and servicing clearance heights for the commercial proposals, landscaping design, typography, and level changes in the final scheme.

Throughout construction, the development will also need to ensure continued delivery, servicing and pedestrian routes across the site, and everything will need to be balanced alongside the overarching constraints of the complex phased development, including the two railway lines to the north and south of the development.

However, despite the above, there may be opportunity to further reduce the overall discharge rates for phases 2 & 3 during the next stages of the design process. As the development is phased over a number of years it is proposed that the detail for the outline phases is submitted at RMA stage demonstrating a maximum 2 times greenfield run off rates and a further betterment where achievable.

The revised proposals for Phases 2 & 3 can be found on drawing 104878-PEF-ZZ-XX-DR-D-100010, and are summarised in the table below. Based on a greenfield runoff rate of 4.35 l/s/ha, we have a maximum greenfield discharge rate of 34.4 l/s for Phase 2 & 3 of the proposed development.

Phase	Net Developable Area (ha)	Impermeable Area (ha)	Discharge Rate (l/s)	Volume of Attenuation (m^3)
2A	1.18	0.915	10.2	766
2B	0.43	0.387	3.7	286
3A	0.64	0.485	5.6	428
3B	1.72	1.242	14.9	1200
Total	**3.97**	**3.029**	**34.4**	**2,680**

Table 5 – Outline Application Attenuation

5.3 Sitewide Summary

To summarise the above, the revised proposal is based on the following:

- Phase 1 – Discharge rates equivalent to greenfield runoff rates. However further detailed design co-ordination is required to ensure cohesive landscape and public realm design that meets the aspirations of the scheme.
- Phase 2 & 3 – Discharge rates for the outline application phases are proposed at a rate 2 times that of the equivalent greenfield runoff rate. Condition to be imposed on decision notice to ensure a detailed drainage scheme for phase 2 & 3 is submitted at RMA stage, with every effort made to reduce overall discharge to a rate equivalent to greenfield runoff where possible.

The revised discharge rates and associated attenuation volumes for each phase are presented in Table 6 below, as a summary of the sitewide proposals.

Phase	Net Developable Area (ha)	Impermeable Area (ha)	Discharge Rate (l/s)	Volume of Attenuation (m^3)
1A	0.34	0.180	1.5	234
1B	0.65	0.525	2.8	521
1C	0.76	0.623	3.3	576
2A	1.18	0.915	10.3	766
2B	0.43	0.387	3.7	286
3A	0.64	0.485	5.6	428
3B	1.72	1.242	15.0	1200
Total	**5.72**	**4.357**	**42**	**4,011**

Table 6 – Sitewide Attenuation

The reduction in flow rates associated with the updated approach are set out in table 7 below. The overall sitewide runoff rate is a combination of the proposed discharge rates for the detailed and outline application and is therefore between greenfield runoff and 2 times greenfield runoff rates (approximately 1.7 in total).

Return Period (Years)	Existing Runoff Rate (l/s)	Proposed Runoff Rate (l/s)	Reduction (%)
1	520	42	91.9%
2	647		93.5%
30	1240		96.6%
100	1337		96.9%

Table 7 – Estimated Reduction of Runoff Rates

In addition to the above it should be noted that the proposed discharge rate for the proposed development is lower than the equivalent greenfield runoff rate for the 30- and 100-year rainfall events noted in Table 2.

The surface water layout has been prepared to ensure that the development can be delivered in phases, with storage structures located to cater for each plot and its surrounding catchment. It should also be noted that existing infrastructure has been re-utilised for connections where possible to provide a more sustainable approach to infrastructure delivery. Whilst this results in a number of outfall locations for the site, the overall discharge rate for the entire development will be controlled to the discharge rates for each phase i.e. Phase 1 at greenfield runoff rates, and Phases 2 and 3 at 2 times the greenfield runoff.

Furthermore, each catchment has been designed such that discharge rates are a proportion of the overall sitewide discharge rate, so that the maximum approved discharge rate is never exceeded no matter how the development is phased.

6.0 Response to LLFA Comments Received on 24/10/22

The below table sets out the comments raised by Camden Lead Local Flood Authority on the 24th October 2022, and our responses to those comments.

1.	Please provide confirmation why the site can't be modelled with all attenuation features being considered including a blue roof, discharging through a single outfall rather than two separate outfall locations. Please consider this in line with the above about attenuation sizing requirements	Site has been modelled to include for attenuation shown on drawing 104878-PEF-ZZ-XX-DR-D-100010, which is based on an overall site discharge equivalent to circa 1.7 times the greenfield run-off (Phase 1 at greenfield runoff rate, and phases 2 & 3 at 2 times greenfield runoff rate). This is set out in detail in the Drainage Strategy Report Ref 104878-PEF-ZZ-ZZ-RP-D-100017-S4. Whilst a blue roof system provides some additional storage within the footprint of the building, there are a number of other issues associated with installation of a blue roof that go beyond the considerations of surface water management. Firstly, these structures add additional weight to proposed structures as they are required to be considered full at all times for the design. This adds unnecessary loading to the design which in turn increase the requirements for concrete, steel, and carbon and therefore does not align with the reduced carbon ambitions of the scheme and indeed many schemes across London. Typically roof areas also include an allocation for provision of plant required for the building's operation. This allocation reduces the overall space available for blue roof structures and therefore the overall efficiency of any storage that may be provided. It is also difficult to route roof drainage to a bule roof structure with a small footprint, which may result in increased risk of standing water and incurring increased management, maintenance, and risk of defects at roof level. As such, given the low efficiency of the blue roof structure external surface water storage, the inherent design issues, and impact on embodied carbon required, these are not seen as suitable for this site and indeed many across London.

		The surface water layout has been prepared to ensure that the development can be delivered in phases, with storage structures located to cater for each plot and its surrounding catchment. It should also be noted that existing infrastructure has been re-utilised for connections where possible to provide a more sustainable approach to infrastructure delivery. Whilst this results in a number of outfall locations for the site, the overall discharge rate for the entire development will be controlled to the discharge rates for each phase i.e. Phase 1 at greenfield runoff rates, and Phases 2 and 3 at 2 times the greenfield runoff. Furthermore, each catchment has been designed such that discharge rates are a proportion of the overall sitewide discharge rate, so that the maximum approved discharge rate is never exceeded no matter how the development is phased.
2.	The LLFA require the high range storage volume value of 2,878m3 to be used particularly for major developments. Can the applicant re-consider their storage requirement based on this for the development. This will help to reduce the proposed runoff rate from 260l/s	Detailed network modelling has now been provided for each catchment which specifies the exact volume requirement. Therefore, there is no longer a need to consider a range of volume estimates. The modelling results are included in appendix I of the Drainage Strategy Report Ref 104878-PEF-ZZ-ZZ-RP-D-100017-S4.
3.	An exceedance flow diagram is required including sufficient mitigation measures for flooding.	This has now been provided as drawing104878-PEF-ZZ-XX-DR-D-100017, and is included in Appendix D of the Drainage Strategy Report Ref 104878-PEF-ZZ-ZZ-RP-D-100017-S4.
4.	Once the runoff rate has been reduced to account for the attenuation volume of 2,878m3, the applicant needs to provide written confirmation from Thames Water confirming that they consent to the proposed discharge rate	Approval for a discharge rate of greenfield runoff rates for Phase 1 and 2 times greenfield runoff for Phases 2 & 3, will be sought from Thames Water but would request that a meeting is arrange to disucss this with all parties.
5.	The applicant has not provided justification as to why the site can't be modelled with all attenuation features being considered, including a blue roof discharging through a	Refer to response to point 1 above

	single outfall rather than two separate outfall locations. Please consider this in line with the above about attenuation sizing requirements.	
6.	The applicant has now confirmed the required storage volume for the site to the meet greenfield runoff rate of 68.6l/s in the 1 in 100 year plus climate change event is 4605m3. However, the applicant is currently only proposing 3347m3 and not achieving greenfield runoff rate.	The proposed total storage volume provided on the proposed development is 3791 m3. The 100-year 6 Hour greenfield runoff volume is 2662 m3, as set out in table 2.2 of the Drainage Strategy Report Ref 104878-PEF-ZZ-ZZ-RP-D-100017-S4. The existing site is greater than 90% impermeable and the proposed site is circa 75% impermeable which represents a net reduction of impermeable surface of around 15%. Therefore, proposed development runoff volumes will be reduced. In accordance with policy S5 of Defra 'Non-statutory technical standards for sustainable drainage system', the proposed storage volume is greater than the greenfield runoff volume and lower than the existing development runoff volume.
7.	The applicant has not provided an exceedance flow diagram with sufficient mitigation measures for flooding.	Refer to response to point 3 above
8.	The applicant has not provided written confirmation from Thames Water confirming that they consent to the proposed discharge rate.	Refer to response to point 4 above
9.	The applicant is required to provide blue roofs within the proposed development. The LLFA require the use of blue roofs to increase the storage capacity they provide to meet the storage volume required.	Refer to response to point 1 above
10.	The applicant has not demonstrated that the site will not flood as a result of the 1 in 30-year rainfall event and that there will be no flooding of buildings as a result of events up to and including the 1 in 100-year rainfall event	Refer to response to point 2 above

11.	Shows the proposed single discharge point from site and associated hydrobrake on the drainage layout drawing	Refer to response to point 1 above
12.	Confirms that the proposed SuDS features (attenuation tanks, green roofs, permeable paving, and swale/pond) provide storage equal to or in excess of the attenuation storage required for the 1 in 100-year climate change event for greenfield runoff rate or as close as practically possible. This information should also be evidenced within the drainage calculations.	The proposed total storage volume provided on the proposed development is 3791 m3. The 100-year 6 Hour greenfield runoff volume is 2662 m3, as set out in table 2.2 of the Drainage Strategy Report Ref 104878-PEF-ZZ-ZZ-RP-D-100017-S4. The existing site is greater than 90% impermeable and the proposed site is circa 75% impermeable which represents a net reduction of impermeable surface of around 15%. Therefore, proposed development runoff volumes will be reduced. In accordance with policy S5 of Defra 'Non-statutory technical standards for sustainable drainage system', the proposed storage volume is greater than the greenfield runoff volume and lower than the existing development runoff volume.
13.	Confirm the proposed runoff rate once agreed within the updated drainage calculations	Appendix I of the Drainage Strategy Report Ref 104878-PEF-ZZ-ZZ-RP-D-100017-S4 now includes all Microdrainage results for each catchment based on a greenfield runoff rate for Phase 1, and 2 times greenfield runoff for Phases 2 & 3.
14.	Illustrates the exceedance flow routes on a diagram and explain the proposed mitigation measures for flooding.	Refer to response to point 3 above
15.	Illustrates the proposed blue roofs within the development, which are required by the LLFA in order to increase the provided attenuation and reduce the proposed runoff rate.	Refer to response to point 1 above
16.	The applicant should include a review of rainwater pipe locations to be submitted at detailed design stage with the potential to include rainwater discharge to planters around the building.	Suggest that this forms part of a condition to the planning application to be addressed when more detail building designs are available identifying all drainage points for buildings.
17.	The applicant should reconsider the sizing of the attenuation box crates and include all storage features provided within the attenuation calculation. This should reduce	Conditions to be agreed for both detailed and outline drainage schemes.

	the need for as much underground box crate storage and use more sustainable methods for managing attenuation on site to compliment below ground storage.’	