Graven Hill, D1 Site, Bicester

Outline Sustainable Drainage Systems (SuDS) Strategy

Prepared for

Graven Hill Purchaser Ltd

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Graven Hill, D1 Site, Bicester

Outline SuDS Strategy for Planning

1.0 Introduction

Outline planning permission was granted for a mixed-use development in August 2014 (ref: 11/01494/OUT) at the former Ministry of Defence-owned sites D1 and EL1 at Graven Hill, to the south of Bicester. The site is located on the southern side of Graven Hill and is identified for employment use in the consented outline application and proposals for development for B8 Storage or Distribution use are now being taken forward.

A new outline planning application is therefore being submitted in relation to the proposed development of the D1 and EL1 sites. Alan Baxter Ltd have been appointed by Graven Hill Purchaser Ltd to produce an outline Sustainable Drainage Systems (SuDS) strategy to support these proposals.

The outline SuDS strategy summarises the broad drainage arrangement on the existing site and sets out the key principles of the developing SuDS scheme. It has been informed by pre-application discussions with Oxfordshire County Council (OCC), who are the Lead Local Flood Authority (LLFA) for the area. See Appendix D for ABA's note recording this meeting.

2.0 Summary of Existing Site

The D1 and EL1 sites, OX26 6HF, cover an area of approximately 30.5 hectares on the southern side of Graven Hill (see Figures 01 and 02 in Appendix A for the site location). The site is bounded to the southwest by a railway embankment, to the west by woodland, to the north by Pioneer Road/Anniversary Avenue and the southeast by Wretchwick Farm.

The site was historically used by the Ministry of Defence (MOD) to store and distribute military equipment and contains five main warehouses, a number of smaller ancillary buildings, and a fire station. These buildings are linked by a number of private roads and railway lines. The existing buildings on site all date from 1941, apart from the fire station, which dates from the 1970's. Figure 03 in Appendix A shows the existing site plan.

2.1 Topography, Geology and Hydrology

Levels on the site vary from approximately 71m AOD along the northern boundary to 61.5m AOD in the south-eastern corner of the site, giving an average gradient of approximately 1:60. Although the site generally slopes gently, there are some local variations including the banks, cuttings and ditches relating to the existing railway lines. Graven Hill, which rises to approximately 115m AOD, is immediately to the north of the site. See Figure 04 for the existing site topography.

Geological maps and initial site investigations indicate that the site geology consists of made ground and topsoil over Oxford Clay. From nearby borehole logs, the bottom of the Oxford Clay strata appears to be approximately 20-30m below site ground level. Soakaway tests undertaken during the site investigation have confirmed that the underlying Oxford Clay has a very low permeability with no infiltration recorded at any of the test locations. See Appendix B for the site Ground Investigation report.

The topography and impermeable nature of the underlying soil means that in its natural condition, water falling on the site would likely have permeated through the topsoils and run south, following the contours of the hill, before eventually joining streams and ditches which drain into the River Ray (a tributary of the River Cherwell). There is a tributary to the River Ray which runs close to the south-eastern boundary of the site. This connects to the River Ray approximately 1 mile to the south of the site. See Figure 05 for the assumed existing site drainage.

Approximately 125,000 m^2 of building and roads have been constructed on the site since its development in the 1940's. These are understood to drain to the stream to the south of the site through a system of below ground pipes and ditches. It is not thought that any form of flow control or attenuation is incorporated into the existing site drainage.

Foul water drains via gravity to a Thames Water pumping station in the western part of the site. This pumps foul water through a rising main, which runs under the railway embankment south of the site and discharges to Bicester sewage treatment works, to the northwest of Graven Hill.

There are a number of sewers crossing the site, including a Thames Water foul sewer running along the site's eastern boundary, which is proposed to be partially diverted as part of the development of the site. All other live sewers and drains crossing the site are to be intercepted and diverted away from the site boundary by the current owner, the Graven Hill Village Development Company (GHVDC).

2.2 Theoretical Greenfield and Existing Brownfield Runoff Rates

The theoretical greenfield and existing runoff from site has been estimated to inform the developing SuDS strategy.

The theoretical greenfield runoff rates for the 1:1, 1:30, 1:100 and mean annual flood ($Q_{\_BAR}$) events were determined using the Flood Estimation Handbook (FEH) datasets on Microdrainage. See Table 1.

Storm Event	Greenfield Runoff Rate (l/s/ha)	Theoretical Site Greenfield Discharge Rates (l/s)
Q_1	2.8	85.4
$Q_{\_BAR}$	3.3	100.7
Q_{30}	7.6	231.8
Q_{100}	10.5	320.3

Table 1: Estimated Greenfield Runoff Rates

As noted in Section 2.1, the site was developed over the 20th Century and has an impermeable surface area of approximately 12.5 Ha. The discharge from these areas has been estimated based on constant rate rainfall intensities given by the Wallingford Procedure. The results are summarised in Table 2.

Storm Event	Rainfall Intensity (mm/h) 15 min Storm	Discharge Rate from Hardstanding Areas (l/s/ha)	Theoretical Discharge from Hardstanding Areas (l/s)
1:1	31.5	87.5	1093.8
1:30	77.3	214.7	2683.7
1:100	100.1	278.0	3475.0

Table 2: Estimated Discharge Rate from Hard Drained Areas

Total discharge from the site is therefore the combination of runoff generated from soft landscaped and impermeably surfaced areas, as summarised in Table 3.

The capacity of the existing site outflow pipe has also been assessed based on the available survey information. The pipe-full flow rate is approximately equal to the 1:1 year storm event, and it is therefore likely that discharge from the site is limited to this rate during more extreme events. Consequently, the positive impact of the proposed development on surface water runoff rates will be assessed against the pipe-full flow rate of 1140 l/s. See Appendix C for supporting calculations.

Storm Event	Discharge from Permeable Areas (l/s) *(18 Ha* **Soft Areas***)*	Discharge from Impermeable Areas (l/s) *(12.5 Ha Hard Area)*	Discharge from Existing Site (l/s) *(30.5 Ha Total Area)*	Capacity of Existing Outflow Pipe (l/s) *(675Ø pipe at 1:70 falls)*
1:1	50.4	1093.8	1144.2	~1140
1:30	136.8	2683.7	2820.5	
1:100	189.0	3475.0	3664.0	

Table 3: Estimated Total Discharge Rate from Existing Site

3.0 Proposed Development

It is proposed to construct approximately 1.1 million sq. ft of internal floor space for B8 Storage or Distribution us, along with associated access roads, loading areas, infrastructure and tertiary buildings on the vacant brownfield site. The internal floorspace is proposed to be provided across nine separate units, as shown on the proposed site plan (Figure 06 in Appendix A).

The total site area is approximately 30.5 Ha. The proposed impermeable area of approximately 21.9 Ha comprises 10.4 Ha of roofed area and 11.5 Ha of impermeable paved area.

Due to the nature of the development, it has been agreed with the OCC during pre-application consultation that an Urban Creep allowance does not need to be included when considering the proposed impermeable areas, as discussed in Section 4.1.

4.0 Outline SuDS Strategy

4.1 Key Principles Agreed During Pre-Application Consultation

The design team met with OCC's Senior LLFA Engineer on 14/02/2022 to review the emerging proposals and agree the key principles of the strategy to be taken forward to outline planning.

The agreed principles are in part based on Waterman's 'Sustainable Drainage Design Code' ref. CIV15119 ES 001 Rev A01, which was included in the previously consented outline planning application, and have been revised to take account of the OCC's current requirements. The agreed principles are:

- Infiltration of surface water is not feasible. This has been verified by infiltration testing undertaken as part of the SI, which found the soil to be completely impermeable.
- Surface water discharged from the proposed site should be drained to the same location as existing. Sites D1 and EL1 should continue to drain southwards towards outfall 'SW4' which drains to a tributary of the River Ray.
- The discharge of surface water from the site should be limited to $Q_{\_BAR}$ greenfield rate for all rainfall events up to the 1:100 + 40% climate change, unless this is shown to be unfeasible.
- In order to achieve these discharge rates during periods of heavy rainfall, on-site surface water attenuation will be required.
- Surface water attenuation should, wherever possible, be provided in the following SuDS features:
    - Swales and ditches
    - Filter drains and perforated pipes
    - Filter strips and rills
    - Open attenuation basins
- Where space is restricted such that the measures noted above are not practical, below-ground storage may be used to attenuate surface water runoff.
- Given the nature of the proposed development, an urban creep allowance does not need to be considered when determining the required volume of attenuation storage.

4.2 Proposed SuDS Strategy

The methods of discharging surface water runoff in Table 4 were considered during the development of this SuDS strategy.

Method of Discharge	Comments	Feasible
Infiltration	Site investigations have shown that the underlying soils are impermeable (see Appendix B). Concentrated methods of infiltration (e.g. soakaways) are therefore not feasible.	No
Open Watercourse	The existing site drains via the existing topography to an existing watercourse southeast of the site. It is therefore considered feasible that the proposed development can drain to the same location, as has been agreed with the LLFA during the pre-application process.	Yes
Surface Water Sewer	This method of discharge has not been considered, as it has been agreed with LLFA that the site should discharge as existing to an open watercourse.	N/A
Combined Sewer	This method of discharge has not been considered, as it has been agreed with LLFA that the site should discharge as existing to an open watercourse.	N/A

Table 4: Assessment of Surface Water Discharge Options

As noted in Section 4.1, the proposed development will continue to drain to the existing watercourses to the southeast of the site. In accordance with local planning requirements, the SuDS strategy will aim to limit the rate of discharge of surface water from the proposed hardstanding areas on site to as close as is practicable to the Q_{BAR} greenfield runoff rate for all rainfall events up to the 1:100 year (+40% climate change). Given a proposed site impermeable area of around 21.9 Ha, the target discharge rate for the impermeable areas will be 72.4 l/s.

Outline Microdrainage calculations indicate that in order to achieve this discharge rate for the 1:100 + 40% climate change rainfall event, a total of between around 16,000 and 22,500 m^3 of attenuation storage could be required on the site (Appendix C).

Table 5 summarises the viability of different methods of attenuation that have been considered for the development.

Attenuation Type	Comments	Feasible
Rainwater Harvesting	Likely to be suitable for use in site irrigation.	Yes
Green Roofs	The type of building proposed in the development generally precludes the use of green roofs.	No
Permeable Paving & Porous Build-Ups	Due to known durability issues, permeable paving will be limited to low trafficked areas. Porous build-ups below impermeable paving may be used more widely where levels permit, with harder wearing impermeable surfacing. Any porous build-ups will be tanked (type 3) to prevent water softening the clay formation.	Yes
Below Ground Tanks & Oversized Pipes	The use of below ground attenuation to be limited to situations when storage cannot be provided in above ground basins.	Yes, but not preferred
Swales	To be used to convey flows between attenuation basins where possible.	Yes
Open Basins	Preferred method of attenuation. To provide the majority of attenuation storage on the site and to be designed to provide amenity benefits.	Yes

Table 5: Assessment of Surface Water Discharge Options

Figure 07 summarises the outline SuDS proposals for the site. The attenuation volumes shown are based on a high-level Microdrainage cascade model, which indicates that the total attenuation storage required is 19,970 m^3. This model will be developed in greater detail at the next design stage. A train of SuDS features will be provided across the site. Permeable surfacing, small rain gardens and rainwater harvesting for irrigation will be provided where practicable throughout the development to act as source control.

Small basins, swales and areas of permeable paving/porous build-ups will act as local SuDS elements to each sub catchment. Where possible, the local swales and basins will be designed to provide amenity benefits as well as attenuation storage, and will be incorporated into the overall landscape design for the scheme. A residual uncertainty allowance (freeboard) will be provided to surface water storage feature, the details of which will be confirmed during the detailed design of the drainage network and site levels.

The outflow from each of these local SuDS features will be fitted with flow controls to restrict the outflows to the Q_{BAR} rate for the upstream catchment. Overflows will be provided to allow water that cannot be contained in each feature to drain to the next element of the train.

The final element of the SuDS train will be large landscaped basins in the south east corner of the site. The outline proposals allow for this to provide the majority of the site attenuation storage. A flow control on the outflow from this basin will restrict the discharge rate to $Q_{\_BAR}$ for all rainfall events up to the 1:100 + 40% climate change event (72.4 l/s based on the outline masterplan).

The soft landscaped areas on the proposed site will continue to drain at greenfield rates with a Q_1 rate of 24.1 l/s and Q_{100} rate of 90.3 l/s (based on the approximately 8.6 Ha of soft landscaping in the proposed scheme).

As such, the overall proposed site discharge rate will be restricted to around 96.3 l/s for a 1:1 year rainfall event and 152.9 l/s for a 1:100 year rainfall event. As summarised in Table 6, this represents a reduction in discharge rate of 91% for the 1:1 year event and 87% for the 1:100 year event when compared to the existing conditions, contributing to a reduction of flood risk downstream of site.

Rainfall Event	Current Discharge (l/s)	Proposed Discharge (l/s)	Reduction
1:1	~1140	96.3	~91%
1:100	~1140	162.6	~86%

Table 6: Assessment of Discharge Reduction

4.3 Maintenance and Adoption of SuDS Features

A surface water drainage maintenance strategy will be developed to safeguard the long-term performance of the drainage infrastructure on site. It is assumed that this will be through establishing an estate management company, whose responsibilities would include the inspection and maintenance of the site's drainage infrastructure, along with the site roads, which are to remain private.

4.4 Phasing

The proposed development of the site will take place in several stages, and surface water drainage will be considered throughout. Firstly, the existing buildings, roads, railways and hardstanding will be demolished, with the demolition arisings to be cleaned, graded and stored on site for later reuse. Clearing the site will significantly reduce the area of hardstanding, which will in turn result in reduced surface water runoff rates during the demolition phase.

The site will then be graded to suit the proposed levels arrangement. This grading will include forming the various attenuation basins as well as the swales, ditches and pipes which will link the various landscaped attenuation basins. The drainage system will therefore be installed prior to the construction of any new impermeable surfaces. The site services and roads will then be constructed before the individual development plots are built out in stages, until the completed scheme is fully constructed.

4.5 Exceedance

Although the surface water drainage infrastructure will be designed to contain rainwater for storms up to the 1:100 + 40% climate change event, there is a residual risk that surface water runoff could overtop the system and result in overland exceedance flows in a more extreme event. This could be caused by exceptionally high rainfall levels or unexpected flows from upstream catchments.

The exceedance strategy for the proposed development aims to limit the risk of flooding to the buildings on the site in the event of the drainage infrastructure being overwhelmed. In an exceedance event, runoff will follow the site topography and flow to the south east and the proposed site outfall. Flows will be directed to the various basins, and away from the building entrances to reduce the risk to people and property. Figure 08 sets out the outline exceedance strategy for the site, which will be further developed at detailed design stage to confirm the on-site routes.

4.6 Effect of Flood Events Downstream of Site on the Drainage System

4.6.1 Drainage System Invert Level

It is proposed that the attenuated runoff from the site will discharge immediately upstream of the culverted section of the Ray tributary which passes under the railway embankment.

Initial modelling from the project's flood risk consultant (RPS Group) suggests that the water level in the channel upstream of the culvert may rise above the top of bank level during extreme events (refer to RPS' Flood Risk Assessment for more details). To reduce the risk of the site discharge from being locked during flood events, the system invert level has been set at the channel's top of bank level, as advised by RPS. This level is 61.72m AOD, i.e. approximately level with the soffit of the existing culvert.

4.6.2 Potential for Site Discharge to be Blocked & Effect on Attenuation Volumes

1D modelling suggests that the water level in the channel may rise above 61.72m AOD for up to 6 hours during the most extreme events. Flooding at this level would effect the ability of the site to discharge, and would require the SuDS scheme to provide additional storage to account for the time the outfall is locked. Initial calculations show approximately 1,600m^3 of additional attenuation may be required.

Where additional storage is required, it could be provided by increasing the depth and extent of the attenuation basins, or by installing porous build-ups more widely across the site. See Figure 09 for areas where further storage could be provided. This comprises approximately 6,700 m^2 of basin and 13,700 m^2 of porous build-ups, and are therefore sufficient to provide the additional attenuation that may be necessary.

However, it has been noted that the 1D modelling does not accurately reflect the behaviour of the flood level once it rises above the bank full level, and that the real flood level will be significantly lower than the level they have modelled. Additional 2D modelling is required to accurately determine the height and extent of flooding over time, and to confirm whether flooding downstream of site will require the SuDS strategy to provide additional attenuation. This modelling will be undertaken by the flood risk consultant at the next design stage.

5.0 Outline Foul Drainage Strategy

A new foul drainage system will be constructed to convey the site's foul runoff under gravity to the existing Thames Water pumping station, from which it will be pumped to Bicester sewage treatment works. A Thames Water foul sewer crosses adjacent to the site's eastern boundary, and it is proposed to divert this sewer to fit the layout of the proposed development. Additionally, a short run of Thames Water sewer which is being made redundant by the works will be abandoned.

All other private live sewers and drains crossing the site are currently being intercepted and diverted away from the site boundary by the Graven Hill Village Development Company (GHVDC).

Based on a previously submitted Impact Assessment undertaken by Thames Water (Appendix D), it is understood that no off-site capacity upgrades will be required to accommodate the proposed development.

6.0 Summary

It is proposed to develop the D1 and EL1 sites at Graven Hill, Bicester for B8 Storage or Distribution use. This will comprise several warehouse units and associated infrastructure and landscaping. A surface water drainage strategy has been developed for the proposed re-development of the site, based on the principles agreed with LLFA during pre-application consultation.

The development will limit the rate surface water discharge to Q_{BAR} for rainfall events up to the 1:100 year plus 40% climate change. This will significantly reduce surface water runoff from the site during extreme events, reducing the risk of flooding downstream.

Open attenuation basins will provide the majority of surface water storage on the site, and a number of source control features such as rainwater harvesting, swales, permeable paving and porous build-ups will provide additional storage as well as water quality benefits. The open basins will be designed to provide amenity and biodiversity benefits, which will be considered in more detail post-planning.

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Appendix A
Figures

Appendix B

Ground Investigation Report

Appendix C

Drainage Modelling Outputs

Appendix D

Correspondence