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CONSULTING ENGINEERS
AN EMPLOYEE OWNED COMPANY

Bellway Homes Ltd.

Yarnton Way

Yarnton Way, Belvedere, Bexley, DA18 4AF

Flood Risk Assessment and Drainage Strategy

REPORT REF.
194180-R04 Draft

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HEAD OFFICE: 3rd Floor, The Hallmark Building, 52-56 Leadenhall Street, London, EC3M 5JE **T** | 020 7680 4088
EDINBURGH: Suite 35 4-5 Lochside Way Edinburgh EH12 9DT **T** | 0131 516 8111
ESSEX: 1 - 2 Crescent Court, Billericay, Essex, CM12 9AQ **T** | 01277 657 677
KENT: Suite 10, Building 40, Churchill Business Centre, Kings Hill, Kent, ME19 4YU **T** | 01732 752 155
MIDLANDS: Office 3, The Garage Studios, 41-43 St Mary's Gate, Nottingham, NG1 1PU **T** | 0115 697 0940
SOUTH WEST: Temple Studios, Bristol, England, BS1 6QA **T** | 0117 456 4994
SUFFOLK: Suffolk Enterprise Centre, 44 Felaw Street, Ipswich, IP2 8SJ **T** | 01473 407 321

Email: enquiries@ardent-ce.co.uk

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Distribution

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1. Introduction

Preface

1.1. Ardent Consulting Engineers (hereafter referred to as Ardent) has been commissioned by Bellway Homes Ltd to prepare a Flood Risk Assessment and Drainage Strategy for the proposed residential development at Yarnton Way, Belvedere in the London Borough of Bexley (hereafter referred to as the "Site").

1.2. This document has been prepared to accompany a planning application to the London Borough of Bexley, as both the Local Planning Authority (LPA), and Lead Local Flood Authority (LLFA).

1.3. This document has been written with specific reference to the requirements of the National Planning Policy Framework (NPPF) updated in July 2021 and the Planning Practice Guidance (PPG), which superseded the Technical Guidance to the NPPF in 2014, updated in August 2022.

2. Baseline Parameters

Existing Site

2.1. The Site is located along Yarnton Way, Belvedere within the London Borough of Bexley, DA18 4AF, centred on OS Grid Reference (mE 549231, mN 179334). Yarnton Way exists to the North of the Site and a Railway exists to the South, with Belvedere Station located approximately 300m southeast. To the west is an industrial park, and to the south and east, the Site is surrounded by residential properties. The Site is currently occupied by a former Gas Holder Station and largely consists of overgrown shrub and vegetation. See Figure 2-1 below for details.

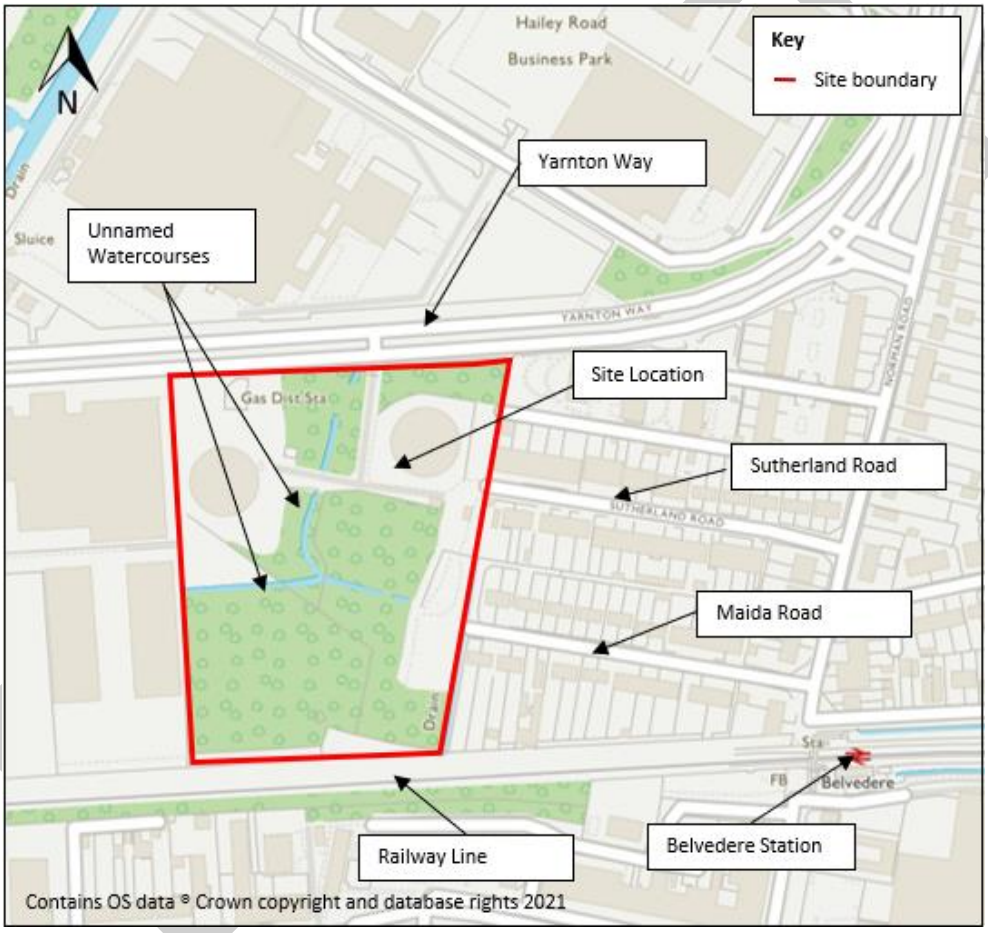

Figure 2-1: Site Location Plan

Development Proposals

2.2. The scheme proposals comprise Redevelopment of the Site to provide residential units including affordable housing (Use Class C3) and commercial floorspace (Class E) in new buildings ranging between 3 to 5 storeys in height, together with associated car parking and cycle storage, landscaping including new areas of public open space

and a reptile retention zone, associated infrastructure including new junctions off Yarnton Way, drainage and land raising.

2.3. Amenity space will also be provided consisting of balconies, garden areas and communal space. The communal areas will be planted with species rich planting and trees as well as incorporate swales which will promote biodiversity uplifts. In addition, an innovative 'Tiny Forest' scheme within the communal areas will be introduced. The tiny forest scheme will be a dense tree planting area that could potentially accommodate significant numbers of new trees and planting.

2.4. The proposed Site layout plans can be found in **Appendix A**, and an extract of the ground floor plan in Figure 2-2 below.

Figure 2-2: Proposed Development (Ref. 3499-STO-SW-ZZ-PL-A-9010000-WIP)

2.5. The development is classified as having an overall 'More Vulnerable' land use within the NPPF.

Topography

2.6. A topographical survey of the Site was carried out by Hook Survey Partnership in July 2020 and is included **in Appendix B**.

2.7. The survey shows the Site to be relatively flat, falling to the north from 1.2m AOD to 0.3m AOD over a length of approximately 215m with an approximate gradient of 1:240.

Hydrology

2.8. The nearest main River is the tidal River Thames located approximately 1.5km to the north and west of the Site. An unnamed tributary of this, also classed as a Main River, exists approximately 125m to the north-west of the Site. There are no other main rivers in the vicinity of the Site.

2.9. A number of ordinary watercourses exists through the centre of the Site; one flowing from west to east and one from north to south. The current condition of the ditches is poor with standing water throughout. A ditch also exists, just outside the eastern boundary of the Site, running parallel to the Site boundary.

Ground Conditions

2.10. Using data from the British Geological Survey (BGS) as displayed in Figure 2-3 and Figure 2-4 below, the Site is shown to be underlain by alluvium superficial deposits of clay, silt, sand and peat which are in turn underlain by the Thanet Sand Formation.

2.11. Borehole records just north on the Site on Yarnton Way (ref TQ47NE41) indicate the ground conditions to comprise "topsoil and firm grey-brown sandy CLAY" to a depth of 5 ft (1.52 m) bgl underlain by "soft dark grey peaty CLAY" a depth of 11 ft (3.35 m) bgl which is underlain by "soft brown PEAT" to a depth of 15ft (4.57 m) bgl. This is in turn underlain by "soft, grey, very organic silty CLAY" to a depth of 28 ft (8.53 m) bgl which is underlain by sand and gravels for the remainder of the depth of the borehole (50 ft (15.24 m) bgl). Groundwater was encountered at a depth of 4 ft (1.2m) bgl. Refer to **Appendix C** for the borehole logs.

2.12. An in-situ geotechnical investigation was undertaken at the Site,but the results are being awaited.

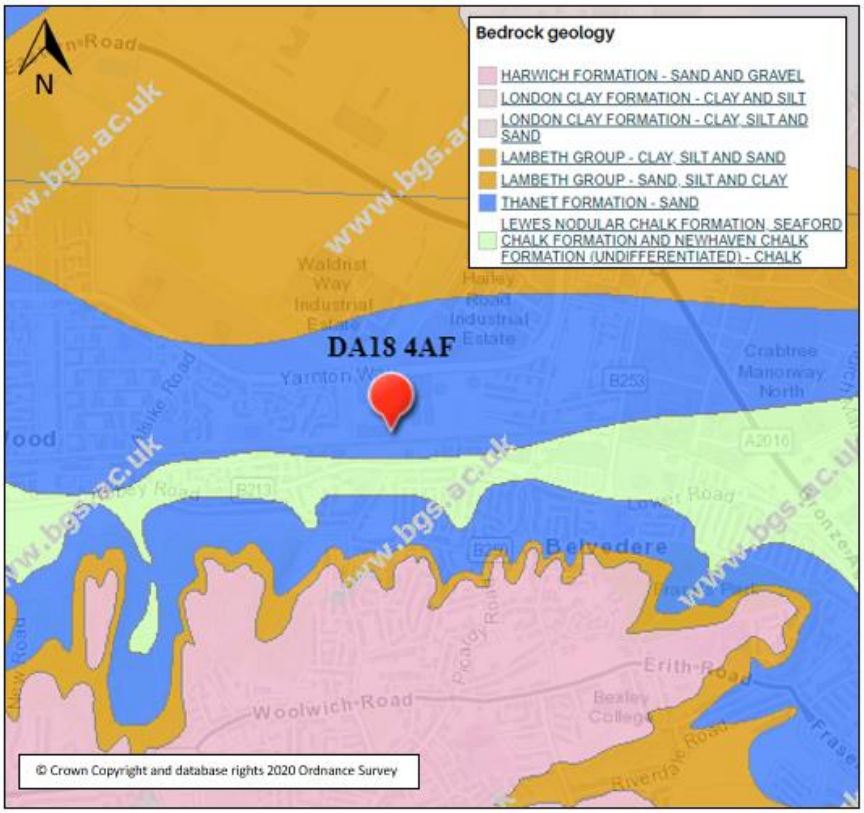

Figure 2-3: BGS Geology Maps (Bedrock Geology)

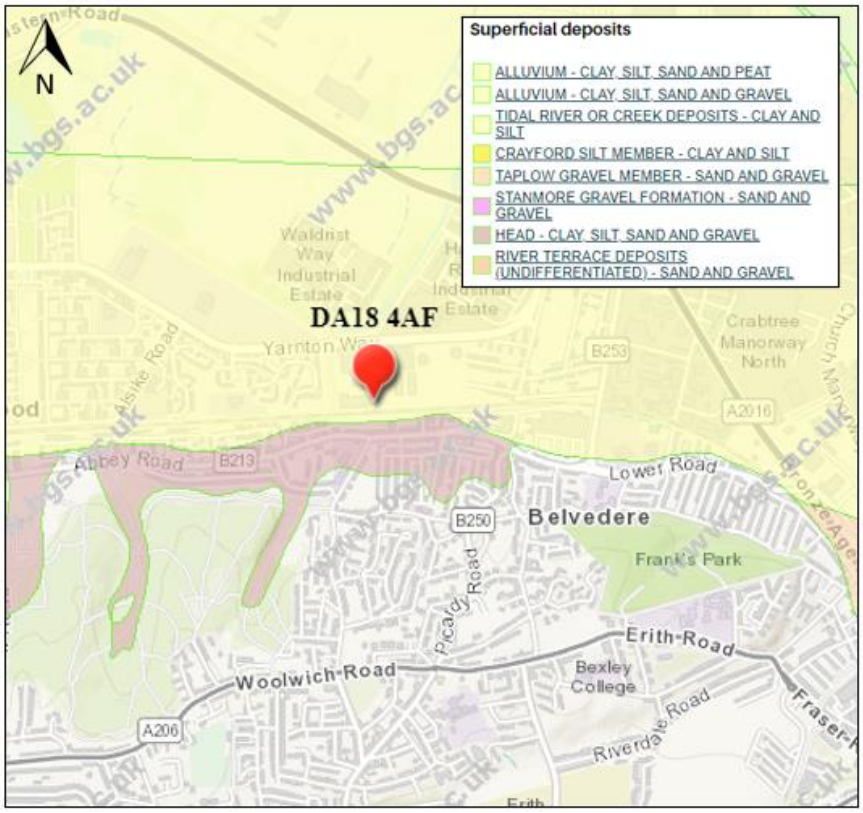

Figure 2-4: BGS Geology Maps (Superficial Geology)

2.13. The Department for the Environment, Food and Rural Affairs (Defra) mapping indicates the Site is not located within a Source Protection Zone.

Existing Sewer Infrastructure

2.14. Figure A9 included within Appendix A of the London Borough of Bexley SFRA details the Thames Water Network within the Borough. An extract of this is shown in Figure 2-5 below.

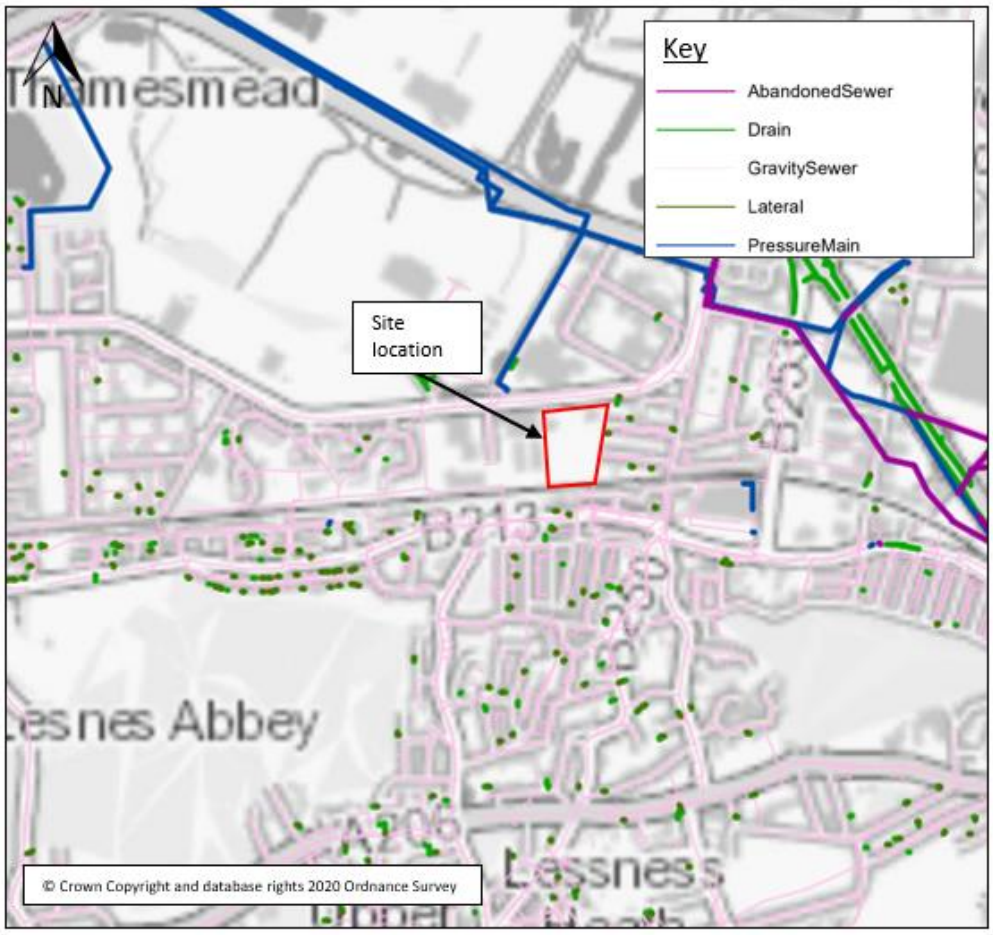

Figure 2-5: Extract of Thames Water Sewer Records (Figure A9 of LBB SFRA)

2.15. An extract of Thames Water sewer records is also provided in Figure 2-6 below. A full copy of the plan is included in **Appendix D**.

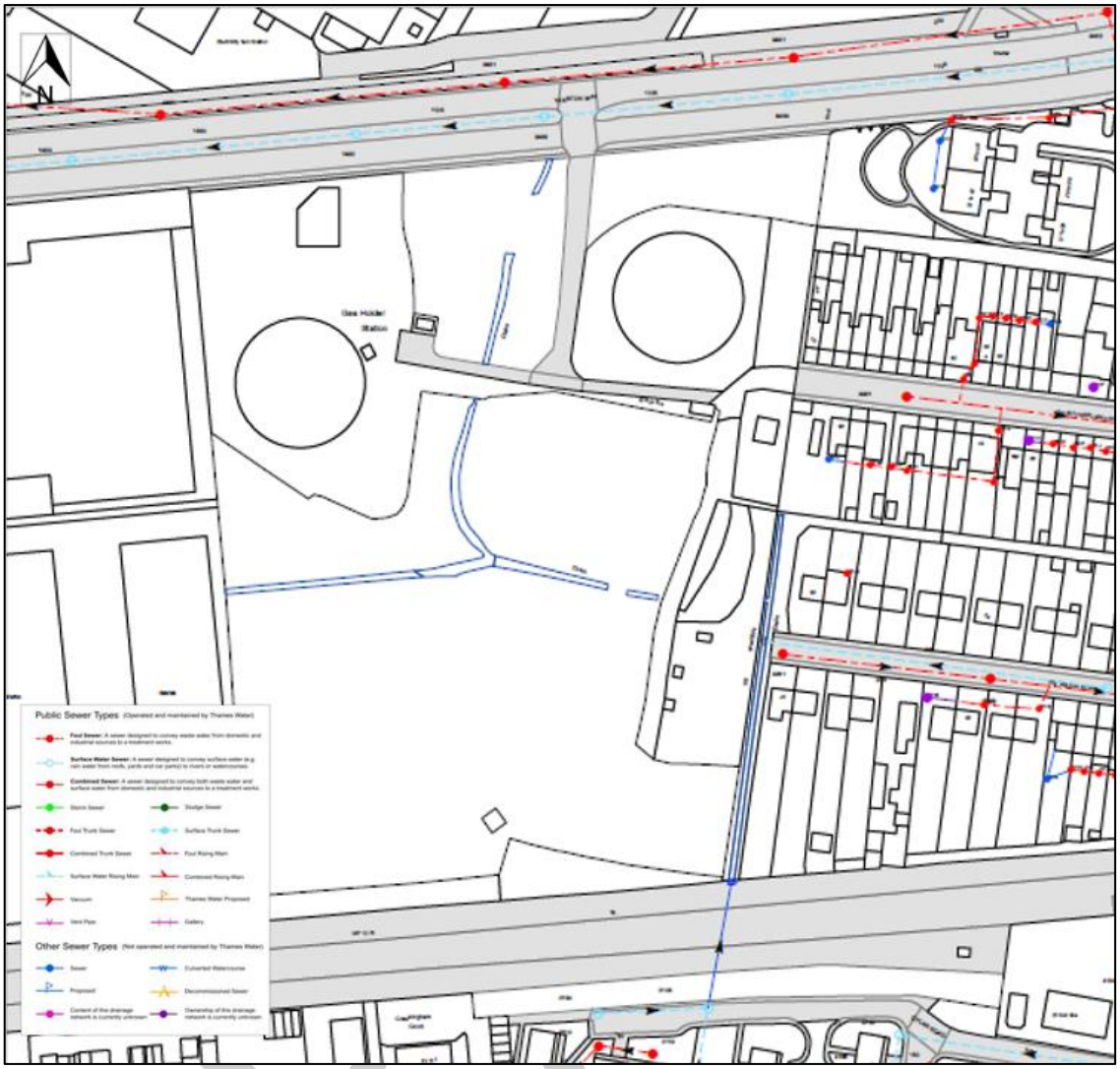

Figure 2-6: Extract of Thames Water Sewer Records

2.16. The plan shows public surface water sewers run along Yarnton Way at the Site northern boundary. No gullies are present within the Site boundary.

2.17. A number of foul sewers also exist around the Site. Foul sewer running west is present on Yarnton Road. A number of sewers running east also exist on Maida Road and Sutherland Road.

3. Policy Context

National Planning Policy Framework

3.1. The National Planning Policy Framework (NPPF) was introduced on 27 March 2012. This document was revised in updated in July 2021 where paragraphs 159 to 169 inclusive, establish the Planning Policy relating to flood risk management. The Technical Guide to the NPPF was superseded by the Planning Practice Guidance (PPG) in March 2014.

3.2. The main focus of the policy is to direct development towards areas of the lowest practicable flood risk and to ensure that all development is safe, without increasing flood risk elsewhere. The main considerations are:

a) applying the sequential test and then, if necessary, the exception test as set out below;

b) safeguarding land from development that is required, or is likely to be required, for current of future flood management;

c) using opportunities provided by new development to reduce the causes and impacts of flooding (where appropriate through the use of natural flood management techniques); and

d) where climate change is expected to increase flood risk so that some existing development may not be sustainable in the long-term, seeking opportunities to relocate development including housing, to more sustainable locations.

Flood and Water Management Act (2010)

3.3. The Flood and Water Management Act places a duty on all flood risk management authorities to co-operate with each other. The act also provides lead local flood authorities and the Environment Agency with a power to request information required in connection with their flood risk management functions.

Sustainable Drainage Systems - Non-statutory technical standards for sustainable drainage systems March 2015

3.4. The Non-statutory technical standards for sustainable drainage systems were published in March 2015. They should be used in conjunction with the Planning Practice Guidance. In addition, the Best Practice Guidance for the Planning Practice Guidance for the Non-Statutory Technical Standards was published in July 2015 by LASOO.

3.5. The Local Planning Authority (LPA) may set local requirements for planning permission that have the effect of more stringent requirements than these non-statutory technical standards.

3.6. In addition, SuDS should be designed in accordance with CIRIA 753 "The SuDS Manual", which represents current best practice.

The London Plan & Supplementary Planning Guidance (March 2021)

3.7. London Plan Policy SI 12 'Flood risk management' outlines the Mayor's approach to flood risk management stating that 'Current and expected flood risk from all sources (as defined in paragraph 9.2.12) across London should be managed in a sustainable and cost-effective way in collaboration with the Environment Agency, the Lead Local Flood Authorities, developers and infrastructure providers.'

3.8. London Plan Policy SI 'Sustainable drainage' outlines the Mayor's approach to sustainable drainage, stating that:

- *'Development proposals should aim to achieve greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible. There should also be a preference for green over grey features, in line with the following drainage hierarchy:*

    1) *rainwater use as a resource (for example rainwater harvesting, blue roofs for irrigation)*
    2) *rainwater infiltration to ground at or close to source*
    3) *rainwater attenuation in green infrastructure features for gradual release (for example green roofs, rain gardens)*
    4) *rainwater discharge direct to a watercourse (unless not appropriate)*

5) *controlled rainwater discharge to a surface water sewer or drain*

6) *controlled rainwater discharge to a combined sewer.*

- *Development proposals for impermeable surfacing should normally be resisted unless they can be shown to be unavoidable, including on small surfaces such as front gardens and driveways.*

- *Drainage should be designed and implemented in ways that promote multiple benefits including increased water use efficiency, improved water quality, and enhanced biodiversity, urban greening, amenity and recreation.*

Thames Estuary 2100 Plan

3.9. The Thames Estuary 2100 Plan was published by the EA in November 2012. It sets out recommendations for flood risk management for London and the Thames estuary. Action Zone 2 within the Thames Estuary in Central London (Wandsworth to Deptford & London City) is where the Site resides. The recommended policy for the area is to take further action to reduce flood risk beyond that required to keep pace with climate change.

The London Borough of Bexley Local Plan (April 2023)

3.10. The Bexley Local Plan is the key strategic planning document for Bexley, setting out long term objectives for the Borough. The plan sets out how the Council will seek to deliver the principles of sustainable development, and the development management process.

3.11. The Local Plan contains strategic, non-strategic and Site allocation (for residential and residential-led mixed-use development) polices. DP 32 Flood Risk Management and DP 33 Sustainable drainage systems are relevant to this assessment alongside DP18 Waterfront Development.

3.12. DP 32 Flood Risk Management States the following:

Planning for Flood Risk

3.13. In areas at risk of flooding, as identified in the Bexley Strategic Flood Risk Assessment (SFRA), development proposals, including redevelopment (except minor development), must:

a. be within a sustainable development location if the Site is within Flood Zones 2 and 3a, and the development type is acceptable within the Flood Zone, as only these locations have passed the Local Plan sequential test;

b. apply the exception test, where required, to Sites within flood zones 2 and 3a that have met the requirements of part 1a;

c. comply with the guidance and recommendations set out in the Bexley SFRA Level 1 and 2;

d. apply the sequential approach advocated in the NPPF to all sources of flooding, not just tidal and fluvial;

e. be used as an opportunity to reduce the causes and impact of flooding;

f. make as much use as possible of natural flood management techniques as part of an integrated approach to flood risk management); and,

g. provide floodplain storage capacity as close to the development as possible, where the proposed development will reduce this capacity.

Tidal and fluvial flooding

3.14. Habitable rooms in residential development within the fluvial flood zones, should be set 300mm above the predicted 1 in 100 year plus climate change peak flood water level.

3.15. Development in areas designated as functional floodplain (as identified in the SFRA Level 1 and the submission policies map) will not be permitted outside of water-compatible development, as defined in the NPPF.

3.16. All proposals for development in flood zones 2 and 3, and all proposals on Sites of 0.25 hectares or larger regardless of what flood zone the Site is in, must include a Site-specific flood risk assessment (FRA), including a drainage impact assessment.

3.17. New developments in riverside locations are required to help reduce flood risk now and into the future. Development proposals located within 100 metres of the Thames tidal flood defences should demonstrate consideration of and act on the recommendations of the TE2100 Plan; and be designed in such a way as to easily facilitate the raising and re-engineering of the tidal flood defences.

3.18. Basements will not be permitted in Flood Zones 2 or 3

Surface water, groundwater and sewer flooding

3.19. Development must not increase flood risk on-Site or off-Site, and exceedance flows must be considered and appropriately managed.

3.20. All basement developments should include, within their proposal, protection to the property by installing, for example, a non-return valve or other suitable device to avoid the risk of backflow at a later date, on the assumption that the sewerage network may surcharge to ground level during storm conditions

Safe refuge, access and egress in, to and from development

3.21. New developments below the predicted flood water level should include a detailed evacuation plan that clearly outlines how people can easily leave to safety or move upwards from the lower floors to

3.22. DP33 Sustainable Drainage Systems states the following:

- *All development proposals, whether increasing or decreasing the impermeable area of the Site, will be required to manage surface water through sustainable drainage systems (SuDS) in line with all national, regional and local policies and related guidance, in order to minimise flood risk, improve water quality and enhance biodiversity and amenity.*
- *In addition, all development proposals will be required to demonstrate that:*
  a. the drainage for the Site achieves greenfield runoff rates for flood events up to and including 1 in 100 years plus 40% climate change;
  b. surface water run-off has been reduced by sustainably managing run-off on Site;
  c. permeable paving has been used for hardstanding areas (e.g. car parks);
  d. the nature of water flow (both surface water and groundwater) across a steeply sloping Site has been considered in order to provide suitable SuDS; and
  e. water reuse mechanisms have been included for either indoor or outdoor purposes.

- *Development proposals on Sites of 0.25 hectares or greater require a drainage strategy, which must be accompanied by a suitable maintenance management plan.*

3.23. DP 18 promotes the utilisation of the active space along waterfronts including lakes, ditches and dikes with the promotion of green infrastructure to improve water quality where possible.

3.24. The Local Plan details areas within the borough in which sustainable development has been allocated. The Site is located within one such area named the 'Lower Belvedere sustainable development location' under Site allocation SA7. It should be noted that; The Site is classified as 'More Vulnerable' and situated in Flood Zone 3. Therefore, the Site is required to undergo the Sequential and Exception Tests under the requirements of the NPPF. This has been carried out by LBB in the Bexley Draft Local Plan (2021) and supporting Local Plan Flood Risk Sequential and Exception Test Technical Paper (2021). The Site (Local Plan ref. SA7) passed both the sequential and exception tests.

The London Borough of Bexley Local Flood Risk Management Strategy (2017)

3.25. The Local Flood Risk Management Strategy sets out how flood risk is managed in Bexley, who is responsible for water from different sources and presents an action plan to reduce flood risk. It has been produced as part of the requirements of the Flood and Water Management Act 2010. Within the legislation the London Borough of Bexley has been made a Lead Local Flood Authority. This means that it is responsible for overseeing the strategic management of flooding from Surface Water Flooding, Ground Water Flooding and Ordinary Watercourse Flooding

The London Borough of Bexley Strategic Flood Risk Assessment (SFRA) – Level 2 (2014)

3.26. The NPPF and PPG highlight the role of Local Planning Authorities to use a risk based approach to understand and manage flood risk, requiring a Strategic Flood Risk Assessment (SFRA) to inform local plans. The London Borough of Bexley have produced a SFRA setting out the local evidence and requirements.

3.27. The SFRA is a tool to inform the spatial planning process and guide safe development, from a flood risk perspective. The Level 1 SFRA is intended to:

- *Identify main rivers and flood zones within the Borough;*
- *Assess the potential impact of climate change on flood risk;*
- *Identify areas at risk from other sources of flooding such as surface and groundwater;*
- *Identify flood risk management measures including their location and standard;*
- *Provide guidance on the application of the Sequential Test; and*
- *Provide guidance on flood risk management through the design process. The finished floor levels of more vulnerable uses should be above the predicted maximum water level resulting from a breach in the defences during the 1 in 200 year plus climate change tidal event*

3.28. The SFRA states the following guidance relevant to the development; Where highly vulnerable, more vulnerable, essential infrastructure development are permitted finished floor levels should be set to based on the source of risk:

- *In areas of fluvial or surface water flood risk finished floor levels should be set above the 1 in 100 (1%) annual probability plus 35% climate change flood level, plus an appropriate freeboard allowance (300 mm if the Site is behind fluvial defences and 600mm if not).*
- *In areas of tidal residual flood risk only, finished floor levels of sleeping accommodation need to be raised above the 1 in 200 (0.5%) annual probability for the 2115 epoch, which includes an allowance for climate change.*

3.29. In addition, the SFRA states that NPPF classes self-contained basement dwelling (i.e. with no internal access to upper floors) as 'highly vulnerable', and as such not permitted in flood zone 3a or 3b

Sequential Test

3.30. The aim of the sequential test is to steer new development to areas with the lowest risk of flooding from any source. Development should not be allocated or permitted if there are reasonably available Sites appropriate for the proposed development in

areas with a lower risk of flooding. The strategic flood risk assessment will provide the basis for applying this test. The sequential approach should be used in areas known to be at risk now or in the future from any form of flooding.

3.31. As the Site is shown to be located within Flood Zone 3 of the Environment Agency flood mapping, it is necessary for the Site to undergo the Sequential Test.

3.32. As detailed above, the Local Plan (April 2023) confirms that the Site has passed the sequential test.

Exception Test

3.33. Table 3 of the PPG replicated below in Figure 3-1, confirms that the Exception Test is required for "More Vulnerable" uses in Flood Zone 3a.

Flood risk vulnerability classification (see table 2)		Essential infrastructure	Water compatible	Highly vulnerable	More vulnerable	Less vulnerable
Flood zone (see table 1)	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.

Figure 3-1: Extract from the PPG: Flood Risk Vulnerability

4. Sources of Flooding

4.1. The NPPF requires flood risk from the following sources to be assessed, each of which are assessed separately below:

- Fluvial sources (river flooding);
- Tidal sources (flooding from the sea);
- Groundwater sources;
- Pluvial sources (flooding resulting from overland flows);
- Sewer Flooding;
- Artificial sources, canals, reservoirs etc.; and,
- It also requires the risk from increases in surface water discharge to be assessed (surface water management).

Fluvial/ Tidal Flood Risk

4.2. The London Borough of Bexley is bounded to the north by the River Thames which flows from west to east. A relatively large proportion of the London Borough of Bexley (including the Site) is located within the defended tidal Flood Zone 3a associated with the River Thames.

4.3. An extract from the indicative online Flood Zone Map is provided below in Figure 4-1. According to the Flood Map for Planning, the Site is located wholly in Fluvial/Tidal Flood Zone 3 associated with the River Thames. The Borough is currently protected from combined tidal and fluvial flooding by the River Thames Tidal Defences (TTD) up to the 0.1% annual probability (1 in 1000 year) event.

4.4. The Site is therefore assessed as being at low risk of tidal flooding.

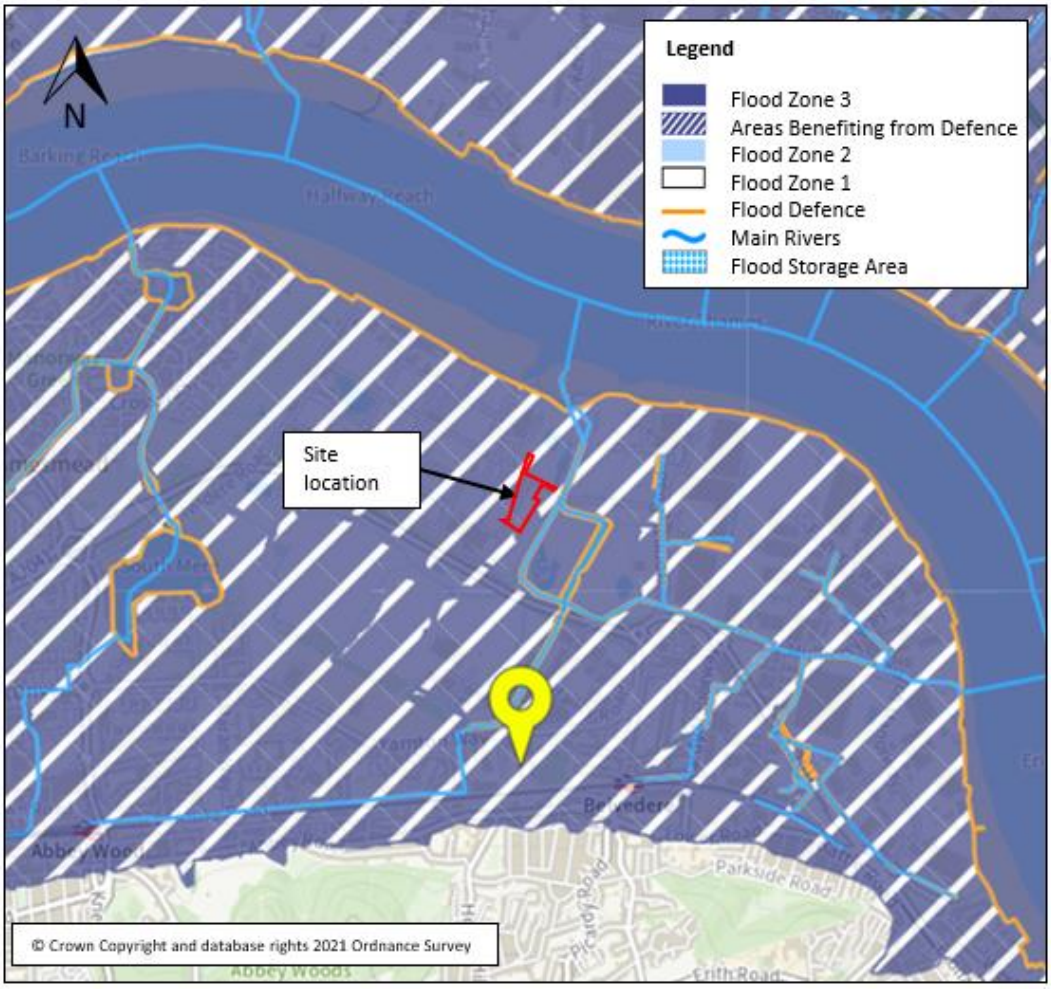

Figure 4-1: Environment Agency Flood Map for Planning

Residual Tidal Flood Risk

4.5. The EA flood map for planning shows the Site is located within Flood Zone 3, however, the Site is protected by a series of flood defences along the River Thames. With these defences in place, the Site would not be at risk of flooding even in an extreme flood event (0.1% annual exceedance probability event) and is therefore considered to have a residual, very low, annual probability of tidal/fluvial flooding, at less than 0.1%.

4.6. The River Thames Tidal flood defences close to the Site provide a present-day Standard of Protection (SoP) equivalent to a 1 in 1000 (0.1%) annual probability tidal flood event. The defences are all raised, man-made, and privately owned. They are maintained to a crest level of 7.1mAOD which is the statutory flood defence level in this reach of the Thames.

4.7. Flood defences reduce the risk of flooding however they cannot completely remove the risk as they may be overtopped or breached during a flood event.

4.8. Whilst the Site is defended against flooding from the River Thames, there remains a residual risk of failure of these defences and therefore, it is essential that planning decisions are taken with due consideration to the scale (and variability) of this risk.

4.9. The Site falls within of the extents of the Environment Agency Thames Tidal Upriver Breach Inundation Modelling 2018. The tidal events were modelled for all breach locations upstream of the Thames Barrier for the 2005 epoch as well as 2115 epoch to include an allowance for climate change.

4.10. The maximum flood level for the River Thames Breach modelling for the Site for the 0.1% AEP (2115) with climate change is 2.63m AOD.

4.11. As mentioned in Section 2, the Site has a gentle and prevailing fall from the south to north (approximately 0.9m over 215m length). The highest ground level of the Site is 1.2m AOD to the south, with a low point of 0.3m AOD to the northwest. Local lower ground

4.12. According to The London Borough of Bexley SFRA, in areas of tidal residual flood risk only, finished floor levels of sleeping accommodation need to be raised above the 1 in 200 (0.5%) annual probability for the 2115 epoch, which includes an allowance for climate change. Additionally, however, the Environment Agency would expect sleeping accommodation to be set about the 1 in 1000 year, with climate change, level. This approach has been confirmed as acceptable by the Environment Agency. Refer to correspondence in **Appendix E**.

4.13. The water level for the 1 in 200 (0.5%) annual probability for the 2115 epoch is 2.49m AOD. Allowing for a 300mm freeboard, the finished floor level for the proposed development sleeping accommodation will be set at a minimum of 2.79m AOD which is above the 2115 epoch 1 in 1000 (0.1%) with climate change event of 2.63m AOD.

Pluvial Flood Risk

4.14. The Environment Agency's surface water flood map shows that the Site is almost entirely situated at 'Very Low' risk of surface water flooding (Figure 4-2).

4.15. A small area of low risk flooding exists at the north-western corner of the Site and other areas of low risk are present, associated with the ordinary watercourses within the Site boundary.

4.16. The London Borough of Bexley database for historical flooding identifies Battle and Pembroke Road in Belvedere area as having the most flooding events reported in the Borough. Historical surface water flooding incidents have been recorded to the South of the Site and around the Belvedere Railway Station. This was also reiterated through consultation carried out the LBB during the pre-application process. Refer to correspondence in **Appendix F**.

4.17. Within the SFRA a number of surface water models were produced to demonstrate the risk of flooding in the borough, taking into account Climate change. Localised areas of flooding on the Site are shown during the 1 in 100 (1%) annual probability surface water flooding event corresponding with low spots within the Site.

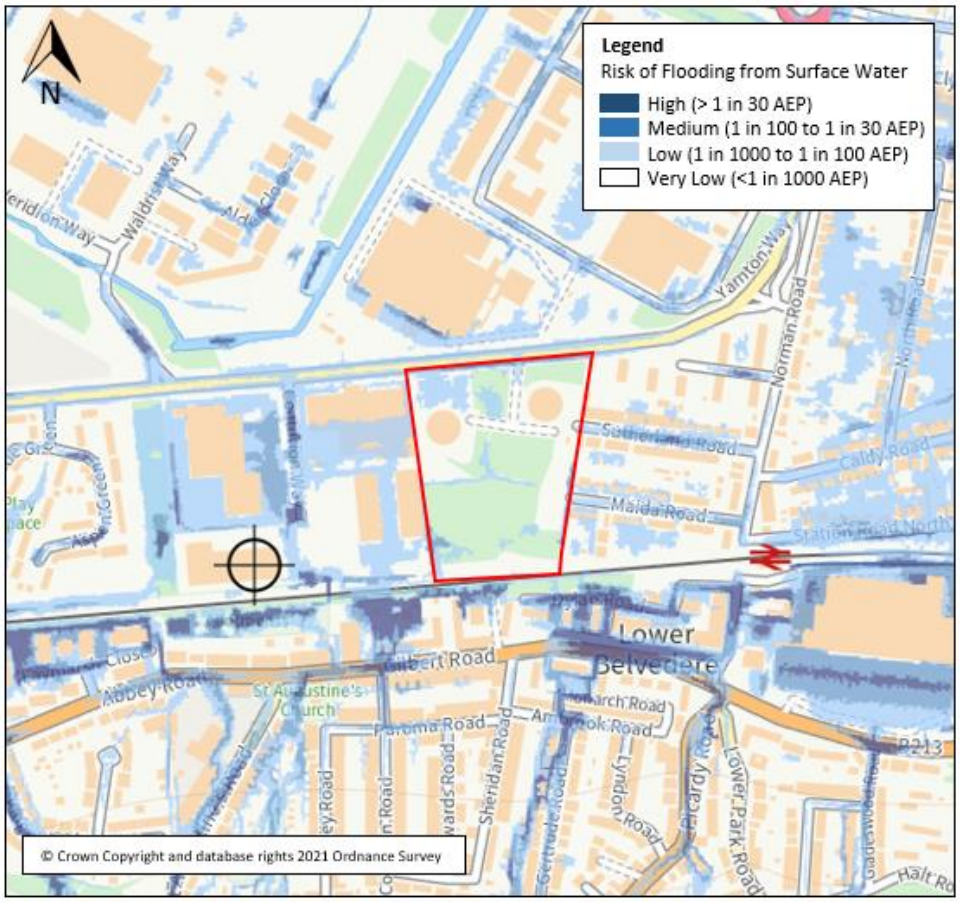

Figure 4-2: Environment Agency Flood Map for Surface Water (Extents)

4.18. The risk of pluvial flooding to the Site is therefore assessed low, however consideration should be given to flood risk as a result of the development.

4.19. The development of the Site will bring improvements to the flood risk in the surrounding area through the implementation of a surface water drainage strategy, as described in **Section 5** of this report.

Groundwater Flood Risk

4.20. Groundwater Vulnerability mapping included in the in the SFRA and as shown in Figure 4-3 below demonstrates that the Site is located within an area of classified as being Minor_HU. This indicates the Site is underlain by low permeability deposits meaning the risk of groundwater flooding at the Site is low.

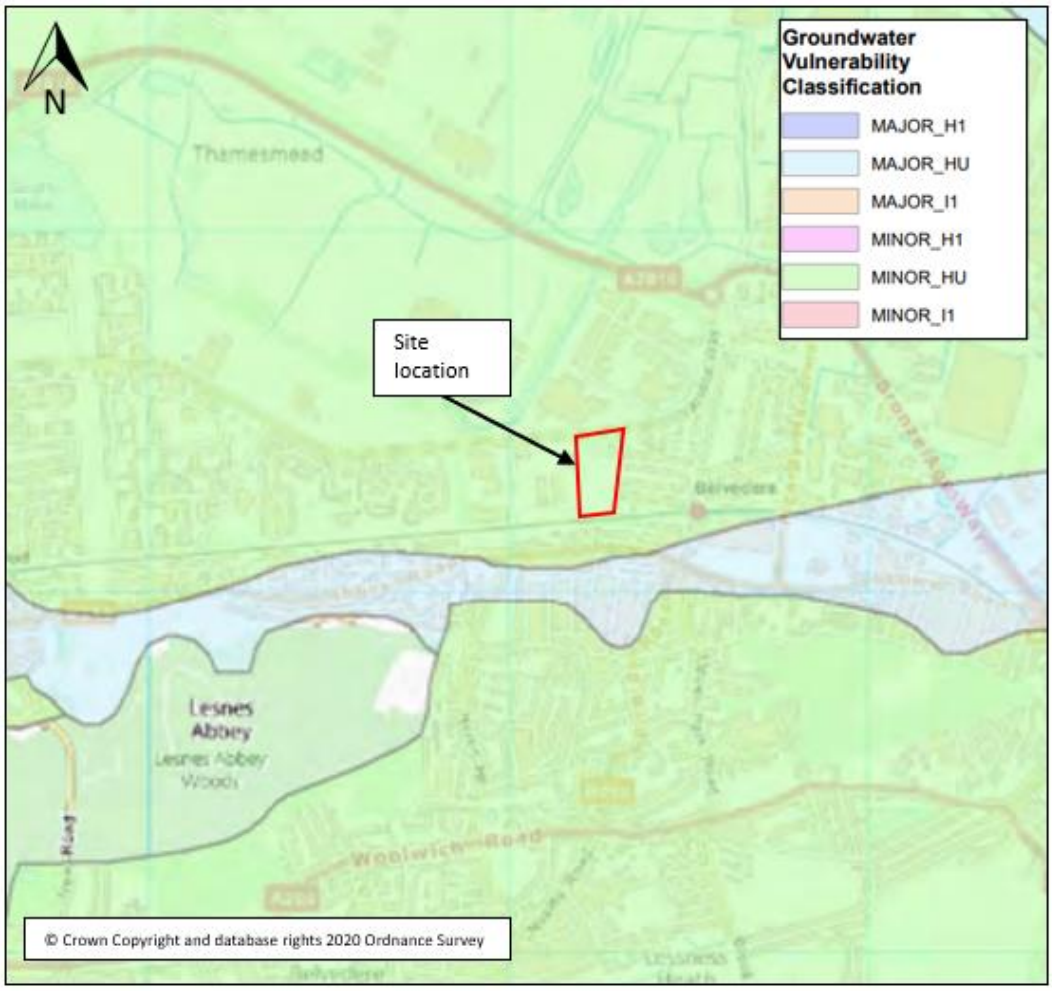

Figure 4-3: Groundwater Vulnerability

4.21. British Geological Survey borehole records (ref TQ47NE41) recorded groundwater at a depth of 1.52m at the Site. An in-situ geotechnical investigation was undertaken at the Site, but the results are being awaited.

4.22. The development does not involve any below ground construction such as basements therefore risk of groundwater flood risk to the proposed development is likely to be low, however due to the maps from the SFRA, and Bexley council it is suggested an intrusive Site investigation be carried out as part of the detailed design, including groundwater monitoring.

4.23. The groundwater flood risk to the Site is therefore considered to be moderate.

Sewer Flood Risk

4.24. As shown on Figure A9 of the SFRA, there are no sewers located within the Site boundary.

4.25. The SFRA also details the historic flood events associated with this sewer network as recorded by Thames Water. The majority of flood events are external flooding events, so flooding that does not enter the property.

4.26. No incidents of sewer flooding have been recorded within the DA18 postcode in which the Site is located therefore the risk of flooding from sewers is considered to be low.

Flood Risk from Artificial Sources

4.27. The Environment Agency's flood maps from reservoirs indicate that the Site is not within an area at risk of flooding from reservoirs, canals, or other artificial water bodies.

4.28. The risk to the Site from reservoir flooding is therefore considered to be very low.

5. Surface Water Management

Existing Surface Water Discharge

5.1. The planning redline boundary equates to approximately 3.46 ha which is currently considered to be approximately 12% hardstanding due to existing use as a gas holding Site. In order to assess the current discharge from the Site, the *Modified Rational Method* has been used to predict the current surface water discharge rate from the hardstanding area, as shown below.

Q = 2.78*C*i*A

Where:

Q = Peak Discharge (l/s)

i = Rainfall Intensity (mm/hr)
(50.8 mm/hr for 1yr, 5 min storm TRRL Report 595)

A = Impermeable Area (ha)

C = Runoff Coefficient

5.2. Therefore, based on the Modified Rational Method, peak runoff rates generated from the existing Site for a 1 in 1 year, 1 in 30 and 1 in 100-year, 5 minutes storm are provided in **Appendix E**.

5.3. For comparison the equivalent Greenfield runoff rates from the Site have been determined using the *ICP SuDS Mean Annual Flow Method* (IoH 124).

5.4. A summary of both the existing Brownfield and equivalent Greenfield runoff rates are proposed in Table 5-1 below.

Scenario	Area	$Q_{Bar.}$	$Q_{1yr.}$	$Q_{30yr.}$	$Q_{100yr.}$
Brownfield	0.43 ha	-	61.0 l/s	135.7 l/s	172.8 l/s
Greenfield	3.46 ha	1.2 l/s	1.0 l/s	2.7 l/s	3.7 l/s

Table 5-1: Comparison of Existing Brownfield and Equivalent Greenfield Runoff Rates

Drainage Hierarchy

In accordance with the London Plan Policy SI 13 (B), surface water runoff should be disposed of according to the following hierarchy:

1. Store rainwater for later use;
2. Use infiltration techniques, such as porous surfaces in non-clay areas;
3. Attenuate rainwater in ponds or open water features for gradual release;
4. Attenuate rainwater by storing in tanks or sealed water features for gradual release;
5. Discharge rainwater direct to a watercourse;
6. Discharge rainwater to a surface water sewer/drain; and
7. Discharge rainwater to the combined sewer.

5.5. These are assessed in full below.

Into the Ground (Infiltration)

5.6. The Site is located on an a relatively permeable bedrock geology; Thanet Sand Formation; which would promote infiltration. However, considering the industrial make-up of it the Site it is understood that the Site will potentially contains significant depths of Made Ground of which infiltration could cause the mobilisation of contaminants.

5.7. Furthermore, groundwater is known to be shallow; circa 1.2m below ground level; which would be a significant constraint to feasible infiltration.

5.8. Considering all of the above together, infiltration is not considered a feasible means of discharge.

To a Surface Water Body

5.9. The are a number of Ordinary Watercourses (OWC) and ditches present within the Site. As a positive connection can be attained from within the Site boundary, it is proposed that surface water will be discharged at a restricted rate into the OWC

running from west to east through the Site before discharging into the wider network to the east of the Site.

To a surface water sewer, highway drain, or another drainage system

5.10. There is an existing Thames Water sewer within Yarnton Way to the north of the Site. Should the connection to the OWC discussed above not be feasible it will be proposed to discharge into the existing public network. However, as this is further down the hierarchy this has not been considered at this stage.

To a combined sewer

5.11. There are no combined water sewers and drains within the vicinity of the Site. As this is further down the hierarchy than discharging to a surface water body this method of discharge has not been considered.

Proposed Sustainable Drainage Systems (SuDS)

5.12. The constraints and opportunities for the use of SuDS techniques within the Site is appraised in Table 5-2 below, adopting the management train approach outlined in CIRIA C753 '*The SuDS Manual*'.

Type	***Infiltration Devices (Source Control)***
Constraints	High groundwater anticipated within the Site make infiltration unfeasible.
Opportunities	None
Type	***Permeable Paving (Source Control)***
Constraints	Main roads through the Site are understood to be offered up for adoption therefore not enabling permeable paving.
Opportunities	Limited. Shared surfaces and parking areas can be utilised as lined permeable paving to manage localised runoff.
Type	***Rainwater Harvesting (Source Control)***
Constraints	The benefits of rainwater harvesting on a specific design storm event cannot be quantified, due to the seasonal availability of storage within the structure.
Opportunities	Features are not considered as part of the surface water management plan. However, rainwater butts could be utilised at individual residential properties for irrigation purposes.
Type	***Swales etc. (Permeable Conveyance)***
Constraints	Significant land requirement to accommodate 1:3 side slopes.

Opportunities	Ponds proposed within the open space to provide attenuation and amenity to the Site.
Type	***Bio Retention Systems***
Constraints	Limited benefits to attenuation requirements in larger developments.
Opportunities	Potential for rain gardens around the individual residential properties.
Type	***Living Roofs***
Constraints	Limited benefits to attenuation requirements in larger developments and not commonly utilise don residential units.
Opportunities	Potential for provision of living roof on flat roofs associated with the flat developments.
Type	***Attenuation Tanks (End of Line Treatment)***
Constraints	None.
Opportunities	Should attenuation be required this could be achieved through oversized pipework or geocellular attenuation tanks.

Table 5-2: C753 SuDS Management Train

5.13. After consideration of the CIRIA C753 approach the most viable SuDS option for the development Site is considered to be a combination of lined permeable paving, shallow geo-cellular attenuation tanks and above ground pond features. This will provide the necessary storage and treatment for up to the 1 in 100-year storm event including an allowance of 40% for climate change.

Pre and Post Development Impermeable Area

5.14. The planning redline boundary equates to approximately 3.46 hectares of which 12% is considered existing hardstanding areas. The redevelopment proposals will increase the impermeable area across the Site through the introduction access roads and a number of residential buildings.

5.15. A summary of the change in impermeable area across the Site is provided in Table 5-3 below.

Site Ref.	***Area (ha)***	***Impermeable Area (ha)***	***Permeable Area (ha)***	***% Impermeable***

Pre-Development	3.460	0.432	3.028	12 %
Post-Development	3.460	2.340	1.12	68 %

Table 5-3: Summary of Pre- and Post-Development Impermeable Areas

Proposed Discharge Rates

5.16. The London Plan requires that, where possible, new developments should achieve a discharge rate of no greater than the equivalent greenfield rate where possible. Where greenfield rates are not considered practicable due to the justifiable constraints it is expected to propose a rate as close as reasonably practicable.

5.17. The Greenfield runoff rate was estimated for the Site using Innovyze's Microdrainage *Source Control* module. A summary of the Greenfield rates is provided in Table 5-4 below.

Site Ref.	**Return Period**			
	Q_{Bar}	$Q_{1yr.}$	$Q_{30yr.}$	$Q_{100yr.}$
Yarnton Way *Greenfield*	1.2 l/s	1.0 l/s	2.7 l/s	3.7 l/s

Table 5-4: Greenfield Surface Water Runoff Rates

5.18. It is proposed to control the rates to equivalent greenfield rates with a maximum discharge of 3.7 l/s.

Proposed Surface Water Attenuation

5.19. As introduced above, the surface water discharge will be restricted to equivalent Greenfield rates. The required storage provisions to achieve this restricted rate for the Site under various storm scenarios are presented in Table 5-5 overleaf.

Discharge Rate	Return Period			
	$Q_{1yr.}$	$Q_{30yr.}$	$Q_{100yr.}$	$Q_{100yr. + 40\%}$
Pre-Development	61.0 l/s	135.7 l/s	172.8 l/s	-
Post-Development	1.0 l/s	2.7 l/s	3.7 l/s	3.7 l/s
Percentage Reduction	98.3 %	98.0 %	97.8 %	-
Estimated Storage Requirements	1675.8 m^3			

Table 5-5: Surface Water Storage Provision

5.20. The *Network* module of XP Solution's MicroDrainage was utilised to calculate the storage requirements. These calculations were run for the 1 in 1 year, 1 in 30 year, 1 in 100 year and 1 in 100 year + 40% climate change events with the volume required equal 1675.8 m^3. The hydraulic calculations can be found in **Appendix F**.

5.21. It is proposed that a lined permeable paving, shallow geo-cellular attenuation tank(s) and above ground pond features will provide sufficient storage volume for the 1 in 100-year storm event including a 40% allowance for climate change.

5.22. The proposals seek to create a new positive outfall into the existing watercourse running from west to east across the Site, within the open space where it is proposed to remain open, at a restricted rate of equivalent Greenfield rates through the use of a private pumping station. However, the proposals do necessitate the culverting of the existing watercourse which is subject to detailed design to ascertain the levels and proposed crossings.

5.23. Please refer to *Drawing No. 194180-D-014* within **Appendix G** for the indicative surface water drainage layout.

5.24. The drainage strategy is currently indicative and the proposed connection to the watercourse is subject to detailed design and confirmation of the condition of the existing downstream culvert.

Urbanisation

5.25. In accordance with the LASOO guidance an allowance of 10% for the proposed residential units, not including the flats, has been accounted for within the calculations.

Long Term Storage

5.26. As the development is discharging at equivalent Greenfield rates there is no requirement to considered Long Term Storage.

Water Quality

5.27. The pollution hazard associated with a residential development would be '*very low*' and the utilisation of catchpit manholes within the drainage network, in conjunction with the permeable paving and above ground ponds will provide sufficient mitigation. Furthermore, the use of rain gardens and tree pits, throughout appropriate parts of the network, will provide treatment and benefits to the surface water runoff. A summary of the mitigation indices is provided in Table 5-6 below.

Individual property driveways, residential car parks, low traffic roads (eg cul de sacs, home zones and general access roads) and non-residential car parking with infrequent change (eg schools, offices) ie < 300 traffic movements/day			
Source	**Required Mitigation Indices**		
	TSS	*Metals*	*Hydrocarbons*
Low	0.50	0.40	0.40
Type of SuDS Component Provided			
Permeable Paving	0.70	0.60	0.70
Pond	0.35	0.35	0.25
Total	1.05	0.95	0.95
Check	**+0.55**	**+0.55**	**+0.55**

Table 5-6: SuDS Mitigation Indices

Maintenance and Management of System

5.28. The maintenance of all SuDS components will be in accord with the best practices and the CIRIA Manual C753. A private management company will be set up to maintain the surface water drainage network. The name of the Management Company is to be advised.

6. Foul Water Management

Existing Foul Water Drainage Strategy

6.1. The Site is currently occupied, almost in its entirety, by gas holders and associated amenity buildings. However, given the small size of these buildings it is estimated that the the existing peak foul water flow rate from the Site is 0.0 l/s.

Proposed Foul Water Drainage Strategy

6.2. The peak foul flow rate for the proposed development is estimated to be 17.97 l/s, based on a maximum of 392 residential units.

6.3. It is proposed to discharge the foul water into the existing Thames Water network within Yarnton Way although the invert level of these sewers is unknown. It is therefore conservatively proposed to allow for a foul water pumping station which will pump the water to a discharge chamber prior to a gravity outfall into the Thames Water network. The proposed pumping rate is subject to discussion with Thames Water and survey of the existing public network. A cordon sanitaire of 15m has been allowed for from the pumping station.

7. Conclusions

7.1. Ardent Consulting Engineers (hereafter referred to as Ardent) has been commissioned by Bellway Homes Ltd to prepare a Flood Risk Assessment and Drainage Strategy for the proposed residential development at Yarnton Way, Belvedere in the London Borough of Bexley (hereafter referred to as the "Site").

7.2. The scheme proposals comprise Redevelopment of the Site to provide residential units including affordable housing (Use Class C3) and commercial floorspace (Class E) in new buildings ranging between 3 to 5 storeys in height, together with associated car parking and cycle storage, landscaping including new areas of public open space and a reptile retention zone, associated infrastructure including new junctions off Yarnton Way, drainage and land raising.

7.3. The nearest main River is the River Thames located approximately 1.5km to the north and west of the Site. An unnamed tributary of this, also classed as a Main River, exists approximately 125m to the north-west of the Site. There are no other main rivers in the vicinity of the Site.

7.4. A number of ordinary watercourses exists through the centre of the Site; one flowing from west to east and one from north to south. A ditch also exists, just outside the eastern boundary of the Site.

7.5. The Site is located wholly in Fluvial/Tidal Flood Zone 3 associated with the River Thames. The Borough is currently protected from combined tidal and fluvial flooding by the River Thames Tidal Defences (TTD) up to the 0.1% annual probability (1 in 1000 year) event.

7.6. Whilst the Site is defended against flooding from the River Thames, there remains a residual risk of failure of these defences and therefore, it is essential that planning decisions are taken with due consideration to the scale (and variability) of this risk.

7.7. The water level for the 1 in 200 (0.5%) annual probability for the 2115 epoch is 2.49m AOD. The finished floor level for the proposed development sleeping accommodation will be set to 2.79m AOD which is above 2115 epoch 1 in 1000 (0.1%) with climate change event of 2.63m AOD.

7.8. The proposed surface water discharge rate will be restricted to the equivalent greenfield rate for the existing Site with a maximum rate of 3.7 l/s. The *Network* module of XP Solution's MicroDrainage was utilised to calculate the storage

requirements. These calculations were run for the 1 in 1 year, 1 in 30 year, 1 in 100 year and 1 in 100 year + 40% climate change events with the volume required equal 1675.8 m^3.

7.9. It is proposed that a lined permeable paving, shallow geo-cellular attenuation tank(s) and above ground pond features will provide sufficient storage volume for the 1 in 100-year storm event including a 40% allowance for climate change.

7.10. The proposals seek to create a new positive outfall into the existing watercourse running from west to east across the Site, within the open space where it is proposed to remain open, at a restricted rate of equivalent Greenfield rates through the use of a private pumping station. However, the proposals do necessitate the culverting of the existing watercourse which is subject to detailed design to ascertain the levels and proposed crossings.

7.11. In conclusion, this FRA demonstrates that the proposals are consistent with the aims of NPPF, PPG and Development Plan. The Site would not be at risk of flooding or increase the flood risk to others as a result of the proposed development.