DUNTON HILLS

BRENTWOOD

Representations to Brentwood Borough Council
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Flood Risk, Ground Conditions, Air Quality and Waste

March 2016

Dunton Hills
Brentwood

Flood Risk, Ground Conditions, Air Quality & Waste
Preliminary Appraisal

Brookbanks

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Appendix

1 Introduction

1.1 Brookbanks Consulting Limited (BCL) is appointed by CEG Land Promotions Ltd (CEG) to complete a Flood Risk, Ground Contamination and Air Quality Assessment for a proposed development of Dunton Hills, Brentwood.

1.2 The objective of the study is to demonstrate the development proposals are acceptable from an environmental perspective.

1.3 This report summarises the findings of the study and specifically addresses the following issues in the context of the current legislative regime:

- Flooding Risk (in respect of storm and foul water drainage)
- Ground Contamination (and general ground conditions)
- Air Quality

2 Background Information

Location & Details

2.1 The proposed development lies 10km southeast of Brentwood.

2.2 The site is largely undeveloped and the land is not thought to have been historically subject to any significant built development. The site location is shown indicatively on Figure 2a, below.

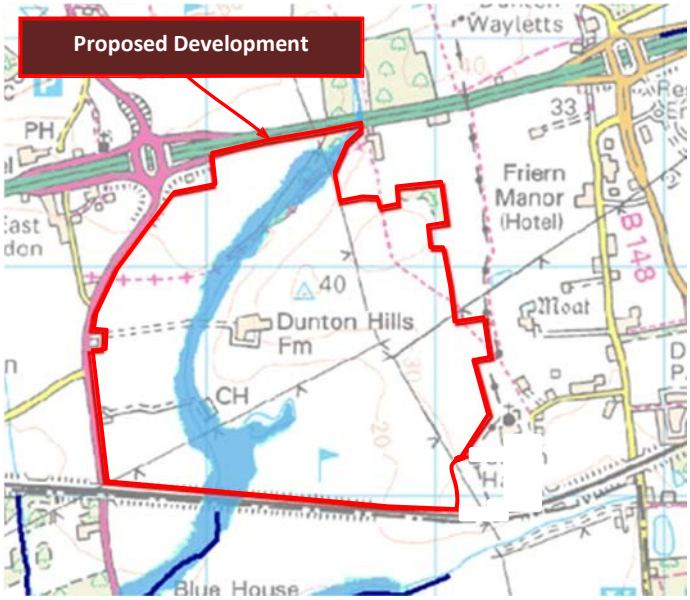

Figure 2a: Site location

Development Criteria

2.3 The site parameters are as follows:

- 2500 dwellings
- 1 FE nursery, primary and secondary school (on one site)
- 2 FE primary school (on its own site)
- 2 no Local Centres
- 5 ha of Employment Land
- Community Hall/Health facility

3 FLOOD RISK – BACKGROUND DATA

Sources of Information

3.1 The following bodies have been consulted while completing the study:

• Anglian Water	-	Storm & foul water drainage
• Environment Agency	-	Flood risk and storm drainage

3.2 The following additional information has been available while completing the study:

• Mastermap Data	-	Ordnance Survey
• Published Geology	-	British Geological Survey

Topography & Site Survey

3.3 No Topographic survey was available at the time of writing. Topography across the site is characterised by falls generally in a south-westerly direction.

Watercourse Systems & Drainage

3.4 Reference to the Flood Estimation Handbook CD dataset V3 shows the site to lie within the catchment of Eastlands Stream, flowing from north to south through the site. This links with Mar Dyke before flowing into the Thames just upstream of Purfleet.

3.5 With an URBEXT1990 value of 0.0136 the catchment can be described as “essentially rural”. The FEH catchment is shown in Figure 3a, below.

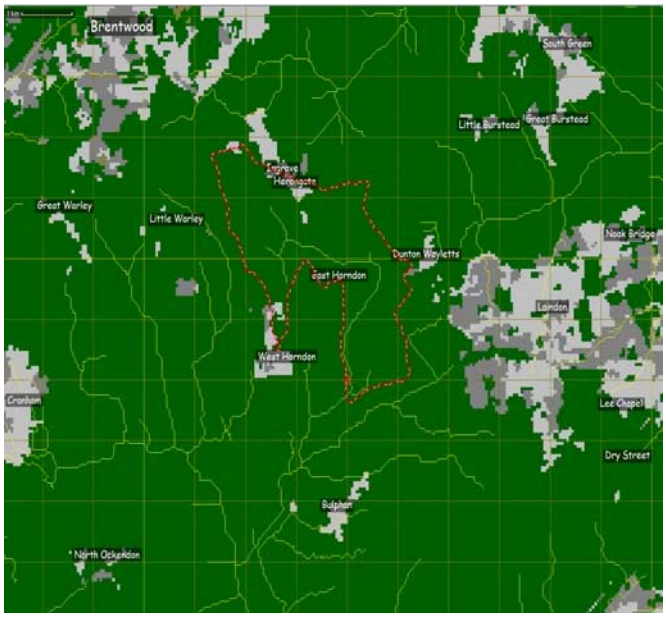

Figure 3a: FEH reported catchment.

National Planning Context

3.6 The National Planning Policy Framework (NPPF) was introduced in March 2012 and sets out Governmental Policy on Development and Flood Risk. The allocation of development sites and local planning authorities' development control decisions must be considered against a risk based search sequence, as provided by the document.

3.7 Allocation and planning of development must be considered against a risk based search sequence, as provided by the NPPF guidance. In terms of fluvial flooding, the guidance categorises flood zones in three principal levels of risk, as follows:

Flood Zone	Annual Probability of Flooding
Zone 1: Low probability	< 0.1 %
Zone 2: Medium probability	0.1 – 1.0 %
Zone 3a / 3b: High probability	> 1.0 %

Figure 3b: NPPF Flood Risk Parameters.

3.8 The guidance states that Planning Authorities should *"apply a sequential, risk-based approach to the location of development to avoid where possible flood risk to people and property and manage any residual risk, taking account of the impacts of climate change."*

3.9 According to the NPPF guidance, residential development at the proposed site, being designated as "More Vulnerable" classifications, should lie outside the envelope of the predicted 1 in 100 year (1%) flood, with preference given to sites lying outside the 1 in 1,000 (0.1%) year event and within Flood Zone 1.

3.10 Sites with the potential to flood during a 1 in 100 (1%) year flood event (Flood Zone 3a) are not normally considered appropriate for proposed residential development unless on application of the "Sequential Test", the site is demonstrated to be the most appropriate for development and satisfactory flood mitigation can be provided. Additionally, proposed residential developments within Flood Zone 3a are required to pass the "Exception Test", the test being that:

- The development is to provide wider sustainability benefits
- The development will be safe, not increase flood risk and where possible reduce flood risk

Local Policy Context

3.11 **Preliminary Flood Risk Assessment for Essex:** Essex County Council has prepared a Preliminary Flood Risk Assessment (PFRA), as required of all upper tier local authorities in England by the Flood Risk Regulations (2009). This is a county wide analysis which considers past and possible future flooding from local flood sources:

- surface water runoff
- groundwater
- ordinary watercourses
- flooding from canals and small impounded reservoirs

3.12 Flooding from Main Rivers is dealt with in the South Essex Catchment Flood Management Plan (CFMP).

3.13 **Development Flood Risk Assessment:** At a local, site by site, level the NPPF guidance and supporting documents advocate the preparation of a Flood Risk Assessment (FRA). NPPF requires that developments covering an area of greater than one hectare prepare an FRA in accordance with the guidance. The FRA is required to be proportionate to the risk and appropriate to the scale, nature and location of the development.

Flood Mechanisms

3.14 Having completed a site hydrological desk study and walk over inspection, the possible flooding mechanisms at the site are identified as follows:

Mechanisms	Potential?	Comment
Fluvial (Annex C: C4)	Y	The Eastlands Spring runs from north to south through the site.
Coastal & tidal (Annex C: C5)	N	No tidal watercourses lie within an influencing distance of the proposed development.
Overland flow (Annex C: C6)	N	The site slopes from east to west, and is generally considered not to be at risk form overland flow.
Groundwater (Annex C: C7)	N	Not known currently
Sewers (Annex C: C8)	N	Not known currently
Reservoirs, Canals etc (Annex C: C9)	Y	The lake within the Golf Course to the east of Eastlands Spring appears to be a reservoir, and thus may have an influence on the proposed development.

Figure 3c: Flooding mechanisms.

3.15 Where potential risks are identified in Figure 3b, above, more detailed assessments have been completed and are outlined below. Further background is also outlined below.

Fluvial Flooding: C4

3.16 The Environment Agency's (EA) National Generalised Modelling (NGM) Flood Zones Plan indicates predicted flood envelopes of Main Rivers across the UK. In many circumstances, the NGM is based on basic catchment characteristic data and modelling techniques.

3.17 The Flood Zone mapping identifies flooding along the reach through the site with flows out of bank during the 1 in 100 (1% AEP) and 1 in 1,000 year (0.1% AEP) events.

3.18 The mapping shows the proposed site to lie within Flood Zone 1, being an area of Low Probability of flooding, outside both the 1 in 100 (1% AEP) and 1 in 1,000 (0.1% AEP) year flood events. The EA Flood Zone plan is reprinted as Figure 3d below.

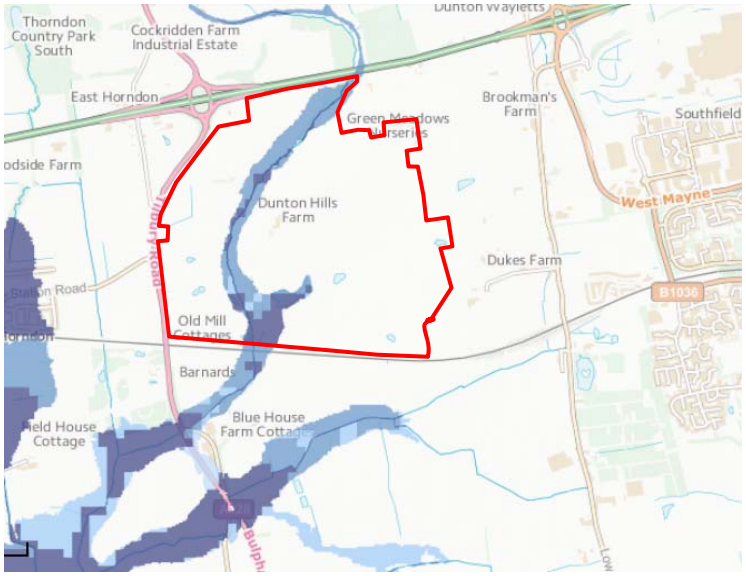

Figure 3d EA Flood Zone Plan showing 1 in 100 & 1 in 1,000 year floodplains.

Flooding from rivers without defences – 1 in 100 year (1%) event (Zone 3)

Extent of extreme flood – 1 in 1,000 year (0.1%) event (Zone 2)

Flood defences

Areas benefiting from flood defences

Coastal Flooding C5

3.19 The site lies a significant distance from the nearest tidal watercourse and the coast. As such there is no material risk of tidal or coastal flooding at this location.

Overland Flow: C6

3.20 No topographic survey currently available.

Groundwater: C7

3.21 Not known currently

Sewerage Systems: C8

3.22 Not known currently

Summary

3.23 In terms of fluvial and tidal flood risk, the site lies within Flood Zone 1 and hence has a low probability of flooding from this mechanism. All built development will lie in Flood Zone 1.

3.24 Assessment of other potential flooding mechanisms shows the land to have a low probability of flooding from overland flow, ground water and sewer flooding.

3.25 Accordingly, the proposed development land is in a preferable location for residential development when appraised in accordance with the NPPF Sequential Test and local policy.

Objectives

3.26 The key development objectives that are recommended in relation to flooding are:

- Compliance with SFA 7th Edition and EA guidance in relation to flood routing through the proposed development in the event of sewer blockages.

4 FLOOD RISK - Storm Drainage

Drainage Options

4.1 The following paragraphs in this section outline the proposed drainage strategy to meet national and local design requirements and guidance.

4.2 Current guidance[1] requires that new developments implement means of storm water control, known as SUDS (Sustainable Drainage Systems), to maintain flow rates discharged to the surface water receptor at the pre-development 'baseline conditions' and improve the quality of water discharged from the land.

4.3 It is proposed to implement a SUDS scheme consistent with local and national policy at the proposed development. All sites require the following:

- SuDS
- Greenfield discharge rates
- 1 in 100 year on-site attenuation taking into account climate change

4.4 Space should be specifically set aside for SuDS and used to inform the overall site layout.

4.5 When appraising suitable storm water discharge options for a development site, Part H of the Building Regulations 2002 (and associated guidance) provides the following search sequence for identification of the most appropriate drainage methodology.

"Rainwater from a system provided pursuant to sub-paragraphs (1) or (2) shall discharge to one of the following, listed in order of priority -

(a) an adequate soakaway or some other adequate infiltration system; or where that is not reasonably practicable,

(b) a watercourse; or where that is not reasonably practicable,

(c) a sewer. "

4.6 Dealing with the search order in sequence:

(a) Source control systems treat water close to the point of collection, in features such as soakaways, porous pavements, infiltration trenches and basins. These allow discharging surface water back to ground rather than just temporarily attenuating peak flows before discharging it to a receiving watercourse or sewer.

As source control measures generally rely upon the infiltration of surface water to ground, it is a prerequisite that the ground conditions are appropriate. Site specific investigations should be completed to confirm whether the underlying geology is sufficiently impermeable that infiltration can be adopted as a drainage strategy. Preliminary investigations suggest that the superficial geology is largely London Clay, so it is assumed that infiltration will not be viable for much of the site.

(b) Next in the search sequence, defined by Part H, is discharge to a watercourse or suitable receiving water body. Where coupled with appropriate upstream attenuation measures, this means of discharge can provide a sustainable drainage scheme that ensures that peak discharges and flood risk in the receiving water body are not increased.

Eastland Spring, which flows from north to south through the site, could provide an appropriate receptor for surface water subject to land being available to make a direct and suitable connection. Furthermore, in order to discharge flows to this watercourse the development will be required to reduce the site run-off to the pre-existing 'greenfield' rate of run-off.

(c) Last in the search sequence is discharge to a sewer. In the context of SUDS this is the least preferable scheme as it relies on 'engineered' methods to convey large volumes of water from development areas, has a higher likelihood of flooding due to blockage and provides less intrinsic treatment to the water.

As yet no information is available on the presence or otherwise of public sewers in the area surrounding the site.

4.7 The search sequence outlined above indicates that a number of potential options are available for the site in order to discharge surface water run-off from the proposed development. The site also has the potential to employ source control measures and on-line SuDS to control peak discharges to no greater than the baseline conditions.

4.8 Proposals have been developed to inform the strategic drainage network across the development. It is proposed that the drainage system for the site utilise a SuDS system as the primary storm water management scheme.

4.9 A SUDS drainage strategy plan will be prepared at the preliminary masterplanning stage.

4.10 Coupled with the storm water control benefits, the use of SUDS can also provide an improvement to water quality. National guidance in the form of CIRIA 609 outlines that by implementing SUDS, storm water from the site can be polished to an improved standard thus ensuring the development proposals have no adverse effects on the wider hydrology.

4.11 The following paragraphs outline the potential SUDS features appropriate for use on-site.

Primary Drainage Systems (source control)

4.12 At the head of the drainage network, across the site, source control measures could be implemented to reduce the amount of run-off being conveyed directly to piped drainage systems.

4.13 The common aims of a Primary Drainage System are:

- Reduction in peak discharges to the agreed site wide run-off rate from the development areas.
- Provide water quality treatment where appropriate

4.14 Generally, source control measures to be implemented will need to remain flexible, providing each house builder with a 'toolkit' of options to reach an agreed target for peak discharge reduction and water treatment. The following paragraphs describe a number of options available.

Permeable Paving

4.15 Permeable Paving can act as a receptor for surface water run-off from nearby commercial buildings and house roofs. However, the system is perhaps best suited to manage parking areas and shared surfaces where block paving is typically used as the surface treatment and ongoing maintenance can be ensured by way of a management company or the like.

4.16 There is little need for underground pipes or gullies, and the attenuation afforded within the sub-base layer helps to reduce the volume of storage required elsewhere.

Figure 4a: Permeable paving.

Filter Strips

4.17 Filter strips have been used in the drainage of highways alike for many years. The absence of traditional pipe work in such a system frees the drainage design to employ shallow gradients on both channels and drains, which in turn also act as a means of passive treatment to improve water quality.

4.18 Highways within the development could potentially be amended to incorporate filter drains. Alternatively, filter strips can be used to collect flows from areas such a group of house. Figure 4b below shows an example of a filter strip in a road corridor.

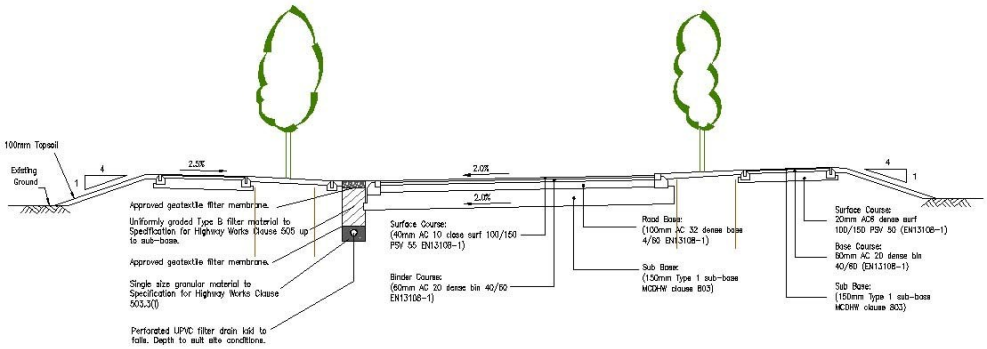

Figure 4b: Filter Strip along highway.

Ditches

4.19 Ditches may be used along highways and in common areas to infiltrate, attenuate and convey flows from hard surfaces across the development before being discharged in to the secondary system. Linear features, such as ditches and filter strips provide an efficient means of improving water quality.

Attenuation Drainage Systems

4.20 Attenuation drainage systems collect partially treated, excess, water from the primary, source control systems at a local level, thereafter providing both flow and water quality attenuation and flow conveyance through the site towards the main outfall.

4.21 It is anticipated that a basin will be utilised and designed to primarily be normally dry with permanently wet low flow channels to convey run-off in periods of low rainfall, which will in turn provide the passive treatment benefits offered within the remainder of the surface water management network.

4.22 The primary aims of the basin will therefore be:

- Final flow and water quality conditioning
- Provide landscaping, amenity and ecological benefits

Figure 4c: Storage Basin

Drainage Design Criteria

4.23 Preliminary assessment of the requirements for storm drainage has been based on the following criteria:

Application Site Area:	230 ha
Residential Area:	180 ha
Impermeability - Residential:	0.55
Sewer design return period	1 in 1 years
Sewer flood protection	1 in 30 years
Fluvial / Development flood protection	1 in 100 years
M5-60$^{(2)}$	21.0 mm
Ratio r$^{(2)}$	0.43
Minimum cover to sewers	1.2 m
Minimum velocity	1.0 m/sec
Pipe ks value	0.6 mm

Allowance for climate change 30%

4.24 National policy dictates that new developments control the peak discharge of storm water from a site to the baseline, undeveloped, site conditions. Over very large development areas, the baseline rate of run-off is normally estimated using the FEH methodologies. However, Paragraph 3.1.2 of the FEH guidance states:

"The frequency estimation procedures can be used on any catchment, gauged or ungauged, that drains an area of at least 0.5km^2. The flood estimation procedures can be applied on smaller catchments only where the catchment is gauged and offers simple flood peak or flood event data"

4.25 On undeveloped and ungauged catchments of less than 0.5km^2 in area, it is correct to complete baseline site discharge assessments using the nationally accepted IoH124 methodology for small rural catchments. Local policy is to employ IoH124 in a manner set out by CIRIA C697. This methodology requires that, for catchments of less than 50ha, the IoH assessment is completed for a 50ha area with the results linearly interpolated to determine the flow rate value based on the ratio of the development to 50ha.

4.26 The individual catchment boundaries are to be designed to fall below the 50ha threshold, thus the IoH124 methodology is therefore the most appropriate for appraising the baseline run-off from the development.

4.27 The baseline IoH run-off rates are shown on Figure 4d below.

Event	IoH 124 (180ha)	IoH 124 Scaled to 1ha
1 in 1 year (l/s)	488	2.7
Qbar (l/s)	574	3.2
1 in 100 year (l/s)	1829	10.2

Figure 4d: IoH124 baseline discharge rates.

4.28 In order to determine the permitted rates of run-off from the development, the future impermeable catchment areas must be derived. This has been based on a BCL measured ratio from previous projects. Calculations below show these ratios and areas and how these correlate to the rates of discharge.

4.29 In accordance with the SFRA document and NPPF guidance, it is proposed to implement a drainage strategy that provides attenuation of peak storm water discharges from the developed land to the baseline rate determined using IoH124 methodology.

4.30 In order to mitigate for the increased volume of run-off associated with built development, peak flows in the 1 in 100 year event must be attenuated to the mean annual flow (Qbar):

Catchment	Land Use	Developable Area (ha)	Impermeable Area (ha)	Existing 100 Year Run-off (l/s)	Proposed 100 Year Run-off (l/s)	Improvement [%]
A	Residential	180	99	1829	315	83%

Figure 4e: Run-off calculation.

4.31 Using these methods, development at the site will comply with the requirements set out in paragraph 9 of the Technical Guide to the National Planning Policy Framework (NPPF), with the discharge of surface water from the proposed developments not exceeding that of the existing greenfield sites, thus ensuring that there is no material increase in the flood risk to surrounding areas.

4.32 Assessments have thereafter been completed to determine the characteristics of proposed SuDS features to be situated within the development. Best practice methods have been employed by performing detention routing calculations for both the 1 in 1 and 1 in 100 year inlet and outlet return periods using the WinDES Source Control module. Employing the lower and upper end return periods with common characteristics provides for detention that will ensure peak outflows are within the baseline return discharges for the full range of storm events. The summary calculations are contained in the Appendix.

Catchment A

4.33 Calculations demonstrate that storm water detention storage extending to maximum 64,400m^3 will be required to attenuate storm water discharges from the site during the critical 1 in 100 year event storm. This will limit the peak discharges to 315l/s, being equivalent to the mean annual storm (Qbar), estimated by the IoH124 calculations above, representing an 85% reduction on peak greenfield rates. Figure 4f, below summarises the overall detention requirements. The summary calculations are contained within the Appendix.

Catchment Area (ha)	Impermeable Area (ha)	1 in 100 Year Run-off (l/s)	Detention Volume for 1 in 100 Year Event (m^3)	SUDS Type
180	99	315	64,400	Detention Basin

Figure 4f: Summary run-off & detention assessment output.

4.34 A side overflow weir will be provided on the detention feature, at a level above the 1 in 100 year + 30% flood level to allow more extreme event flows to safely be conveyed away from properties, while at the same time not increasing flood risk to surrounding areas, in line with current good practice recommendations. The detailed design stage will provide further detail into the positioning of overflows and direction of flow.

4.35 A conceptual layout for the drainage system has been developed to accord with the design requirements. While this Assessment informs the general principles of the proposed drainage system, at detailed design stage, each device will be individually designed for the site characteristics developed for this application.

4.36 Furthermore, based on FRA work undertaken to support previous applications, it is recognised and accepted that in addition to the developments strategic attenuation basins, the implementation of source control measures can achieve a minimum 15% betterment in peak run-off from each development parcel, thus should this be a viable option, a further betterment may be achieved.

Water Quality

4.37 Impermeable surfaces collect pollutants from a wide variety of sources including cleaning activities, wear from car tyres, vehicle oil and exhaust leaks and general atmospheric deposition (source: CIRIA C609). The implementation of SUDS in development drainage provides a significant benefit in removal of pollutant from development run-off.

4.38 In most cases, contaminants become attached to sediment particles either before entering the water body or upon entry. CIRIA 609 reports that up to 90% of certain contaminants, usually trace elements, are transported in this way leaving a dissolved concentration of circa 10%.

4.39 Many SUDS systems rely on the infiltration of water through the ground layer into permeable sub soils or through sedimentation in low flow storage basins. This settling and filtering of contaminated run off through a fine grained matrix separates the suspended contaminated sediment from the body of water subsequently causing the water to leave the SuDS device in a more polished form than how it entered; porous paving is a prime example of this.

4.40 Furthermore, by implementation of SUDS features it is possible to optimize overall pollutant removal as water will undergo this process of filtering before being discharged to an appropriate receptor. The overall percentage of removal can be calculated individually for each differing SuDS technique, this is shown by the formula below:

Overall pollutant removal = (TPLxC1) + (RPLxC2) + (RPLxC3) +.....for each other control in series

Where: TPL – Total Pollutant Load
RPL – Remaining Pollutant Load (after previous treatment(s))
C(x) – Suds Control removal efficiency

Figure 4g: Pollutant removal formula as set out in CIRIA C609.

4.41 At present, the site and surrounding area does not benefit from any additional measures of stormwater treatment.

4.42 Due to the need to provide wider sustainability benefits and view the development at a strategic level, SUDS will be implemented to passively treat run off from the development so as to have a positive impact on the surrounding natural environment.

4.43 The site will employ one SUDS feature, porous paving (where applicable) and detention basins as these are widely accepted to be of high pollutant removal efficiency (CIRIA 609). This provides for two stages of treatment onsite.

4.44 As the site is not presently served by any means of storm water treatment mechanisms, by providing SUDS within the proposed development it will be possible to maintain present water quality in the area and thus the development can be seen to be having no significant environmental impact in relation to water.

Implementation Proposals

4.45 The conceptual drainage proposals have been developed in a manner that will allow the site wide system to be designed to encourage passive treatment of discharged flows and to improve the water quality by removing the low level silts, oils and metal associated with urban run-off. Final design will provide for appropriate geometry and planting to maximise this benefit. The detention features will provide open channel outfalls to the ordinary watercourse receptors.

4.46 The storm water management features will be constructed and operational for each phase of this build programme in full prior to the first occupation of each phase of new houses across the site.

4.47 The storm water management features to be implemented will be designed to enhance the biodiversity and landscape character of the site, while also providing amenity space and acting as a functional feature to control storm discharges from the site and improve water quality.

4.48 An illustrative maintenance regime would include:

Frequency	Operation
Post major storm events	Inspection and removal of debris.
Every two months	Grass mowing (growing season) & litter removal.
Annual	Weeding & vegetation maintenance. Minor swale clearance. Sweeping of permeable pavements.
2 years	Tree pruning.
5-10 years	Desilting of channels. Remove silt around inlet and outlet structures.
15-20 years	Major vegetation maintenance and watercourse channel works.

Figure 4h: Framework maintenance of detention / retention system.

4.49 The Floods and Water Management Act gained royal assent in April 2010. This confers the responsibility to adopt and maintain the SuDS systems to the Local Authority by requiring SUDS Approving Bodies (SAB's) to be set up within each council.

Summary

4.50 A strategy for storm drainage at the site has been developed to meet both national and local policy. The above options outline the viability of the site to employ means of drainage to comply with NPPF guidance, together with the SFRA and other national and local guidance.

4.51 The development drainage system will manage storm water by way of a SUDS management train and ensure peak discharges from the developed land are reduced to 85% below the appraised baseline rates. The system will also provide improvements to the quality of water discharged from the development.

Objectives

4.52 The key objectives for the site drainage will be:

- Implementation of a sustainable drainage scheme in accordance with current national and local policy together with principals of good practice design.
- Control of peak discharges from the site to below the baseline conditions.
- Development of storm water management proposals that improve water quality and biodiversity of the site.
- Implementation of the storm water management system prior to first occupation of dwellings.

5 FLOOD RISK - Foul Drainage

Background

5.1 A copy of the Anglian Water sewerage network records will be obtained to confirm the presence of foul sewers in the area of the proposed site.

Design Criteria / Network Requirements

5.2 Peak design discharges have been calculated based on the current development criteria as described in Section 2 of this report and for the following:

Domestic peak = 4,000 litres / dwelling / day (peak)[3]

5.3 Assessed in accordance with SFA 7th Edition requirements, the development will have a design peak discharge of approximately 162l/s.

Network Requirements / Options

5.4 Anglian Water have confirmed that the development foul water flows can be pumped from the site to discharge via new rising mains directly into the nearby Upminster Water Recycling Centre, where spare capacity is available.

Treatment Requirements

5.5 Water companies have a statutory obligation through the Water Industry Act 1991, 2003, to provide capital investment in strategic treatment infrastructure to meet development growth. This investment planning is managed and regulated by OFWAT through the Asset Management Plan (AMP) process. The five yearly cyclical process requires that water companies allocate finances to a range of strategic projects to meet their statutory obligations.

5.6 Where development programming requirements necessitate the reinforcement of facilities ahead of allocation in an AMP period, mechanisms are available to ensure the infrastructure can be delivered in a timely fashion, to the meet the development programme.

Implementation Proposals

5.7 The proposed drainage network across the site will be designed to current Sewers for Adoption 6th Edition Standards, employing a point of connection agreed with South West Water. The system will be offered for the adoption of Anglian Water under S104 of the Water Industry Act 1991.

Summary

5.8 A site drainage strategy has been developed that meets with current regulatory requirements by discharging drainage to a sewerage network with capacity to accommodate the flows.

5.9 Once development is complete, the network conveying flows from the site will be adopted by Anglian Water and be maintained as part of their statutory duties.

Objectives

5.10 The key development objectives required for the site drainage scheme are:

- Implementation of a drainage scheme to convey water to the local Anglian Water network which is designed and maintained to an appropriate standard.

6 GROUND CONDITONS

Introduction

6.1 The contents of this note will form the basis of a Phase 1 Geo-Environmental Desk Study as part of any future planning application.

6.2 The studies on ground conditions to date confirm that there are no adverse risks present within the site extents which would compromise a satisfactory delivery of development.

Historical Site Uses

6.3 In appraising the site history, published Ordnance Survey maps have been reviewed dating from the late 19th Century up to the present day and is summarised below:

- **1872-1881:** (On-site) Agricultural fields surrounding Dunton Hills farm. **East Horndon Mills** adjacent to south-west of Boundary later shown as Oldmill Cottages (1921). Surrounding rural area comprises agricultural fields and woodland.

- **1898:** London, Tilbury & Southend Section of the **Railway Line** constructed adjacent to southern boundary.

- **1947:** A127 road constructed adjacent to northern boundary, with further widening shown in the 1970s. Residential development shown in the surrounding areas, between 500-1km of the site boundary and this is shown to have expanded considerably over the years.

- **1972-77:** (On-site) **Works & tanks** shown in the south-west of the site. an **electrical substation** 350m south-east of boundary. These are no longer shown on the map in 2006.

- **1980-83:** Automobile Research Centre tracks 1km north-east.

- **2006:** **Overhead electricity line** runs across the site from the south-west to the north-west and the north-east to the south-east. Cockridden Industrial Estate 800m north-west.

6.4 Having reviewed the historical site mapping the following potentially contaminative land uses are identified within the site boundary: agricultural, former works with tanks shown in the south-west of the site.

6.5 The surrounding area includes the following potentially contaminative land uses: agricultural, the adjacent A127 road to the north, adjacent railway line to the south and an electrical substation 350m to the south-east.

6.6 Further assessment of the site's soils may be required at the detailed design stage to establish baseline site conditions.

Geology

6.7 With reference to the British Geological Survey map, the site is shown to be underlain by bedrock comprising clay, silt and sand belonging to the London Clay Formation. Superficial deposits identified on site include alluvium along Mar Dyke watercourse and head deposits, both of which comprise clay, silt, sand and gravel.

Figure 6a BGS Published Geology

Radon

6.8 The site is situated within a low probability area affected by radon, where less than 1% of homes are estimated to be above the action level. It is reported that no radon protection measures are necessary for the construction of new developments within the site.

Waste

6.9 There are no records of the following within 1,000m of the site boundary:

- BGS Recorded Landfill Sites
- Historical Landfill Sites

- Integrated Pollution Control Registered Waste Sites
- Licensed Waste Management Facilities (Landfill Boundaries)
- Licensed Waste Management Facilities (Locations)
- Local Authority Recorded Landfill Sites
- Registered Landfill Sites
- Registered Waste Transfer Sites
- Registered Waste Treatment or Disposal Sites.

Hazardous Substances

6.10 There are no records of the following on or within a 1,000m radius of the site boundary:

- Control of Major Accident Hazards Substances (COMAH)
- Explosive Sites
- Notification of Installations Handling Hazardous Substances (NIHHS)
- Planning Hazardous Substance Consents
- Planning Hazardous Substance Enforcements.

Industrial Land Uses

6.11 There are forty seven Contemporary Trade Directory entries recorded within 1km of the site boundary.

6.12 There is one 'open' Fuel Station recorded approximately 973m east of the site boundary and one obsolete station recorded approximately 417m to the east.

Sensitive Land Uses

6.13 The site is identified to lie within an area designated by DEFRA as a Surface Water Nitrate Vulnerable Zone.

6.14 The Site is situated within Areas of Adopted Green Belt, as adopted by Brentwood Borough Council on 25th August 2005 and outlined in their Replacement Local Plan.

6.15 Thorndon Country Park, an area of semi-natural woodland and ancient parkland, is situated approximately 791m north-west of the site boundary. The Country Park was designated as a Site of Special Scientific Interest in September 1986 by Natural England.

6.16 None of the following are reported within 1,000m of the site boundary:

- Areas of Unadopted Green Belt
- Areas of Outstanding Natural Beauty
- Environmentally Sensitive Areas
- Forest Parks
- Local Nature Reserves
- Marine Nature Reserves
- National Nature Reserves
- National Parks
- Nitrate Sensitive Areas
- Ramsar Sites
- Special Areas of Conservation

- Special Protection Areas

Conclusion

6.17 The information gathered to date in respect of ground conditions confirm that a development can be brought forward without adverse risk or the need for significant mitigation.

7 AIR QUALITY

Local Air Quality Management

7.1 Part IV of the Environment Act 1995 also requires local authorities to periodically Review and assess the quality of air within their administrative area. The Reviews have to consider the present and future air quality and whether any air quality objectives prescribed in Regulations are being achieved or are likely to be achieved in the future.

7.2 Where any of the prescribed air quality objectives are not likely to be achieved the authority concerned must designate that part an Air Quality Management Area (AQMA).

7.3 For each AQMA, the local authority has a duty to draw up an Air Quality Action Plan (AQAP) setting out the measures the authority intends to introduce to deliver improvements in local air quality in pursuit of the air quality objectives. Local authorities are not statutorily obliged to meet the objectives, but they must show that they are working towards them.

7.4 The Sustainability Appraisal of the Brentwood Local Plan states that air quality in Brentwood is generally good; with the number of designated AQMA's soon to be reduced from seven to three.

7.5 Two of the AQMAs that will remain are along the A12 (one at the M25 junction and the other at North Brentwood/Pilgrims Hatch), and the third is within Brentwood town centre at the A128/A1023 junction.

7.6 The Sustainability Appraisal concludes that there are no significant effects predicted in the delivery of the local plan with respect to Air Quality.

Methodology

7.7 The AQ assessment for Dunton Hills has not yet commenced. However, the following method of assessment will be carried out to demonstrate the viable delivery of the development.

7.8 The scope of the assessment has been determined in the following way:

- Review of air quality data for the area surrounding the site and background pollutant maps; and
- Review of the traffic flow data, which has been used as an input to the air quality modelling assessment.

7.9 There is the potential for impacts on local air quality during both the construction and operational phases of the proposed development.

Construction Dust

7.10 To assess the potential impacts associated with dust and PM_{10} releases during the construction phase and to determine any necessary mitigation measures, an assessment based on the latest guidance from the Institute of Air Quality Management[4] will be undertaken.

7.11 This approach divides construction activities into the following dust emission sources:

[4] Guidance on the assessment of dust from demolition and construction, IAQM, February 2014

- demolition;
- earthworks;
- construction; and
- trackout.

7.12 The risk of dust effects (low, medium or high) is determined by the scale (magnitude) and nature of the works and the proximity of sensitive human and ecological receptors.

7.13 The IAQM guidance recommends that an assessment be undertaken where there are sensitive human receptors:

- within 350 m of the Site boundary; or
- within 50 m of the route(s) used by construction vehicles on the public highway, up to 500 m from the Site entrance(s).

7.14 An assessment should also be carried out where there are dust-sensitive ecological receptors:

- within 50 m of the Site boundary; or
- within 50 m of the route(s) used by construction vehicles on the public highway, up to 500 m from the Site entrance(s).

7.15 The significance of the dust effects is based on professional judgement, taking into account the sensitivity of receptors and existing air quality.

7.16 The magnitude of the dust impacts for each source is classified as Small, Medium or Large depending on the scale of the proposed works.

Construction Traffic

7.17 Construction traffic will contribute to existing traffic levels on the surrounding road network. The greatest potential for effects on air quality from traffic associated with this phase of the Proposed Development will be in the areas immediately adjacent to the principal means of access for construction traffic.

7.18 Based on the size of the development it is anticipated that there would be less than 50 heavy duty vehicles (HDV) generate per day during the construction phase.

7.19 The recently published Environmental Protection UK (EPUK) and Institute of Air Quality Management (IAQM) air quality guidance[5] sets out criteria to assist in establishing when an air quality assessment will be required. These criteria indicate that significant impacts on air quality are unlikely to occur where a development results in less than 100 additional vehicle per day in locations outside an AQMA.

Operational Traffic

7.20 The prediction of local air quality will be undertaken using the ADMS Roads dispersion model. This is a commercially available dispersion model and has been widely validated for this type of assessment and used extensively in the Air Quality Review and Assessment process.

7.21 The model uses detailed information regarding traffic flows on the local road network and local meteorological conditions to predict pollution concentrations at specific locations selected by the user. Meteorological data from the Heathrow Airport Meteorological Station has been used for the assessment.

[5] EPUK & IAQM (May 2015) Land-Use Planning & Development Control: Planning for Air Quality

7.22 The model will be used to predict road specific concentrations of oxides of nitrogen (NO_x) and PM_{10} at selected receptors. The predicted concentrations of NO_x will be converted to NO_2 using the LAQM calculator available on the DEFRA air quality website[6].

7.23 Based on the assessments completed to date there is not expected to be any adverse impact on Air Quality.

8 WASTE

Introduction

8.1 The objective of the strategy is to demonstrate that appropriate waste management measures will be implemented at the site and more specifically to consider the following mechanisms during the site reclamation, construction and operation phases:

- Nature of waste typically generated
- Actions to reduce, re-use and recycle waste

8.2 A site waste management plan will be prepared in due course for the development which will follow the broad principles set out in this strategy.

Policy Background

8.3 Around 30 million tonnes of household waste is produced in the United Kingdom each year, and local authority expenditure on waste management in England and Wales in recent years is about £1.4 billion. The Environmental Agency calculated the amount of commercial and industrial waste to be nearly 75 million tonnes.

8.4 The UK's Waste Strategy sets out plans to tackle the growth in waste, in part by increasing the value of returns from recycling, composting and energy recovery. It has also set targets for better waste management.

8.5 At present, Brentwood Borough Council is responsible for refuse collection and disposal of household waste. The Council also has responsibility for the collection of waste at the Household Waste Recycling Centres.

8.6 The Government has set challenging statutory recycling performance targets for all local authorities to contribute to achieving better waste management. Local authorities are making significant strides towards meeting the statutory standards. The standards form part of the Best Value Framework which requires local authorities to set challenging targets to improve their waste management services.

8.7 In 2002 the Government's Strategy Unit also published "Waste Not, Want Not", a strategy for tackling waste in England. The volume of waste is growing and in particular, household waste is rising by 3% per year. The overall aim of the policy is to try and ensure that by 2020 England has a waste management system that allows the nation to prosper whilst reducing harm to the environment and preserving resources for future generations

8.8 In 2002 the Government's Strategy Unit also published "Waste Not, Want Not", a strategy for tackling waste in England. The volume of waste is growing and in particular, household waste is rising by 3% per year. The overall aim of the policy is to try and ensure that by 2020 England has a waste management system that allows the nation to prosper whilst reducing harm to the environment and preserving resources for future generations.

8.9 To achieve the Government's principal goals for reducing waste in the UK, the Landfill Directive (1999/31/EC) was formally brought into force in the UK on 15th June 2002 as the Landfill (England & Wales) Regulations, 2002. This has now been implemented in the UK (from 16th July 2004) and reclassifies landfill sites into inert, hazardous and non-hazardous. The Landfill Directive's principal focus is as follows:

- The historic practice of co-disposal of hazardous wastes with municipal wastes will cease and all hazardous waste will go to designated hazardous waste landfill.
- Co-disposal of non-hazardous wastes with municipal solid waste (MSW) will still be permitted.
- Prohibition of several waste types, e.g. liquid waste, will impact on disposal options available.
- The biodegradable content of new landfills will need to be drastically reduced in accordance with the Directive and the National Waste Strategy targets. This will require major changes in the minimisation, segregation, and treatment / collection of the biodegradable content of current domestic and commercial wastes.

8.10 In addition to the statutory targets and guidance outlined above, the Household Waste Recycling Act 2003 requires all Local Authorities in England to provide doorstep recycling services for at least two recyclable materials by 2010. The aim of the Household Waste Recycling Act is to increase the household waste recycling rate in England, which in 2003 stood at less than 15%. This will be of particular importance with regard to the provision of kerbside collection services by Brentwood Borough Council, which currently provide recycling facilities for paper, food and garden waste, cardboard, textiles, glass, plastics, cans, tins and textiles.

8.11 Other measures by the Government to promote waste minimisation include the landfill tax escalator, packaging regulations, waste awareness campaigns, and producer responsibility, through EU Directives and through voluntary initiatives.

8.12 The DEFRA Waste Strategy 2007 presents the Government's vision for managing waste and resources in both England and Wales in a more sustainable manner. It provides a strategic overview of waste policy and sets challenging targets at a national level for the reduction of household, industrial and commercial waste streams, including the following:

- To recycle or compost at least 40% of household waste by 2010, 45% by 2015 and 50% by 2020
- To reduce biodegradable municipal waste landfilled to 53%, 67% and 75% by 2010, 2015 and 2020, respectively.
- To reduce the amount of industrial and commercial waste going to landfill to 80% of 2004 levels by 2010

8.13 The Site Waste Management Plan Regulations 2008 came into force on 6th April 2008. The Regulations place initial responsibility for the production of a Waste Management Plan with the client organisation, which must be in place prior to implementation. The document must:

- Describe each waste expected to be produced
- Estimate the quantity of each type of waste

- Identify the waste management action for each type of waste including reusing, recycling, recovery or disposal

8.14 During construction, the obligation of management, maintenance and monitoring of the plan pass to the principal contractor.

8.15 National planning policy is now set out in a single overarching National Planning Policy Framework (NPPF) which was published in March 2012.

8.16 The NPPF does not contain specific waste policies but outlines that national waste planning policy will be published as part of the National Waste Management Plan for England. This document is currently out for consultation.

8.17 Therefore, until the National Waste Management Plan is published, Planning Policy Statement 10 (Sustainable Waste Management) remains in place, and therefore the preparation of this Waste Assessment will continue to be informed by, and in conformity with, the guidance and policies outlined within PPS10.

8.18 The introduction of Planning Policy Statement 10 (PPS10): Planning for Sustainable Waste Management, provides clarity on what is required at regional and local levels to ensure that decisions are made at the most appropriate level and in a timely fashion that delivers sufficient opportunities for sustainable waste management. A key objective of PPS10 is progressing waste management 'up the waste hierarchy' in order to reduce the environmental impact of waste. Communities are urged to take responsibility for dealing with their own waste. This 'self-sufficiency' principle is reflected in the new PPS10 through the way regional planning bodies and local authorities are expected to plan for the management of the waste generated by their communities and in accordance with the proximity principle waste will need to be disposed of as near as possible to its place of production.

8.19 This Waste Assessment sets out the principles that will be used during the reclamation, construction and operational phases of the development and so inform the subsequent documentation.

9 WASTE - Site Enabling Phase

Background

9.1 Demolition materials are reported to total approximately 26 million tonnes annually. Typically, demolition waste has a composition as shown on Figure 9a, below.

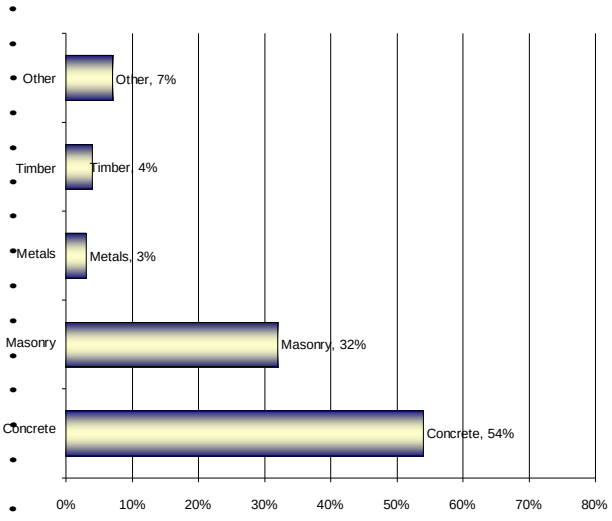

Figure 3a: Typical demolition arisings based on previous site experience

9.2 Given appropriate demolition methodologies and site management, it is typically possible to reuse a large proportion of demolition arisings in the redevelopment proposals.

Implementation Works

9.3 The site is thought to be historically undeveloped. Enabling works will primarily consist of the provision of safe access to site and preparatory earthworks to remove topsoil and provide site levels that are ready for development.

9.4 The following paragraphs outline the processes that will be involved with the site enabling phase:

- **Earthworks**: Site earthworks will involve the removal of topsoil, cutting and filling of sub-soils and the placement of capping material to provide a formation for construction operations.
- Vegetation will be cut out and then shredded and chipped before either being re-used on-site or being taken off site for composting or reuse as mulch.
- Topsoil will be stripped and stored discretely within site stockpiles for reuse in the completed development. It is anticipated that 100% of the topsoil will be reused in garden areas and site structural landscaping.
- Sub-soils will be cut and filled in a controlled manner to avoid contamination or water logging which may render the material unsuitable for reuse. It is anticipated that 100% of the uncontaminated sub-soil material may be reused within the development area.
- Any locally contaminated or unsuitable materials identified during the site investigations will be treated on site where possible to make the material suitable for re-use, or to reduce the volume that is removed from the site. However, all material across the site with the potential to result in harm to flora or fauna will be removed to a suitably licensed reception site.
- **Site Access**: Construction of the main site access and provision of security will principally involve construction of the new highway access and haul roads together with the provision of any necessary security fencing and site welfare facilities.
- Where possible, the permanent works will be incorporated into the enabling works to avoid the need to remove and dispose of works at the end of construction. Where this is not possible, elements such as haul routes will be built using recycled stone with the material subsequently retained and reused on site in permanent works.

9.5 It is anticipated that little disposal of material will result from the enabling phase works. Disposal of material is likely to be limited to either geotechnically unacceptable material or topsoil. Where possible, such materials will be incorporated into the scheme, such as in structural landscaping. However, where it is necessary to remove from site, the materials will be reused on a suitable nearby reception site rather than simply being taken to landfill.

9.6 Prior to starting on site, a Waste Management Plan will be put into place and updated / monitored throughout the construction process to assist in achieving the waste targets.

Summary

9.7 Waste management proposals are to be implemented during the site enabling phase that will reduce waste across the waste hierarchy and result in a significant reuse of materials within the site.

10 WASTE - Construction Phase

Background

10.1 Construction, demolition and refurbishment waste is reported to generate around 100 million tonnes of waste annually. Recent benchmarking activities7 across 23 reference sites suggests typical housing construction related waste streams to be as shown on Figure 10a, below.

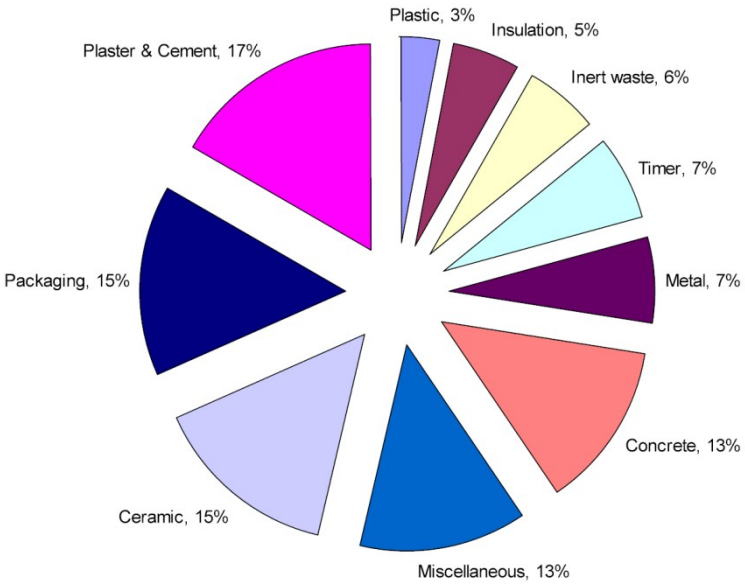

Figure 10a: Typical housing construction waste streams

10.2 The same benchmarking exercise published housing construction Environmental Performance Indicator figures for the volume of waste produced for a given 100m2 of floor area built. The EPI for housing being 19.2m3/100m2. This is reported to equate to 9.6 tonnes over a typical 80m2 housing unit.

Implementation Works

10.3 Measures to reduce waste are considered throughout the project lifecycle with emphasis on developing waste minimisation techniques that focus at the top end of the waste hierarchy, being waste elimination and reduction. Thereafter, measures to re-use and recycle are considered where elimination and reduction is not possible.

10.4 There are industry good practice guidelines and processes in the form of the Considerate Contractors Scheme. Additionally, various design and site based good practice measures that are routinely implemented, including:

Avoidance:	Good site quality control
	Careful storage of materials to avoid weather damage.
	Extensive off-site prefabrication thereby avoiding waste through more efficient production. Procurement of materials from local and sustainable sources
Reduction:	Careful design to minimise waste production.
	Reduction of packaging from suppliers

[7] Developing a Strategic Approach to Construction Waste, DEFRA, BRE, AEA 2006

	Monitoring of site energy and water consumption
Reuse:	Take back / return of certain material packaging and protections such as pallets.
	On-site reuse of topsoil, sub-soil and hardcore.
Recycling:	Returning off-cuts of materials such as plasterboard.
	Preference given to the selection of products with a high recycled content
Disposal:	Provision of segregated skips to aid off-site recycling.

10.5 Ahead of implementation, a Waste Management Plan will be agreed with the council and updated / monitored throughout the construction process to assist in achieving the waste targets.

11 WASTE - Operation Phase

Site Proposals

11.1 The development proposes to implement facilities that are in accordance with those currently put in place by Brentwood Borough Council.

11.2 The Authority provides for the following waste collections:

General Waste Collection: General waste will be collected via black bins and a "curtilage" collection where residents bring their waste to the edge of their property, next to the public highway for collection.

Dry Recyclables: The following dry recyclables will be collected: Glass Bottles, Textiles, Paper, Cardboard & Plastic

Garden Waste: Garden spoil including grass cuttings, tree/bush/hedgerow clippings and any other natural waste can be included.

Food Waste: Food/kitchen waste generated from the preparation of meals.

11.3 Accordingly, the development will incorporate measures that provide for the ready recycling of both dry recyclable materials and garden waste through kerbside collections by the Council plus food waste recycling to both energy and fertilizer.

11.4 Space will be provided within properties for the various bins and recycling boxes that are necessary to implement the scheme. It is therefore expected that the residents of the proposed development will be able fully to assist in achieving local and national waste targets.

Local Waste Disposal Facilities

11.5 To further encourage the recycling of waste, the local authority operates a number of community recycling sites throughout Brentwood, the nearest being the Coxtie Green Recycling Centre which is approximately 8.0km from the site, which will accept:

- Glass bottles and jars
- Newspapers and magazines / Card/Yellow Pages
- Aluminium and steel cans and foil: clean aluminium foil only (recycled with metal)
- Textiles

- Garden/green waste
- Timber
- Metal/domestic appliances
- Large domestic appliances, e.g. cookers, microwaves, washing machines etc
- Small domestic appliances, e.g. toasters, lawn mowers, hairdryers etc
- Ink cartridges
- Flat glass (e.g. window glass)
- Fridges/freezers
- TVs / computer monitors
- Plastic bottles
- Clean mixed plastic packaging
- Tetrapaks
- DIY engine oil
- Vegetable oil
- Car batteries
- Domestic batteries
- Energy saving light bulbs (recycled with fluorescent tubes)

11.6 In conclusion, the development would not create any significant negative impact in respect of waste generation or targets. A thorough waste management plan for each phase of development will be prepared.

Appendix

IH 124 Mean Annual Flood

Input

Return Period (years)	100	Soil	0.450
Area (ha)	180.000	Urban	0.000
SAAR (mm)	600	Region Number	Region 6

Results	**l/s**
QBAR Rural	573.5
QBAR Urban	573.5
Q100 years	1829.4
Q1 year	487.5
Q2 years	505.2
Q5 years	734.1
Q10 years	929.1
Q20 years	1148.8
Q25 years	1231.9
Q30 years	1299.7
Q50 years	1502.5
Q100 years	1829.4
Q200 years	2150.6
Q250 years	2253.8
Q1000 years	2959.2

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	0.467	0.467	146.9	23367.9	O K
30 min Summer	0.602	0.602	220.4	30107.8	O K
60 min Summer	0.735	0.735	282.4	36772.8	O K
120 min Summer	0.863	0.863	320.9	43126.6	O K
180 min Summer	0.930	0.930	331.4	46514.0	O K
240 min Summer	0.973	0.973	335.2	48650.0	O K
360 min Summer	1.031	1.031	337.1	51544.2	O K
480 min Summer	1.067	1.067	337.1	53358.5	O K
600 min Summer	1.091	1.091	337.1	54538.9	O K
720 min Summer	1.106	1.106	337.1	55308.5	O K
960 min Summer	1.121	1.121	337.1	56049.0	O K
1440 min Summer	1.122	1.122	337.1	56102.7	O K
2160 min Summer	1.115	1.115	337.1	55760.7	O K
2880 min Summer	1.101	1.101	337.1	55056.5	O K
4320 min Summer	1.058	1.058	337.1	52912.9	O K
5760 min Summer	1.008	1.008	336.8	50398.5	O K
7200 min Summer	0.957	0.957	334.0	47870.1	O K
8640 min Summer	0.910	0.910	328.8	45512.5	O K
10080 min Summer	0.867	0.867	321.8	43367.7	O K
15 min Winter	0.523	0.523	177.7	26162.0	O K
30 min Winter	0.674	0.674	256.1	33712.7	O K
60 min Winter	0.824	0.824	311.8	41198.1	O K
120 min Winter	0.968	0.968	334.8	48375.5	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	139.226	34
30 min Summer	90.034	49
60 min Summer	55.351	78
120 min Summer	32.852	136
180 min Summer	23.893	194
240 min Summer	18.953	252
360 min Summer	13.678	372
480 min Summer	10.842	490
600 min Summer	9.048	608
720 min Summer	7.802	728
960 min Summer	6.171	964
1440 min Summer	4.428	1238
2160 min Summer	3.173	1596
2880 min Summer	2.502	1992
4320 min Summer	1.789	2780
5760 min Summer	1.409	3584
7200 min Summer	1.170	4344
8640 min Summer	1.005	5112
10080 min Summer	0.883	5864
15 min Winter	139.226	34
30 min Winter	90.034	48
60 min Winter	55.351	76
120 min Winter	32.852	134

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
180 min Winter	1.045	1.045	337.1	52238.8	O K
240 min Winter	1.094	1.094	337.1	54707.1	O K
360 min Winter	1.162	1.162	337.1	58109.7	O K
480 min Winter	1.206	1.206	337.1	60308.3	O K
600 min Winter	1.236	1.236	337.1	61804.8	O K
720 min Winter	1.257	1.257	337.1	62843.5	O K
960 min Winter	1.281	1.281	337.1	64041.5	O K
1440 min Winter	1.289	1.289	337.1	64436.4	O K
2160 min Winter	1.260	1.260	337.1	63012.7	O K
2880 min Winter	1.231	1.231	337.1	61526.1	O K
4320 min Winter	1.149	1.149	337.1	57472.5	O K
5760 min Winter	1.062	1.062	337.1	53099.2	O K
7200 min Winter	0.981	0.981	335.7	49045.1	O K
8640 min Winter	0.910	0.910	328.8	45521.2	O K
10080 min Winter	0.851	0.851	318.4	42536.7	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
180 min Winter	23.893	190
240 min Winter	18.953	248
360 min Winter	13.678	366
480 min Winter	10.842	482
600 min Winter	9.048	598
720 min Winter	7.802	712
960 min Winter	6.171	940
1440 min Winter	4.428	1378
2160 min Winter	3.173	1740
2880 min Winter	2.502	2176
4320 min Winter	1.789	3044
5760 min Winter	1.409	3872
7200 min Winter	1.170	4688
8640 min Winter	1.005	5448
10080 min Winter	0.883	6160

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	21.000	Shortest Storm (mins)	15
Ratio R	0.434	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time / Area Diagram

Total Area (ha) 90.000

Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	10.000	4-8	20.000	8-12	30.000	12-16	20.000	16-20	10.000

Model Details

Storage is Online Cover Level (m) 2.000

Tank or Pond Structure

Invert Level (m) 0.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	50000.0	1.000	50000.0	2.000	50000.0

Hydro-Brake® Outflow Control

Design Head (m) 1.300 Hydro-Brake® Type Md4 Invert Level (m) 0.000
Design Flow (l/s) 315.0 Diameter (mm) 491

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	5.4	1.200	326.3	3.000	325.9	7.000	497.0
0.200	26.3	1.400	302.2	3.500	351.6	7.500	514.5
0.300	62.7	1.600	284.7	4.000	375.8	8.000	531.4
0.400	110.8	1.800	278.1	4.500	398.5	8.500	547.7
0.500	164.9	2.000	279.6	5.000	420.1	9.000	563.6
0.600	219.2	2.200	286.0	5.500	440.6	9.500	579.0
0.800	305.1	2.400	294.9	6.000	460.2		
1.000	336.5	2.600	304.9	6.500	479.0		

DUNTON HILLS

BRENTWOOD

ceg: