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Flood Risk Assessment and Drainage
Strategy for the Proposed Development
at Custom House, The Terrace,
Gravesend, Kent

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for the Proposed Development at Custom House,
The Terrace, Gravesend, Kent

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1 Background and Scope of Appraisal

Herrington Consulting has been commissioned by Mile Property Group to prepare a Flood Risk Assessment (FRA) and Drainage Strategy for the proposed development at **Custom House, The Terrace, Gravesend, Kent, DA12 2BW**.

A FRA appraises the risk of flooding to development at a site-specific scale and recommends appropriate mitigation measures to reduce the impact of flooding to both the site and the surrounding area. New development has the potential to increase the risk of flooding to neighbouring sites and properties through increased surface water runoff and as such, an assessment of the proposed site drainage can help to accurately quantify the runoff rates, flow pathways and infiltration potential at the site. This assessment considers the practicality of incorporating Sustainable Drainage Systems (SuDS) into the scheme design, with the aim of reducing the risk of flooding by actively managing surface water runoff.

Flooding is a major issue in the United Kingdom. The impacts can be devastating in terms of the cost of repairs, replacement of damaged property and loss of business. The objectives of the Flood Risk Assessment (FRA) are therefore to establish the following:

- whether a proposed development is likely to be affected by current or future flooding from any source
- whether the development will increase flood risk elsewhere within the floodplain
- whether the measures proposed to address these effects and risks are appropriate
- whether the site will pass Part B of the Exception Test (where applicable)

New developments are also required to undertake an assessment to identify how the foul water from the site will be managed. This assessment considers how foul water is expected to be discharged from the proposed development and whether there are any appropriate connection points, such as nearby sewers or treatment plants.

This appraisal has been undertaken in accordance with the requirements of the National Planning Policy Framework (2019) and the National Planning Practice Guidance Suite (March 2014) that has been published by the Department for Communities and Local Government. The *Flood Risk and Coastal Change* planning practice guidance included within the Suite represents the most contemporary technical guidance on preparing FRAs. In addition, reference has also been made to Local Planning Policy.

To ensure that due account is taken of industry best practice, this FRA has been carried out in line with the CIRIA Report C624 'Development and flood risk - guidance for the construction industry'.

2 Development Description and Planning Context

2.1 Site Location and Existing Use/Development

The site is located at OS coordinates 565199, 174363, off The Terrace in Gravesend, Kent. The site covers an area of approximately 0.4 ha and currently comprises a Grade II Listed building (Custom House), previously used for offices. The site has been vacant since 2018. The location of the site in relation to the surrounding area and the River Thames is shown in Figure 2.1.

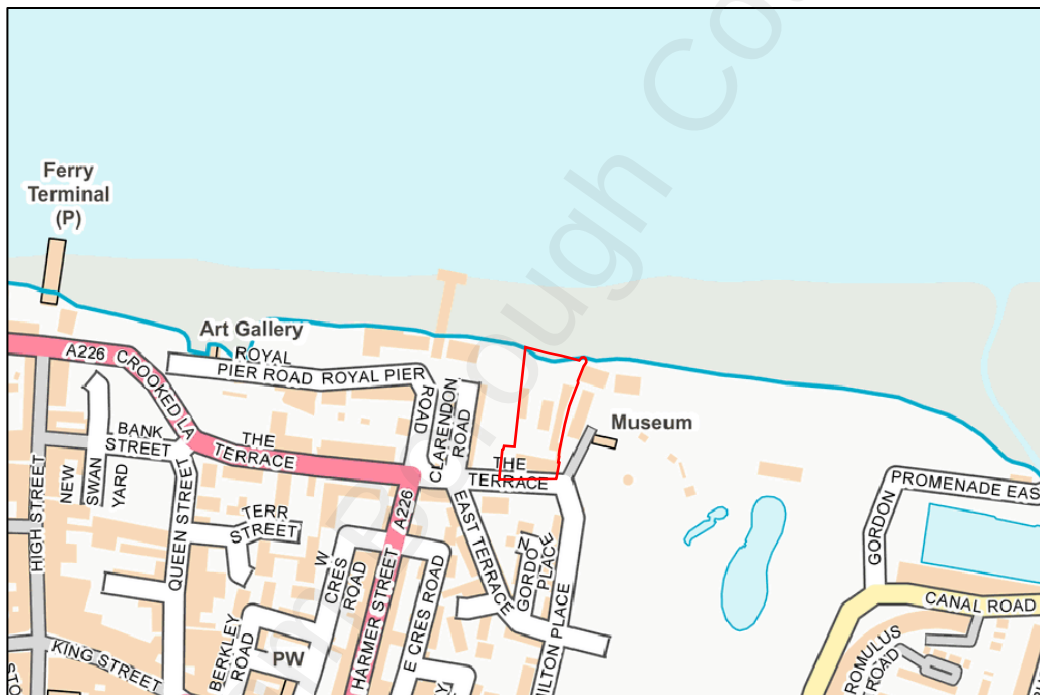


Figure 2.1 – Location map (contains Ordnance Survey data © Crown copyright and database right 2021).

The site plan included in Appendix A.1 of this report provides more detail in relation to the site location and layout.

2.2 Proposed Development

The proposals for development comprise conversion of the Grade II Listed Customs House building and outbuildings, and construction of a new outbuilding to accommodate 27no. residential units with parking, amenity and landscaping. (Figure 2.2).



Figure 2.2 – Proposed site layout.

Drawings of the proposed scheme are included in Appendix A.1 of this report.

2.3

The Sequential Test

The National Planning Policy Framework (NPPF) requires the Sequential Test to be applied at all stages of the planning process and generally the starting point is the Environment Agency's (EA) 'Flood Map for Planning' (Figure 2.3). These maps and the associated information are intended for guidance and cannot provide details for individual properties. They do not take into account other considerations such as existing flood defences, alternative flooding mechanisms and detailed site-based surveys. They do, however, provide high level information on the type and likelihood of flood risk in any particular area of the country. The Flood Zones are classified as follows:

Zone 1 – Low probability of flooding – This zone is assessed as having less than a 1 in 1000 annual probability of river or sea flooding in any one year.

Zone 2 – Medium probability of flooding – This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding or between 1 in 200 and 1 in 1000 annual probability of sea flooding in any one year.

Zone 3a – High probability of flooding - This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding or 1 in 200 or greater annual probability of sea flooding in any one year.

Zone 3b – The Functional Floodplain – This zone comprises land where water has to flow or be stored in times of flood and can be defined as land which would flood during an event having an annual probability of 1 in 20 or greater. This zone can also represent areas that are designed to flood in an extreme event as part of a flood alleviation or flood storage scheme.

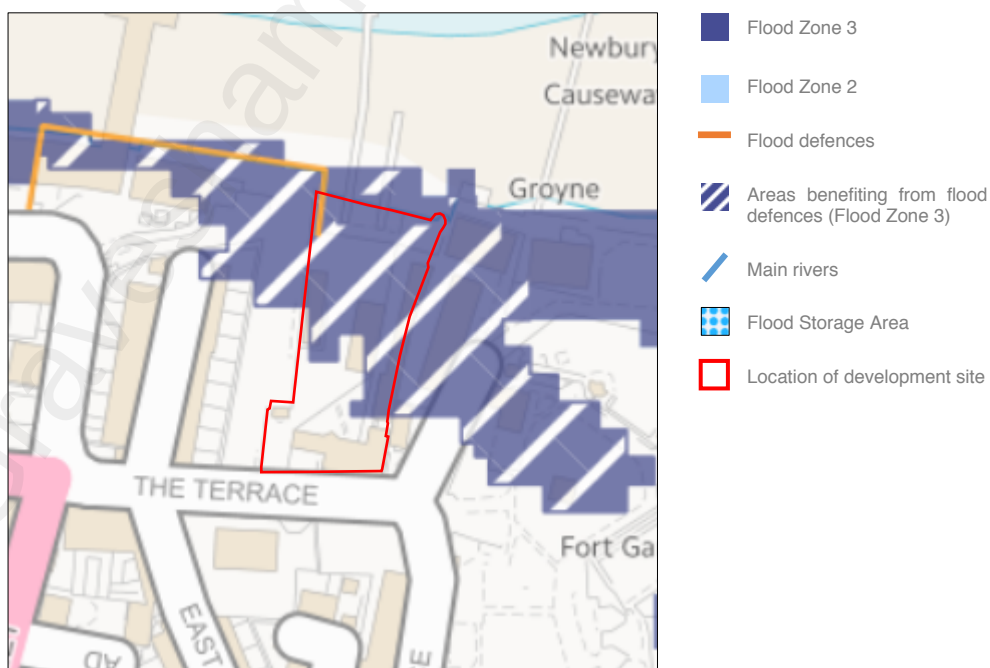


Figure 2.3 – EA's 'Flood Map for Planning' (© Environment Agency).

Figure 2.3 shows the development site is located within Flood Zones 1 and 3 and identifies that the site does benefit from existing flood defences. This mapping does not distinguish between high risk areas and the functional floodplain, i.e., Zones 3a and 3b. This is an important differentiation that needs to be made by the FRA because the NPPF states that no development, other than essential transport and utilities infrastructure, should be located within the functional floodplain.

The NPPG states that the Functional Floodplain is land where water has to flow or be stored in times of flood. The NPPG provides the following definition:

The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. But land which would flood with an annual probability of 1 in 20 (5%) or greater in any year, or is designed to flood in an extreme (0.1%) flood, should provide a starting point for consideration and discussions to identify the functional floodplain. Areas which would naturally flood with an annual exceedance probability of 1 in 20 (5%) or greater, but which are prevented from doing so by existing infrastructure or solid buildings will not normally be defined as functional floodplain.

Based on information provided by the EA and that derived as part of this appraisal, the following Functional Floodplain test is applied:

Do predicted flood levels show that the site will be affected by an event having a return period of 1 in 20 years or less?	X
Is the site defended by flood defence infrastructure that prevents flooding for events having a return period of 1 in 20 years or greater?	✓
Does the site provide a flood storage or floodwater conveyance function?	X
Does the site contain areas that are 'intended' to provide transmission and storage of water from other sources?	X
Is site within the functional floodplain (Zone 3b)?	No

Table 2.1 – Functional floodplain test

The flood zone mapping and associated information has been summarised in Table 2.2 below.

Flood Zone (percentage of site within zone)		Source of flooding	Benefiting from existing flood defences
Zone 1	40%	N/A	N/A
Zone 2	0%		
Zone 3a	60%	River (Tidal)	Yes
Zone 3b	0%	-	-

Table 2.2 – Flood zone classification.

The NPPF states that the Local Planning Authority (LPA) should apply the sequential approach as part of the identification of land for development in areas at risk from flooding. The overarching objective of the Sequential Test is to ensure that lower risk sites are developed before sites in higher risk areas. When applying the Sequential Test, it is also necessary to ensure that the subject site is compared to only those sites that are available for development and are similar in size.

This requires a comprehensive knowledge of development sites within the district and is generally applied as part of the Local Plan process. However, when applying the Sequential Test to sites that have not been assessed as part of the Local Plan it is necessary to apply a bespoke test, and the Flood Risk Assessment can help to provide additional evidence to better quantify the true risk of flooding, enabling an informed judgement to be made.

Whilst a Sequential Test assessment has not been undertaken in support of this FRA, it is possible to use the evidence from the work that has been undertaken as part of this site-specific appraisal in the application of the Sequential Test.

The second level of appraisal is through the application of the more detailed and refined flood risk information contained within the Strategic Flood Risk Assessments (SFRA). Such a document has been prepared for the Gravesham Borough Council and this has been referenced as part of this site-specific FRA.

The most detailed stage at which the sequential approach can be applied is at a site-based level. Careful consideration of the topography of the site and development uses can provide opportunities to locate more vulnerable buildings on the higher parts of the site and placing less vulnerable elements such as car parking or recreational use in the areas exposed to higher risk. This approach is examined later on in this FRA.

2.4

The Exception Test

According to the NPPF, if it is not possible, consistent with wider sustainability objectives, for the development to be located in areas at lower risk, the Exception Test may have to be applied. The application of the Exception Test will depend on the type and nature of the development, in line with the Flood Risk vulnerability classification set out in the NPPG. This has been summarised in Table 2.3 below.

Flood Risk Vulnerability Classification	Zone 1	Zone 2	Zone 3a	Zone 3b
Essential infrastructure – Essential transport infrastructure, strategic utility infrastructure, including electricity generating power stations	✓	✓	e	e
High vulnerability – Emergency services, basement dwellings, caravans and mobile homes intended for permanent residential use	✓	e	x	x
More vulnerable – Hospitals, residential care homes, buildings used for dwelling houses, halls of residence, pubs, hotels, non-residential uses for health services, nurseries and education	✓	✓	e	x
Less vulnerable – Shops, offices, restaurants, general industry, agriculture, sewerage treatment plants	✓	✓	✓	x
Water compatible development – Flood control infrastructure, sewerage infrastructure, docks, marinas, ship building, water-based recreation etc.	✓	✓	✓	✓
Key : ✓ Development is appropriate x Development should not be permitted e Exception Test required  Shaded cell represents the classification of this development				

Table 2.3 - Flood risk vulnerability and flood zone compatibility.

From Table 2.3 above it can be seen that part of the development falls into a classification that requires the Exception Test to be applied. For the Exception Test to be passed it should be demonstrated that:

- A. the development would provide wider sustainability benefits to the community that outweigh the flood risk; and
- B. the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

Both parts of the test will have to be passed for development to be allocated or permitted.

Demonstrating that the development provides wider sustainability benefits to the community that outweigh flood risk is outside the scope of this report. Nevertheless, reference is made to the SFRA to establish the key risks associated with flooding and to help demonstrate that this objective can be achieved. The key focus of this FRA is therefore to establish whether the site is likely to pass Part B of the Exception Test.

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3 Definition of Flood Hazard

3.1 Site Specific Information

Information from a wide range of sources has been referenced to appraise the true risk of flooding at this location. This section summarises the additional information collected as part of this FRA.

Site specific information provided by the EA – The EA has been consulted during pre-application discussions to ensure that the development proposals meet their requirements in relation to flood risk. A copy of the EA's responses is included in Appendix A.2.

In addition, the EA has provided modelled flood level data from the Thames Estuary 2100 study (2008) and Thames Tidal Downriver Breach Inundation Modelling study (2018) which have been referenced as part of this FRA.

Information contained within the SFRA – The 2005 Kent Thameside SFRA contains detailed mapping showing historic flood records for a wide range of sources. This document has been referenced as part of this site-specific FRA.

Information on localised flooding contained within the SWMP – A Surface Water Management Plan (SWMP) is a study to understand the risk of flooding that arises from local surface water flooding, which is defined by the Flood and Water Management Act 2010 as flooding from surface runoff, groundwater, and ordinary watercourses. Such a document has been prepared for Kent Thameside in 2013 and has therefore been referenced as part of this site-specific FRA.

Information provided by Thames Water – Thames Water has provided the results of an asset location search for the site. The response is included in Appendix A.3.

Site specific topographic surveys – A topographic survey and building survey has been undertaken for the site and a copy of this is included in Appendix A.1. From the survey, it can be seen that the level of the site varies between 4.01m and 9.47m Above Ordnance Datum Newlyn (AODN). Ground levels gradually reduce from south to north, towards the River Thames.

Geology – Reference to the British Geological Survey (BGS) map shows that the underlying solid geology in the location of the subject site is Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated). There are no overlying superficial deposits.

Historic flooding – Interrogation of historic flooding records from the EA reveals that there are no records of the site being flooded historically. No further information on historic flooding has been revealed through desktop searches.

3.2 Potential Sources of Flooding

The main sources of flooding have been assessed as part of this appraisal. The specific issues relating to each one and its impact on this development are discussed below. Table 3.1 at the end of this section summarises the risks associated with each of the sources of flooding.

Flooding from Rivers - The site lies within Flood Zone 3 of the tidal reaches of the River Thames (main river) as shown on the EA's 'Flood Map for Planning'. The flood zone maps are used as a consultation tool by planners to highlight areas where more detailed investigation into the risk of flooding is required. Consequently, the risk of flooding from this source has been examined in more detail as part of this FRA.

Flooding from the Sea – The site is a significant distance inland and whilst the River Thames is still tidally influenced at this location, the risk of flooding from the sea is considered to be low.

Flooding from Land (overland flow and surface water runoff) – Overland flooding typically occurs in natural valley bottoms as normally dry areas become covered in flowing water and in low spots where water may pond. This mechanism of flooding can occur almost anywhere, but is likely to be of particular concern in any topographical low spot, or where the pathway for runoff is restricted by terrain or man-made obstructions.

The EA's 'Flood Risk from Surface Water' map (Figure 3.1) shows the majority of the development site is located in an area classified as having a 'very low' risk of surface water flooding. It is only the area in the north-west corner of the site that is shown to be at 'low' to 'high' risk of flooding from surface water.

Inspection of the topographic survey indicates that land levels in the area shown to be affected are slightly lower than the surrounding area. However, the survey also identifies a surface water gully within this topographic depression which is intended to capture any water accumulating in this area. The local drainage system is not included in the EA's mapping. It is therefore considered that the EA's mapping overestimates the actual risk of flooding from surface water in this location.

Notwithstanding this, the EA's mapping can be considered to represent the unlikely scenario whereby the local drainage system was blocked and under this scenario, only a small area of parking would be affected. The proposed residential units would, however, remain dry. On this basis, it is concluded that the risk of flooding from this source is *low*.

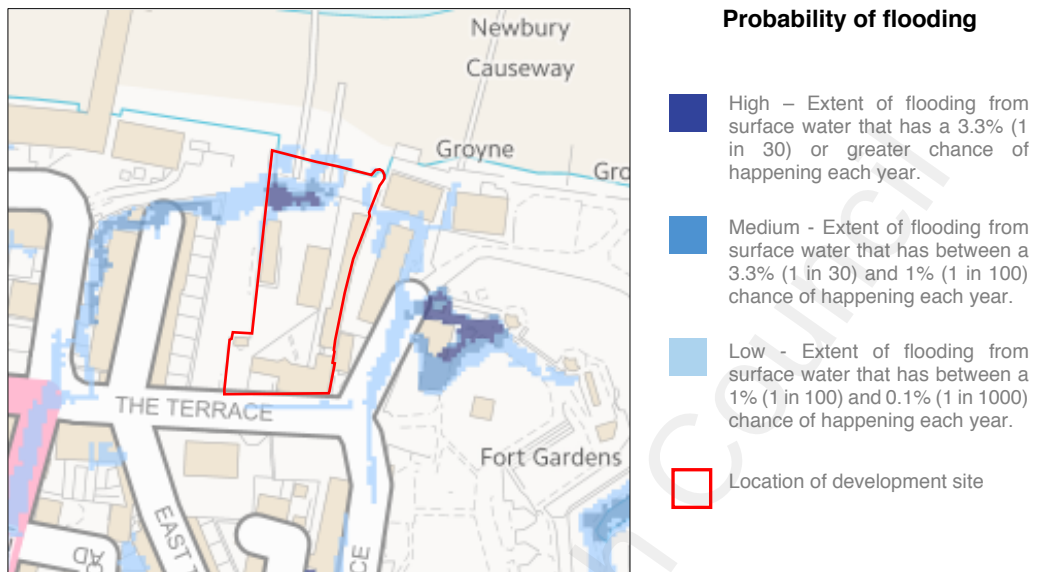


Figure 3.1 – EA's 'Flood Risk from Surface Water' map (© Environment Agency).

Flooding from Groundwater – Water levels below the ground rise during wet winter months, and fall again in the summer as water flows out into rivers. In very wet winters, rising water levels may lead to the flooding of normally dry land, as well as reactivating flow in 'bournes' (streams that only flow for part of the year).

Groundwater flooding is most likely to occur in low-lying areas that are underlain by permeable rock (aquifers). The underlying geology in this area is Chalk, which is typically permeable, and can be associated with groundwater flooding. This is indicated by the BGS groundwater flood risk mapping which shows the site to be in an area at 'moderate' risk of flooding from this source.

Groundwater levels are likely to be congruent with water levels in the River Thames. As the tidal defences prevent river water from flooding the site under extreme conditions, the water level in the river can rise higher than land levels at the site, and this can result in elevated groundwater levels inland of the defences. However, the extreme conditions in the River Thames are only expected to remain for a period less than 12 hours, and therefore it is considered unlikely that groundwater levels will respond quickly enough to result groundwater emergence at the surface. This is supported by the absence of historic records from groundwater flooding in this location in the past in the SFRA and Defra Groundwater Scoping Study. It is therefore concluded that the risk of above ground flooding from this source is low.

Flooding from Sewers – In urban areas, rainwater is typically drained into surface water sewers or sewers containing both surface and wastewater known as "combined sewers". Flooding can result when the sewer is overwhelmed by heavy rainfall, becomes blocked, or has inadequate capacity; this will continue until the water drains away.

Inspection of the asset location mapping provided by Southern Water (SW) (Figure 3.2) identifies that there are a number of sewers near to the site. There are no known records of flooding from

sewers in this area. Additionally, the topography of the land within the site and the surrounding area suggests that any above ground flooding that might occur as a result of a surcharged sewer is expected to flow away from the site within the highway. The risk of flooding from this source is therefore considered to be low.

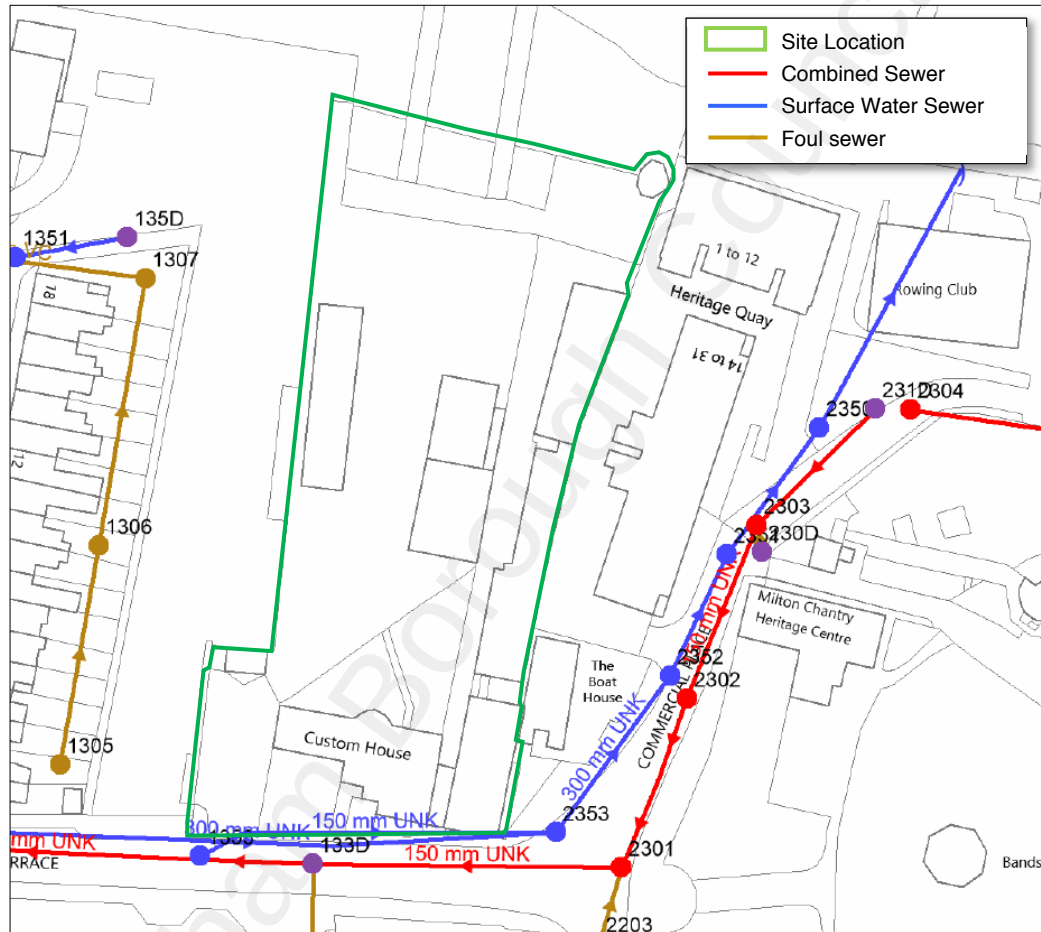


Figure 3.2 - Asset location mapping provided by SW (a full scale copy can be found in Appendix A.3).

Flooding from Reservoirs, Canals and other Artificial Sources – Non-natural or artificial sources of flooding can include reservoirs, canals, and lakes, where water is retained above natural ground level. In addition, operational and redundant industrial processes including; mining, quarrying, sand and gravel extraction, may also increase the depth of floodwater in areas adjacent to these features.

The potential effects of flood risk management infrastructure and other structures also needs to be considered. For example; reservoir or canal flooding may occur as a result of the facility being overwhelmed and/or as a result of dam or bank failure.

Inspection of the Ordnance Survey mapping for the area shows that there are no artificial sources of flooding within close proximity to the site. Furthermore, the EA's 'Flood Risk from Reservoirs'

website shows that the site is not located within an area considered to be at risk of flooding from reservoirs. The risk of flooding from this source is therefore considered to be low.

A summary of the overall risk of flooding from each source is provided in Table 3.1 below.

Source of flooding	Initial level of risk	Appraisal method applied at the initial flood risk assessment stage
Rivers	Appraised further in Section 5	OS mapping and the EA's 'Flood Map for Planning'
Sea	Low	OS mapping and the EA's 'Flood Map for Planning'
Overland Flow	Low	EA's 'Flood Risk from Surface Water' map, and historic records contained within the SFRA, aerial height data, site-specific topographic survey, and OS mapping
Groundwater	Low	BGS groundwater flood hazard maps, Defra Groundwater Flood Scoping Study, BGS Geology of Britain mapping, aerial height data, OS mapping, site-specific topographic survey, historic records in SFRA and Thames Estuary 2100 levels
Sewers	Low	Aerial height data, OS mapping, site-specific topographic survey, asset location data provided by SW and historic sewer records contained within the SFRA
Artificial Sources	Low	OS mapping and EA's 'Flood Risk from Reservoirs' map

Table 3.1 – Summary of flood sources and risks.

3.3 Existing Flood Risk Management Measures

The wider Thames flood defences provide a 1 in 1000 year standard of protection and are all raised, man-made and privately owned. The Environment Agency inspect them twice a year to ensure that they remain fit for purpose. The defences must be maintained by their owners to a crest level of 6.66m AODN to 6.71m AODN (the Statutory Flood Defence Levels along this reach of the Thames). The current condition grade for defences in this area is 2 (good), on a scale of 1 (very good) to 5 (very poor).

The Thames Barrier forms a significant element of the Thames Tidal Defences and is located between Newham and Greenwich. It became operational in October 1982 and was closed for the first time in February 1983. The Barrier is part of a system of tidal defences that currently protect London to an extremely high standard. However, this level of protection is expected to decline in the future.

The Thames Estuary 2100 project sets out the strategic direction for managing flood risk in the Thames Estuary up to the year 2100. The TE2100 plan is now live and forms the overarching flood management strategy for the Thames Estuary. The TE2100 takes into account operation of the Thames Barrier when considering future levels. The Thames Barrier requires regular maintenance and with additional closures the opportunity for maintenance will be reduced. When this happens,

river levels for which the barrier would normally be shut, will have to be allowed through to ensure that the barrier is not shut too often. For this reason, levels will increase, and the tidal walls will need to be heightened to match. The future defence height required in this location is 8.0m AODN

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4 Climate Change

The global climate is constantly changing, but it is widely recognised that we are now entering a period of accelerating change. Over the last few decades there have been numerous studies into the impact of potential changes in the future and there is now an increasing body of scientific evidence which supports the fact that the global climate is changing as a result of human activity. Past, present, and future emissions of greenhouse gases are expected to cause significant global climate change during this century.

The nature of climate change at a regional level will vary: for the UK, projections of future climate change indicate that more frequent short-duration, high-intensity rainfall and more frequent periods of long-duration rainfall could be expected.

These effects will tend to increase the size of Flood Zones associated with rivers, and the amount of flooding experienced from other inland sources. The rise in sea level will change the frequency of occurrence of high water levels relative to today's sea levels. It will also increase the extent of the area at risk should sea defences fail. Changes in wave heights due to increased water depths, as well as possible changes in the frequency, duration and severity of storm events are also predicted.

4.1 Planning Horizon

To ensure that any recommended mitigation measures are sustainable and effective throughout the lifetime of the development, it is necessary to base the appraisal on the extreme flood level that is commensurate with the planning horizon for the proposed development. The NPPF and supporting Planning Practice Guidance Suite state that residential development should be considered for a minimum of 100 years, but that the lifetime of a non-residential development depends on the characteristics of the development. The development that is the subject of this FRA is classified as residential therefore a design life of 100 years has been assumed.

4.2 Potential Changes in Climate

Extreme Sea Level

Global sea levels will continue to rise, depending on greenhouse gas emissions and the sensitivity of the climate system. The relative sea level rise in England also depends on the local vertical movement of the land, which is generally falling in the south-east and rising in the north and west. The accompanying Planning Practice Guidance Suite to the NPPF provides allowances for the regional rates of relative sea level rise and these are shown in Table 4.1.

Administrative Region	Net Sea Level Rise (mm/yr) Relative to 1990			
	1990 to 2025	2026 to 2055	2056 to 2085	2086 to 2115
East of England, East Midlands, London, SE England (south of Flamborough Head)	4.0	8.5	12.0	15.0
South West	3.5	8.0	11.5	14.5
NW England, NE England (north of Flamborough Head)	2.5	7.0	10.0	13.0

Table 4.1 – Recommended contingency allowances for net sea level rise.

The development site is not subject to coastal flooding; however, the River Thames is a tidal river and therefore the figures above are still applicable. As outlined in Section 3.3, water levels within the River Thames are dependent on the closure rules for the Thames Barrier depicted in the TE2100 plan. The impacts of sea level rise over the next 100 years have been taken into consideration as part of the EA's TE2100 modelling study.

Peak Rainfall Intensity

The recommended allowances for increases in peak rainfall intensity are applicable nationally. There is a range of values provided which correspond with the central and upper end percentiles (the 50th and 90th percentile respectively) over three time epochs. The recommended allowances are shown in Table 4. below.

Allowance Category (applicable nationwide)	Total potential change anticipated for each epoch		
	2015 to 2039	2040 to 2069	2070 to 2115
Upper End	+10%	+20%	+40%
Central	+5%	+10%	+20%

Table 4.2– Recommended peak rainfall intensity allowance for small and urban catchments (1961 to 1990 baseline).

Guidance published by the EA states that the 'Upper End' allowance should be considered when designing a sustainable drainage system. As the development subject to this FRA has a planning horizon of 100 years, a 40% increase in peak rainfall intensity has been applied to the hydraulic drainage model constructed to inform the drainage strategy (refer to Section 8). Where this allowance has been applied the abbreviation "+40%cc" has been used.

5 Probability and Consequence of Flooding

5.1 The Likelihood of Flooding

When appraising the risk of flooding to new development it is necessary to assess the impact of the 'design flood event'. Flood conditions can be predicted for a range of return periods and these are expressed in either years or as a probability, i.e., the probability that the event will occur in any given year, or Annual Exceedance Probability (AEP). The design flood event is taken as 1 in 200 year (0.5% AEP) event for sea or tidal flooding, including an appropriate allowance for climate change (refer to Section 4.2).

As identified in Section 3.3, development within the Thames basin area is protected by the Thames Barrier. Water levels upstream of the Barrier are controlled by closure rules depicted in the Thames Estuary 2100 (TE2100) plan, rather than being dictated by extreme weather events with a certain return period. In the absence of flood return period data, Maximum Likely Water Levels (MLWL) have been calculated (by others) for a number of time epochs, chosen to represent the impact of climate change on the water levels in the River Thames for the years 2014, 2065, and 2100. These time epochs are commensurate with the planning horizons defined by the NPPF for each type of development, e.g. residential development (2100) and commercial development (2065).

The development site for which this FRA has been prepared is classified as residential, and therefore the development has been appraised for a lifetime of 100 years (refer to Section 4.1). In the absence of flood level data in respect to event return periods, the site has been appraised to the 2100 epoch MLWLs.

The MLWLs have been calculated (by others) as part of the Thames Upstream Inundation Modelling Study (2015) for a number of time epochs, chosen to represent the impact of climate change. The MLWLs have been taken from the for the closest node point to the development site (3.26) (Table 5.1).

Epoch	MLWL (m AODN)
Present Day	5.78
2100	6.44

Table 5.1 – Modelled flood levels (at Node 3.26) showing the MLWLs in the River Thames.

As outlined in Section 3.3 of this report, the development site benefits from existing defence infrastructure along the River Thames, which provides a 1 in 1000 year standard of protection and have a crest height of 6.66m to 6.71m AODN in this area. Consequently, as shown in Table 5.1. the water level under current day conditions would remain below the crest height of the defences and the site would remain dry.

When taking into account future climate change scenarios, the MLWLs will increase to 6.44 AODN by the year 2100 (refer to Table 5.1). This water level is below the current crest level of the defences, as set out in Section 3.3. Furthermore, the tidal defences are to be raised and adapted where required to keep the barrier closures within operational constraints. It is anticipated that by 2100, the tidal walls along both banks of the river will be raised to a minimum of 8.0m AODN in this area of the River Thames. The crest height of the defences will remain above the MLWL permitted by the barrier and therefore, the site would be protected by the defences and would continue to remain dry in the future. The actual risk of flooding to the site is concluded to be *low*.

5.2 Residual Risk of Flooding

Whilst the Thames tidal defences do provide a very high standard of protection, and are also maintained to a safe and serviceable standard, there is always the risk that a small section of this infrastructure could fail; either as a result of structural failure, or through less predictable mechanism such as ship impact or an act of terrorism. This is known as the *residual risk* of flooding.

The only way that the impact of such a scenario can be quantified is through the use of detailed numerical breach modelling. This type of modelling has been undertaken as part of the Thames Upriver Breach Inundation Modelling study completed in May 2017. The model simulates 5679 continuous tidal breaches along the River Thames from Teddington to the Thames Barrier.

Inspection of the model results provided by the EA shows that the maximum predicted flood level on site during a breach event is **6.32m AODN**. In this scenario, it is predicted the lower part of the site could be flooded, with floodwater predicted to reach a maximum depth of 2.3m adjacent to the defences (Figure 5.1).

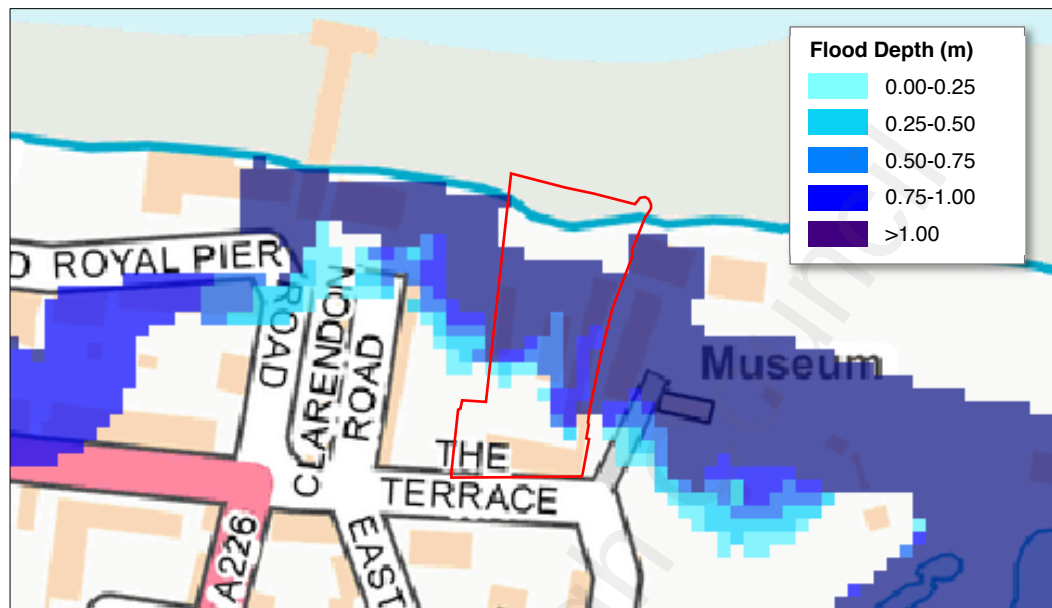


Figure 5.1 – Extract from the Thames Tidal Downriver Breach Inundation Modelling Study delineating the maximum flood depth and extent for the year 2100 (contains Ordnance Survey data © Crown copyright and database right 2021, © Environment Agency).

6 Offsite Impacts and Other Considerations

6.1 Displacement of Floodwater

Development within the floodplain has the potential to displace water and to increase the risk elsewhere by raising flood levels. A compensatory flood storage scheme can be used to mitigate this impact, ensuring the volume of water displaced is minimised.

However, where development is proposed in tidal floodplains such as is the case here, it is generally accepted by the EA that raising the ground or building on the floodplain is unlikely to impact on maximum tidal levels.

6.2 Public Safety and Access

The NPPF states that safe access and escape should be available to/from new developments located within areas at risk of flooding. The Practice Guide goes on to state that access routes should enable occupants to safely access and exit their dwellings during design flood conditions and that vehicular access should be available to allow the emergency services to safely reach the development.

It has been shown that the actual risk of flooding to the development is very low and therefore safe access/egress can be achieved.

In the unlikely event of a failure of the defences, the southern half of the site has been shown to remain unaffected by flooding, and therefore safe dry access would be available from units 3, 4 and 10 and the main custom house.

It is only in the northern part of the development site where flooding could restrict the access to some of the units during the peak of the event. These units include; 12 to 19, the workshop, the boathouse and the northern entrance of the new build. Residents of these units should be prepared to evacuate the site *before* an extreme flood occurs and if insufficient time is available, safe refuge should be sought within their flats. It is therefore recommended that residents of these units sign up to the EA's Early Flood Warning System (refer to Section 7.4).

6.3 Proximity to Watercourse and Flood Defence Structures

Under Schedule 25 of the Environmental Permitting (England and Wales) Regulations 2016, any proposals for development within 16m of a flood defence structure on a tidal river is required to obtain a permit in relation to their Flood Risk Activities, referred to as a Flood Risk Activity Permit (FRAP). This is in addition to planning permission.

Whilst the application boundary lies within 16m of the tidal defence wall, there are no groundworks or new development proposed within the 16m byelaw margin. Notwithstanding this, the EA has been consulted as part of the development of this FRA. The EA response requests further information on the ongoing maintenance and improvements to the defences in line with the TE2100

plan (refer to Section 3.3). The applicant is continuing consultation with the EA to ensure that their requirements can be accommodated within the scheme design.

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7 Flood Mitigation Measures

The key objectives of flood risk mitigation are:

- to reduce the risk of the development being flooded
- to ensure continued operation and safety during flood events
- to ensure that the flood risk downstream of the site is not increased by increased runoff
- to ensure that the development does not have an adverse impact on flood risk elsewhere

The following section of this report examines ways in which the risk of flooding at the development site can be mitigated.

Mitigation Measure	Appropriate	Comment
Careful location of development within site boundaries (i.e. Sequential Approach)	✓	Refer to Section 7.1
Raising floor levels	✓	Refer to Section 7.2
Land raising	X	Not required
Compensatory floodplain storage	X	Not required
Flood resistance & resilience	✓	Refer to Section 7.3
Alterations/ improvements to channels and hydraulic structures	X	Not required
Flood defences	✓	The applicant is in consultation with the EA to provide the necessary details to confirm that the site will remain defended into the future in line with the TE2100 plan.
Flood warning	✓	Refer to Section 7.4
Surface water management	✓	Refer to Section 8

Table 7.1 – Appropriateness of mitigation measures.

7.1 Application of the Sequential Approach at a Local Scale

The sequential approach to flood risk management can also be adopted on a site based scale and this can often be the most effective form of mitigation. For example, on a large scheme this would mean locating the more vulnerable dwellings on the higher parts of the site and placing parking, recreational land or commercial buildings in the lower lying and higher risk areas.

As much of the development comprises the conversion of existing buildings, there is limited opportunity to apply this approach in this instance. However, it can be seen that the development proposals have addressed this, locating the more vulnerable sleeping accommodation on the upper floors of the development for units within the extent of flooding from a breach (i.e. residual risk, refer to Figure 5.1).

7.2 Raising Floor Levels

As the development proposals comprise the conversion of existing buildings, it limits the ability to raise the finished floor level due to ceiling height and access limitations. The EA has been consulted on the proposals and their response confirms that the finished floor level requirements for this development is as follows: *'every dwelling must have all sleeping accommodation set no lower than 600mm above the 1 in 200 year plus climate change breach flood level.'* The applicant has confirmed that, with the exception of the lower ground floor level in Custom House (discussed below), all sleeping accommodation will be situated at a minimum of 6.92m AODN in accordance with the EA's requirements.

The units proposed at lower ground floor level in Custom House will have finished floor levels situated below 6.92m AODN. However, following further consultation with the EA it has been agreed that this approach is acceptable on the basis that there are no points where floodwater can ingress the building to cause the lower ground floor to flood (i.e. no openings below the design flood level 6.32mAODN). Even in the unlikely event of a breach, water is not shown to enter the lower ground floor. Information on the levels across the site, include threshold levels to the lower ground floor level, are included in Appendix A.1.

7.3 Flood Resistance and Resilience

During a flood event, floodwater can find its way into properties through a variety of routes including:

- Ingress around closed doorways
- Ingress through airbricks and up through the ground floor
- Backflow through overloaded sewers discharging inside the property through ground floor toilets and sinks
- Seepage through the external walls
- Seepage through the ground and up through the ground floor

- Ingress around cable services through external walls

It has been demonstrated that the ground floor level of the northern part of the development is liable to flooding in the event of a failure of the defences (i.e., the *residual risk scenario*) and therefore it is recommended that Property Flood Resilience (PFR) measures are retrofitted to reduce the impact of such an event where possible.

To retrofit flood resistant and resilient measures into an existing building requires a survey of the flood performance of the existing building to identify potential locations where floodwater could ingress. Details of an appropriately qualified surveyor can be found at the Blue Pages, hosted on the National Flood Forum website:

<http://bluepages.org.uk/>

A Code of Practice (CoP) for PFR has been put in place to provide a standardised approach for the delivery and management of PFR. Further information on the CoP and guidance on how to make a property more flood resilient can be accessed, and downloaded, from the Construction Industry Research and Information Association (CIRIA) Website:

https://www.ciria.org/Research/Projects_underway2/Code_of_Practice_and_guidance_for_property_flood_resilience.aspx

7.4

Flood Warning

It has been demonstrated that the risk of flooding to the development is limited to the failure of the tidal defences which is associated with a tidal surge conditions in the North Sea. Storm conditions are dependent on meteorological conditions that can be monitored reliably and therefore it is likely that a minimum of 12 hours warning could be given of conditions which may result in a failure of the defences. This forewarning should be sufficient to ensure the residents are aware of the potential for flooding from a breach event and to prepare themselves, and their property, in the event that they are required to evacuate.

It is therefore recommended that the occupants of the site sign up to the EA's Flood Warning Service either by calling 0345 988 1188, or by visiting;

<https://www.gov.uk/sign-up-for-flood-warnings>

As part of pre-application discussions, the EA has acknowledged that the onset of a breach can be rapid. Therefore, in the unlikely event that floodwater reaches the site before residents are able to evacuate, the EA has requested that safe refuge is available on the upper floor of the units, 600mm above the design flood level. Inspection of the scheme drawings shows this has been achieved.

8 Surface Water Management Strategy

8.1 Background and Policy

The general requirement for all new development is to ensure that the runoff from the development is managed sustainably and that the drainage solution does not increase the risk of flooding at the site, or within the surrounding area. In the case of brownfield sites, drainage proposals are typically measured against the existing performance of the site, although it is preferable (where practicable) to provide runoff characteristics that are similar to greenfield behaviour.

The Non-statutory Technical Standards for SuDS (NTSS) specify criteria to ensure sustainable drainage is included within development classified as 'major development' as set out in Article 2(1) of the Town and Country Planning (Development Management Procedure) (England) Order 2010. It is, however, recognised that SuDS should be designed to ensure that the maintenance and operation requirements are economically proportionate.

The proposed development comprises 27 residential units and as a result, the proposals are classified as 'major' development and the NTSS will apply. Reference to the NTSS has therefore been made throughout the following sections of this report to ensure the principles of sustainable drainage are considered.

In addition to the NTSS, Kent County Council's (KCC) Drainage and Planning Policy Statement (June 2017) also states that all major developments should undertake a Surface Water Management Strategy (SWMS) to provide evidence on how SuDS can be incorporated within the proposed development.

8.2 Surface Water Management Overview

The main characteristics of the site that have the potential to influence surface water drainage are summarised in Table 8.1 below.

Site Characteristic	Value
Total area of site	0.41 ha
Impermeable area (existing)	3,779 m²
Impermeable area (proposed)	Roof area = 1,446 m ² Hardstanding = 1,826 m ² Total = 3,272 m²
Current site condition	Brownfield Site
Greenfield runoff rates (based on the ICP SuDS methodology)	QBar = 0.4 l/s/ha Q30 = 0.8 l/s/ha Q100 = 1.0 l/s/ha
Infiltration coefficient	0.0001-0.01m/hr (assumed based on underlying geology and typical soil conditions)
Current surface water discharge method	Directly into River Thames
Is there a watercourse within close proximity to site?	Yes - River Thames

Table 8.1 – Site characteristics affecting rainfall runoff.

Runoff rates have been calculated for a range of annual return probabilities including the 100 year return period event with a 40% increase in rainfall intensity to account for future climatic changes. These hydrological calculations have been undertaken using the Modified Rational Method, and synthetic rainfall data derived using the variables obtained from the Flood Estimation Handbook (FEH) and the routines within Causeway Flow+.

These values are summarised in Table 8.2 for a range of return periods.

Return Period (years)	Peak Runoff (l/s)	
	Existing Site	Developed Site
2	68	59
30	197	170
100	258	223
100 + 40%	361	311

Table 8.2 – Summary of peak runoff.

The total volume of water discharged from the site for the 100 year 6 hour event is also summarised in Table 8.3 below, for both the existing and proposed site conditions.

Site Condition	Total Volume Discharged
Existing site (present day)	374m ³
Proposed development including a 20% increase in rainfall intensity to account for climate change (prior to any mitigation)	324m ³
Difference in volume between existing site (present day) and proposed development (including allowance for climate change)	-50m ³

Table 8.3 – Total volume discharged from the 100 yr+40%cc 6 hour event.

Reference to the tables above show the proposed development will decrease the percentage of impermeable area within the boundaries of the site. Consequently, this will decrease the rate and volume of surface water runoff discharged from the site. Notwithstanding this, it is recognised that the impacts of climate change should be considered as part of any new development, and it is for this reason that it is recommended that SuDS are considered. The overall rate at which surface water runoff is discharged from the site should not increase over the lifetime of the development.

The potential use of SuDS within the proposed development will be considered to assess the practicality of better replicating greenfield behaviour, in accordance with Local Planning Policy and S3 and S5 of the NTSS.

8.3 Existing Drainage

The existing site drainage has not been surveyed and it is currently unknown how the existing buildings at the site currently drain. It is assumed the site drains directly into the River Thames.

SW has provided sewer mapping for the site and surrounding area and an extract from this mapping is shown in Figure 3.2. The nearest surface water sewer is located south of the site within The Terrace and discharges into the River Thames to the east of the site.

8.4 Opportunities to Discharge Surface Water Runoff

Part H of the Building Regulations summarises a hierarchy of options for discharging surface water runoff from developments. The preferred option is to **infiltrate** water into the ground, as this deals with the water at source and serves to replenish groundwater. If this option is not viable, the next option of preference is for the runoff to be discharged into a **watercourse**. Only if neither of these options are possible, the water should be discharged into the **public sewer** system.

Water re-use - Water re-use systems can rarely manage 100% of the surface water runoff discharged from a development, as this requires the yield from the building and hardstanding area to balance perfectly with the demand from the proposed development. Consequently, whilst

rainwater recycling systems can be considered for inclusion within the scheme, an alternative solution for attenuating storm water will still be required.

Infiltration – Reference to BGS mapping shows that the bedrock geology of the site is made up of Lewes Nodular Chalk Formation and Seaford Chalk Formation, no superficial deposits. These strata are likely to have moderate permeability, capable of discharging surface water runoff. However, the close proximity to the river and the potential for elevated ground water levels at the site would restrict the use of infiltration SuDS. Infiltration is therefore not considered to be a suitable solution at this location. Notwithstanding this, it is recommended that infiltration testing and groundwater level monitoring is undertaken to confirm this assumption.

Discharge to Tidal Waterbody – The existing site currently discharges directly into the River Thames to the north. Discharging surface water runoff into the River Thames is considered to be the most appropriate option if infiltration is not viable.

Discharge to Watercourses – There are no smaller watercourses within close proximity to the site in which to permit a direct connection and consequently, there is no opportunity to discharge surface water to an existing watercourse.

Discharge to Public Sewer System – As an alternative preferred solution is available for disposing of surface water runoff, it is assumed that a connection to the existing sewer will not be required.

8.5 Constraints and Further Considerations

The key constraints that are relevant to this development are listed below:

- There is limited open space to incorporate SuDS that require significant areas of land such as wetland areas.
- If a new connection into the tidal waterbody is required, it may be necessary to obtain consent from the Environment Agency and the Marine Management Organisation before construction can commence. The Port of London may also need to be contacted to discuss any new connection.
- Due to the proposed level of the outfall, it is possible that the outfall could become hydraulically blocked (tide locked) for certain durations. Appropriate storage should be provided to ensure that there is an adequate provision to discharge the runoff from the site during a tide locked scenario. A tidal flap valve will also be required to be installed on the outfall pipe.

8.6 Sustainable Drainage Systems (SuDS)

A range of typical SuDS that can be used to improve the environmental impact of a development is listed in Table 8.4 below along with the relative benefits of each feature and the appropriateness for the subject site.

SuDS	Description	Constraints/Comments	Appropriate for site?
Rainwater harvesting systems	Collection of rainwater and storage for reuse on site (e.g., water butts)	There are no known constraints	Yes
Green/blue roofs	Provide landscaping and planting at roof level to reduce surface water runoff rates	Dependent on roof type	No
Infiltration systems	Allow water to percolate into the ground at a controlled rate via natural infiltration	Potentially high groundwater	No
Filter strips	Wide gently sloping densely planted areas promoting sedimentation and filtration	Insufficient space	No
Filter drains	Trenches infilled with stone/gravel providing attenuation, sedimentation and filtration	Limited space, infiltration unlikely to be viable	No
Swales	Broad shallow channels that convey and store runoff and allow infiltration	Insufficient space	No
Bioretention systems / rain gardens	A shallow landscaped depression allowing runoff to pond temporarily on the surface	There are no known constraints	Yes
Permeable pavements	Runoff is allowed to soak into structural paving and stored potentially being allowed to infiltrate	Potentially high groundwater and steep slope	No
Underground storage	Below ground storage which can be used to temporarily store storm water	None	Yes
Detention basins	A landscaped depression for attenuation with a restricted runoff	Insufficient space	No
Ponds and wetlands	A permanent pool of water which can be used for attenuation and controlled outflows by water levels	Insufficient space	No

Table 8.4 – An assessment into the suitability of SuDS at this site.

From Table 8.4 it can be seen that there are a limited range of SuDS which would be suitable for use at this site. At this stage in the planning process, it is envisaged that an underground storage tank will be used to store surface water runoff before discharging into the River Thames.

8.7

Proposed Surface Water Management Strategy (SWMS)

The drainage strategy set out below discusses each of the different elements of the proposed scheme, along with the results of a hydraulic drainage model that has been constructed to demonstrate how the overall objectives can be achieved. This does not represent a detailed surface water drainage design; it is simply an assessment to demonstrate that the objectives and requirements of the NPPF and NTSS can be met at the planning stage.

Water Butts

To reduce the developments reliance on potable water supplies for external use there is the potential to incorporate water butts for the communal green areas. Typical sizes and dimensions of water butts are outlined below.

Typical house water butt options	Dimensions of a typical house water butt	Volume of storage provided (litres)
Type 1 (wall mounted – small)	1.22m high x 0.46m x 0.23m	100
Type 2 (standard house water butt)	0.9m high x 0.68m diameter	210
Type 3 (large house water butt)	1.26m high x 1.24m x 0.8m	510
Type 4 (column tank – very large)	2.23m high x 1.28m diameter	2,000

Table 8.5 – Estimated storage capacity of available water butts.

In this case the demand for potable water for the gardens is likely to be relatively small and as a result, standard house water butts (typical 210 litre units) are likely to be the most appropriate size for inclusion within the scheme.

It is recognised that each of the water butts will need to overflow into the main drainage system for the site, to ensure that in the event the water butt is full prior to the onset of the design rainfall event, water can be discharged away from the properties without increasing the risk of flooding.

Underground Storage (cellular storage crate)

Runoff draining from the roofs, roads and other areas of hardstanding, will be directed via underground pipes into a cellular storage crate located beneath the proposed parking area, adjacent to the river, and subsequently discharged into the River Thames at an unrestricted rate. This approach ensures that the drainage system can accommodate the rainfall generated under a 1 in 100 year return period event (including an allowance for climate change), discharging all of the water to the river.

Notwithstanding this, it is recognised that there is a risk that the outfall could become hydraulically blocked by a rising tide during an extreme event (i.e. a tidal surge), when the flood gates would also be closed. Therefore, further analysis has been undertaken to ascertain what additional measures

may be required to prevent uncontrolled flooding on the site if the blockage of the outfall was to coincide with an extreme pluvial event.

The analysis applies the EA's coastal flood boundary condition database to determine the extreme water level for a 1 in 2 year return period event (T2), including an allowance for climate change for the year 2115 (a maximum still water level of 5.63m AODN). The storage tank has been sized to store the runoff from a 1 in 30 year pluvial event, including a 40% allowance for climate change, for the duration that the outfall is blocked (under the 1 in 2 year tidal event including an allowance for climate change). The hydraulic model of the drainage system has therefore been run for storm events up to and including 360 minutes with the outfall blocked and assumes a tidal flap valve will be fitted to the outfall pipe to prevent sea water from entering the drainage system during a high tide.

A summary of the Causeway Flow+ analysis for the underground storage crate is shown in Table 8.6 below.

Parameter	Value (1:100yr+40%cc event)
SuDS	Cellular Storage Crate
Total area draining to cellular storage crate including a 10% allowance for urban creep.	3245 m ²
Proposed outlet level into River Thames	3.17m AODN
Tide locking duration (T2 + CC)	285 minutes
Critical modelled pluvial storm duration	360 minutes
Volume of storage required	170 m ³
Outlet diameter	150 mm
Maximum discharge rate (1:100+40%cc)	29.6 l/s

Table 8.6 – Summary of storage tank.

It is evident that, with the inclusion of the proposed SuDS, there is the potential to accommodate all the surface water runoff from the site up to, and including, the design rainfall event. If a pluvial event with a higher return period (i.e. 1 in 100 year return period + 40%cc) was to occur during the same tide locked scenario described, the system could surcharge. However, as discussed in

Section 8.10 of this report, water will be safely contained above ground in the parking area until such time that the water level in the river falls and water is able to re-enter the drainage system, discharging freely into the river once more.

8.8 Indicative Drainage Layout Plan

Figure 8.1 below is an indicative drainage layout plan delineating how the proposed SuDS can be incorporated into the scheme proposals.

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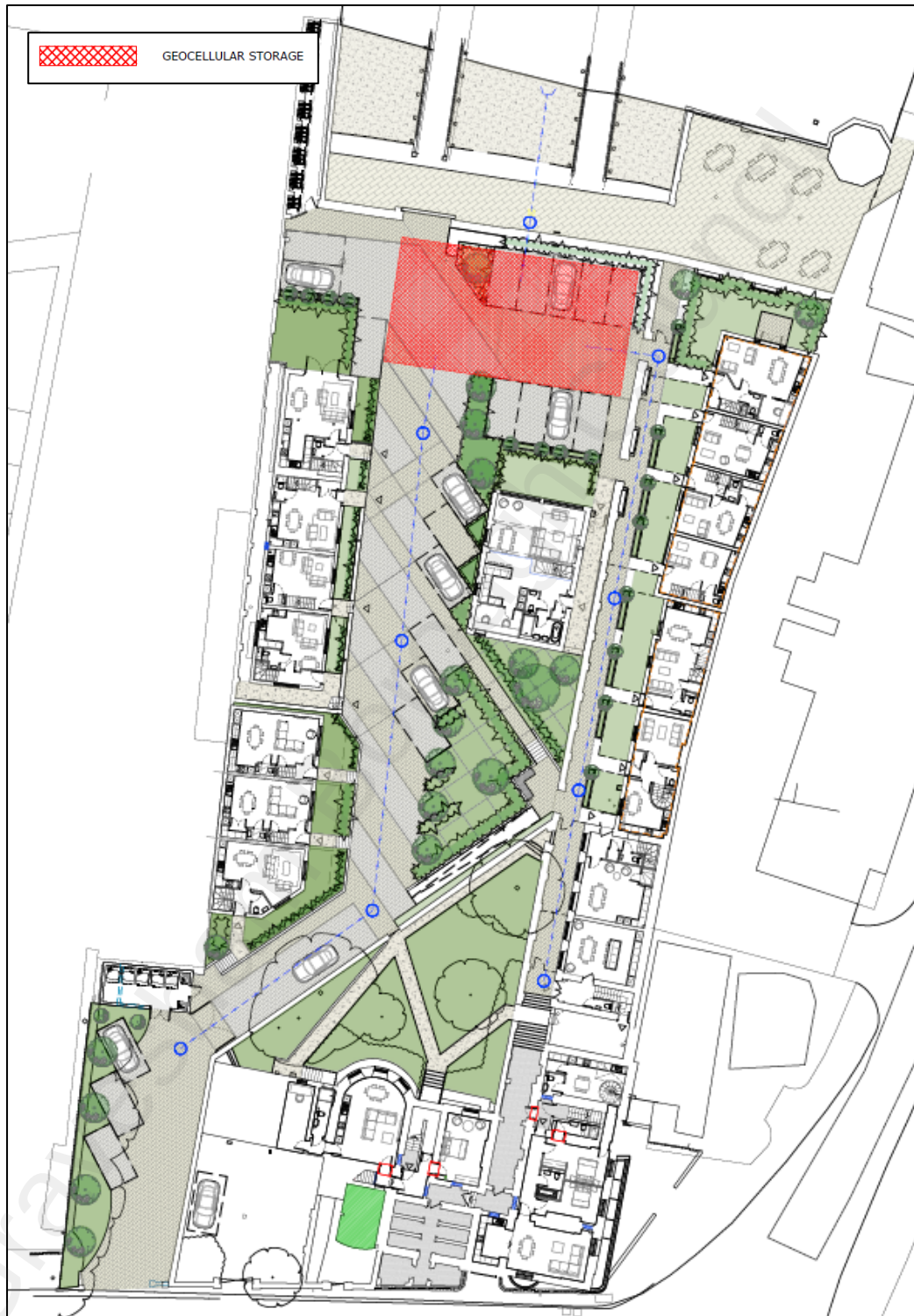


Figure 8.1 - Indicative drainage layout plan showing the proposed location of SuDS.

A full-scale copy of this layout is located in Appendix A.5 of this report.

8.9 Management and Maintenance

For any surface water drainage system to operate as originally designed, it is necessary to ensure that it is adequately maintained throughout its lifetime.

The key requirements of any management regime are routine inspection and maintenance. When the development is taken forward to the detailed design stage, an 'owner's manual' will need to be prepared. This should include:

- A description of the drainage scheme
- A location plan showing all of the SuDS features and equipment, such as flow control devices etc
- Maintenance requirements for each element, including any manufacturer-specific requirements
- An explanation of the consequences of not carrying out the specified maintenance
- Details of who will be responsible for the ongoing maintenance of the drainage system

For the SuDS features recommended by this assessment, the most obvious maintenance tasks will be desilting and cleaning the cellular storage crate. General maintenance schedules have been included within the appendices of this report, which demonstrate the maintenance requirements of the proposed SuDS.

For developments such as this that rely to some extent on the ongoing inspection and maintenance of SuDS, it will be necessary to ensure that measures are in place to maintain the system for the lifetime of the development. In this case, it is likely that the management company responsible for maintaining the rest of the site will be tasked with the inspection and maintenance of the SuDS elements.

Further details of the maintenance and management strategy should be confirmed following the completion of a detailed drainage design for the development.

8.10 Sensitivity Testing and Residual Risk

It is necessary to ensure that the drainage proposals will not increase the risk of flooding if the drainage system becomes blocked, or if a rainfall event which exceeds the design rainfall event occurs.

Inspection of the topography across the site suggests that if the drainage network was to fail, water would flow towards the north of the site and away from the proposed buildings.

Runoff is able to discharge directly into the River Thames whenever the flood gate is open. If the floodgate is closed, water will temporarily accumulate within the car park to the north of the plot,

until it is able to be discharged into the drainage system or into the river directly, by opening the flood gate.

The proposed drainage system has been designed for an extreme rainfall event with a return period of 1 in 100 years, including a 40% increase in peak rainfall intensity (to account for the impacts of climate change) and for a 1 in 30 year pluvial event with 40% allowance for climate change coinciding with the 1 in 2 year tidal event including an allowance for climate change. Nonetheless, the 1 in 100yr+40%cc event coinciding with the 1 in 2 year tidal event has been used to test how the proposed drainage would respond to a larger event.

Figure 8.2 below delineates the most likely path water would take during an event that exceeds the design storm.



Figure 8.2 – Anticipated flow routes during an exceedance or blockage event.

It is recognised that the drainage proposals will incorporate a significant volume of additional storage for storm water, which is not currently provided on the existing site. As a result, when compared to the existing site, it is likely that the volume of water discharged from the site during an

extreme rainfall will be reduced, thus minimising the potential impact of flooding to the surrounding area.

It is therefore concluded that with the inclusion of the proposed SuDS discussed within this strategy, the risk of flooding will not be increased by the new development.

Gravesend Borough Council

9 Foul Water Management Strategy

9.1 Background

The objective of this foul water drainage strategy is to ensure a viable solution is available for managing foul effluent discharged from the proposed development site.

In general, there are two methods for draining effluent from proposed developments. The preferred solution is a connection to the public sewer network, which is controlled by the sewerage undertaker. Nonetheless, if there are no sewers near to the development site or there are particular reasons why a connection to the public sewer system would not be possible i.e. topography, cost, environmental concerns, then the use of package treatment systems or cesspits is permitted.

The Environment Agency's "Binding Rules" control the use of package treatment systems and require the development to connect to the public sewer system if the site boundary is located within 30m of an existing sewer (plus an additional 30 meters for every proposed unit). In this case, the proposed development, is located within close proximity of a public foul sewer and there is an existing connection. Therefore, the use of package treatment systems is unlikely to be considered appropriate for this development.

9.2 Sewer Connection and Capacity

As indicated in Figure 3.2, there is an existing public foul sewer to the south of the site, within The Terrace. It is anticipated that the proposed development will connect into the existing sewer network, as shown in Figure 9.1 below. The proposed foul drawing is indicative, and where possible, the existing site foul sewerage network will be reutilised.



In accordance with the Design and Construction Guidance, the design peak flow rate for foul water discharged from the proposed development has been calculated as 1.3 l/s (108m³/day).

It will be necessary to undertake foul water capacity checks with SW at the detailed design stage, in order to determine the existing capacity within the public sewer network at this location. If insufficient capacity is available within the existing foul sewer, then it will be necessary to undertake a 'Level 2 Capacity Check' to determine the viability of upgrading the existing foul sewer network.

9.3 The Water Industry Act

The Water Industry Act 1991 provides developers with a mechanism for connecting to the public sewerage infrastructure. The type of connection depends on the type and location of the sewers in relation to the site and third-party land.

As the nearest sewers to the site are located outside of the development site boundary, the developer must requisition a new length of sewer from the sewerage undertaker, through a Section 98 application.

As part of the Section 98 process, it is necessary to determine whether the existing sewer network requires any upgrades to accommodate effluent from the development site. If upgrades to the sewerage system are required these will be requisitioned under the same Section 98 application. In this case, it is likely additional offsite works will be required and these will therefore be included within the Section 98 application. It is acknowledged that the cost of a new connection and any additional works which are required to upgrade the public sewer system (to accommodate the additional foul effluent from the development) can be charged to the developer.

Under Section 101, the sewerage undertaker must undertake any works as part of this process within a reasonable timeframe, which is typically 6 months following the agreement being made. Mitigating circumstances and Grampian planning conditions can, however, result in different timescales.

9.4 Summary

The opportunities for managing foul effluent discharged from the development site have been analysed and it is concluded that the existing connection to the public sewer system, located to the south of the site, is likely to present the most viable solution.

Following the award of planning permission, a full detailed design of the site layout and foul drainage system will be required as part of the Section 98 application, which will require a new connection to be requisitioned and any necessary upgrades made to the public sewer system. These upgrades are likely to be economically proportionate to the size of the development, however, it is recognised that a solution for managing foul waste from the proposed development will be available.

10 Conclusions

The overarching objective of this report is to appraise the risk of flooding at Custom House, The Terrace, Gravesend to ensure that the proposals for development are acceptable and that any risk of flooding to the occupants of the proposed residential units is appropriately mitigated. In addition, the NPPF also requires the risk of flooding offsite to be managed, to prevent any increase in flood risk as a result of the development proposals. This report has therefore been prepared to appraise the risk of flooding from all sources and to provide a sustainable solution for managing the surface water runoff discharged from the development site, in accordance with the NPPF, NTSS and local planning policy.

An assessment of a wide range of sources has shown that the risk of flooding to the development site is low, with only the northern half of the site being shown to flood in the extremely unlikely event that the tidal defences along the River Thames were to fail. However, it has been demonstrated that with appropriate mitigation, the development will be safe. The following mitigation is recommended to be incorporated into the development:

- **All sleeping accommodation should be located at least 600mm above the design flood level at a minimum of 6.92mAODN as agreed with the EA during pre-application discussions.** Raising the floor levels will ensure users of the site have safe refuge in the event that residents are unable to evacuate the site before the onset of flooding. The units at lower ground floor level in Custom House present an exception, as the analysis shows that floodwater is unable to ingress below the level of the estimated design flood level.
- **Where finished floor levels will not be raised above the design flood level within some of the northern units, Property Flood Resilience (PFR) measures should be retrofitted to the existing buildings to reduce the impact of flooding where possible.** Retrofitting measures to an existing building may require a survey of the existing flood performance of the building.
- **The residents of the units which are located within the predicted flood extents (from a breach) should sign up to the EA's flood warning service.** It is acknowledged that the onset of a breach is often unpredictable, however, it may be possible to receive forewarning of the conditions which may result in a breach of the defences up to 12 hours in advance. This forewarning could provide residents with time to prepare themselves to evacuate the site before the onset of flooding, or to seek safe refuge on an upper floor if water reaches the site first.

In addition to the above, this FRA has also demonstrated that the development will not increase the risk of flooding elsewhere. A SWMS has been prepared to ensure that there is a sustainable solution for managing surface water runoff discharged from the development in accordance with

the NTSS and local planning policy. It is concluded that the most viable solution for managing all of the surface water runoff discharged from the proposed development will be via a connection to the River Thames.

The use of SuDS has been assessed for the site, and the use of a storage tank has been proposed. The storage tank has been designed to provide appropriate storage for the rainfall generated under a 1 in 30 year return period event, under a scenario whereby the outfall is hydraulically locked by the tide (i.e. during an extreme event with a 1 in 2 year return period). If a rainfall event with a higher return period (i.e. a 1 in 100 year event including climate change) was to coincide with the outfall being blocked, the system has been designed to contain water above ground in a controlled manner. This stored water would subsequently be discharged back into the river once the tide has fallen. Under normal circumstances, the water generated under a 1 in 100 year rainfall event (including an allowance for 100 years of climate change) will discharge into the river without causing above ground flooding.

Details of the typical maintenance and management requirements for each element of the drainage system have been provided to ensure that the proposed drainage solution can be maintained and will continue to operate over the lifetime of the development. It is, however, recommended that an "owner's manual" containing additional product specific maintenance requirements is produced as part of the detailed design for the site.

The opportunities for discharging foul effluent from the site have also been considered and the appraisal demonstrates that the most viable solution is to connect into the existing foul sewer network, located south of the proposed site.

In conclusion, following the recommendations of this report, the occupants of the development will be safe and the development will not increase the risk of flooding elsewhere. Consequently, it has been demonstrated that the development can pass Part B of the Exception Test and will therefore meet the requirements of the NPPF and NTSS.

11 Appendices

Appendix A.1 – Drawings

Appendix A.2 – Environment Agency Correspondence

Appendix A.3 – Southern Water Asset Location Data

Appendix A.4 – Surface Water Management Calculations

Appendix A.5 – Indicative Drainage Layout

Appendix A.6 – Maintenance Schedules