Thurrock Council

Level 1 Strategic Flood Risk Assessment
Report Version 3 - FINAL

Thurrock Council

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Quality information

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1. Introduction

1.1 Approach to flood risk management

1.1.1 Thurrock Council is currently preparing documents that will form part of the Local Plan and set the vision for future development across the Borough up to 2040. Thurrock Council faces the challenge of meeting the need for new development within areas already identified to be at risk of both river (fluvial) and tidal flooding associated with a number of different watercourses including the Thames, Mardyke and Stanford Brook. Furthermore, parts of Thurrock regularly experience localised flooding from surface water generated by heavy rainfall, elevated groundwater, and surcharge of existing drainage systems.

1.1.2 The NPPF[1] and associated PPG[2] for Flood Risk and Coastal Change emphasise the active role LPAs should take to ensure that flood risk is assessed, avoided, controlled, mitigated and managed effectively and sustainably throughout all stages of the planning process. The overall approach for the consideration of flood risk set out in paragraphs 3 and 4 of the PPG is summarised as follows:

1.1.3 This has implications for LPAs and developers as described below.

Assess flood risk

1.1.4 The NPPF outlines that Local Plans should be supported by a Strategic Flood Risk Assessment (SFRA) and LPAs should use the findings to inform strategic land use planning. Figure 1-1 reproduced from the PPG, illustrates how flood risk should be taken into account in the preparation of the Local Plan by Thurrock Council.

1.1.5 Where appropriate[3], for sites in areas at risk of flooding, developers must undertake a site-specific Flood Risk Assessment (FRA) to accompany planning applications (or prior approval for certain types of permitted development[4], or technical details consent[5]). Assessments of flood risk should identify sources of uncertainty and how these are accounted for in a mitigation strategy.

Avoid flood risk

1.1.6 Thurrock Council should apply the sequential approach to site selection so that development is, as far as reasonably possible, located where the risk of flooding from all sources is lowest, taking account of climate change and the vulnerability of future users to flood risk.

1.1.7 In plan-making this involves applying the Sequential Test, and where necessary the Exception Test to Local Plans.

1.1.8 In decision-taking this involves applying the Sequential Test and if necessary, the Exception Test for specific development proposals.

1.1.9 *Within* individual application sites, the most vulnerable aspects of development must be located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location. Measures to avoid

[1] National Planning Policy Framework, July 2021 https://www.gov.uk/government/publications/national-planning-policy-framework--2
[2] Planning Practice Guidance – flood risk and coastal change, August 2022 https://www.gov.uk/guidance/flood-risk-and-coastal-change
[3] Refer to Section 8.1 for when a site specific FRA is required.
[4] Planning Practice Guidance Paragraph 053 'Permitted development rights and flood risk' https://www.gov.uk/guidance/flood-risk-and-coastal-change#para53
[5] Permission in principle guidance, March 2019, https://www.gov.uk/guidance/permission-in-principle

flood risk can also be taken by locating the most vulnerable uses on upper storeys and raising finished floor levels and/or ground levels.

1.1.10 Where the Sequential and Exception Tests have been applied as necessary and not met, development should not be allowed.

Control flood risk

1.1.11 Thurrock Council and developers can investigate measures to control the risk of flooding affecting the site. Early discussions with relevant flood risk management authorities, and reference programmes of flood and coastal erosion risk management schemes will help to identify such opportunities.

1.1.12 Thurrock Council and developers should seek flood risk management opportunities (e.g. safeguarding land), and to reduce the causes and impacts of flooding (e.g. through the use of sustainable drainage systems).

Mitigate flood risk

1.1.13 After applying measures to avoid and control the risk of flooding, the next step is to mitigate flooding. In accordance with paragraph 173(b) of the NPPF, development should only be allowed in areas at risk of flooding where it can be demonstrated that development is appropriately flood resistant and resilient, such that, in the event of a flood, it could be quickly brought back into use without significant refurbishment. Passive flood resilience and resistance measures should be prioritised over active measures as they are likely to be more effective and more reliable.

Manage residual flood risk

1.1.14 Thurrock Council and developers should consider further management measures to deal with any residual risk remaining after avoidance, control and mitigation have been utilised. Residual risks will need to be safely managed to ensure people are not exposed to hazardous flooding. LPAs and developers should provide safe access and escape routes and consider whether adequate flood warning would be available to people using the development.

1.1.15 In accordance with the PPG, measures to manage residual risk need to be considered early in the design process to ensure that they can be complimentary to other design requirements such as catering for the needs of the elderly or those with lesser mobility.

1.2 SFRA Aims and Objectives

1.2.1 The purpose of this SFRA is to collate and present the most up to date flood risk information for use by Thurrock Council to inform the preparation of the Thurrock Local Plan and prudent decision-making by development management officers on a day-to-day basis.

1.2.2 In order to achieve this, the SFRA will:

- Assess all potential sources of flooding, now and in the future, taking account of the impacts of climate change, based on readily available datasets.
- Inform the sustainability appraisal of the Local Plan, so that flood risk is fully taken into account when considering allocation options and in the preparation of plan policies.
- Identify existing flood risk management measures as well as areas that need to be adapted to climate change, and areas that need to be safeguarded for future flood risk management features and structures.
- Consider the potential cumulative impact of development and land use change on the risk of flooding in the study area.
- Inform the application of the Sequential and, if necessary, Exception Tests in the allocation of future development sites, as required by the NPPF, and planning application process.
- Identify the requirements for site-specific Flood Risk Assessments.
- Inform the preparation of flood risk policy and guidance and inform policies for land use change.

- Consider opportunities to reduce flood risk to existing communities and developments through better management of surface water, provision for conveyance and storage for flood water.

1.2.3 Thurrock Council should take an integrated approach to flood risk management when preparing plans, as per NPPF paragraph 161(c). This is a collaborative, catchment-based approach delivering coordinated management of water storage, supply, demand, wastewater, flood risk, quality of water and the wider environment.

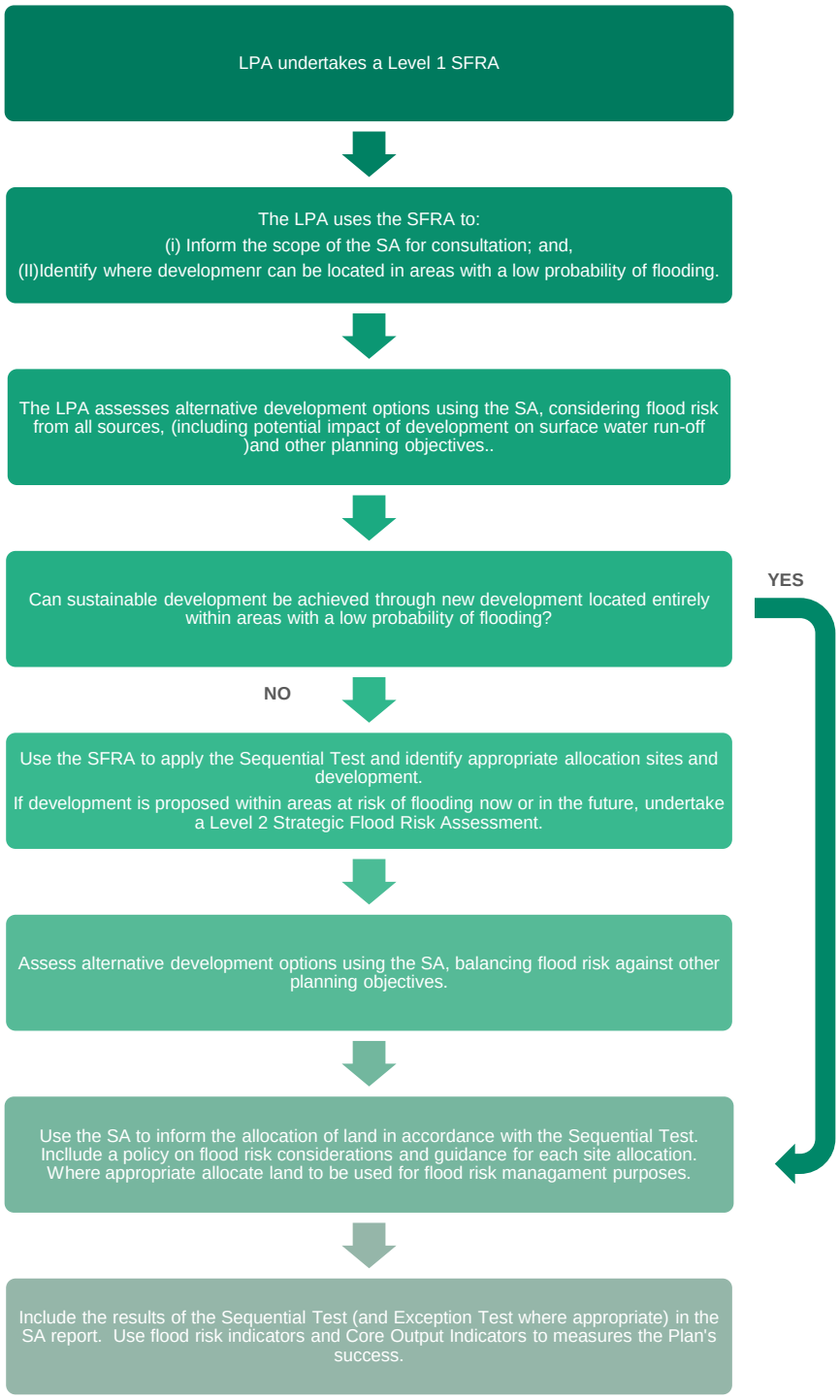


Figure 1-1 Taking flood risk into account in the preparation of strategic policies (Planning Practice Guidance for Flood Risk and Coastal Change Diagram 1)

1.3 Flood Risk Policy and Guidance

1.3.1 There is an established body of policy and guidance documents which are of particular importance when considering development and flood risk. These are identified in Table 1-1 including web links where further detail can be found.

Table 1-1 Flood risk policy and guidance documents

National Policy and Guidance	
National Planning Policy Framework (para. 159-169)	https://www.gov.uk/government/publications/national-planning-policy-framework--2
Planning Practice Guidance – Flood Risk and Coastal Change	https://www.gov.uk/guidance/flood-risk-and-coastal-change
Flood and Water Management Act (2010)	http://www.legislation.gov.uk/ukpga/2010/29/pdfs/ukpga_20100029_en.pdf
Flood Risk Regulations (2009)	http://www.legislation.gov.uk/uksi/2009/3042/pdfs/uksi_20093042_en.pdf
Flood risk assessments: climate change allowances	https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances
Environment Agency Standing Advice	https://www.gov.uk/guidance/flood-risk-assessment-standing-advice#vulnerable-developments-standing-advice
Flood and Coastal Erosion Risk Management Policy Statement 2020	https://www.gov.uk/government/publications/flood-and-coastal-erosion-risk-management-policy-statement
National Flood and Coastal Erosion Risk Management Strategy	https://www.gov.uk/government/publications/national-flood-and-coastal-erosion-risk-management-strategy-for-england--2
Regional Policy and Guidance	
South Essex Catchment Flood Management Plan	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/288893/South_Essex_Catchment_Flood_Management_Plan.pdf
Thames River Basin Management Plan	https://www.gov.uk/government/publications/thames-river-basin-district-river-basin-management-plan
Thames Flood Risk Management Plan	https://www.gov.uk/government/publications/thames-river-basin-district-flood-risk-management-plan
Thames Estuary 2100 Plan	https://www.gov.uk/government/collections/thames-estuary-2100-te2100
Managing future flood risk and Thames Barrier: Thames Estuary 2100	https://www.gov.uk/guidance/managing-future-flood-risk-and-thames-barrier-thames-estuary-2100#
South Essex Green and Blue Infrastructure Study Volume 1 and Volume 2	https://ca1-jsp.edcdn.com/downloads/South-Essex-Strategic-Green-and-Blue-Infrastructure-Study.pdf?v=1608722169 https://ca1-jsp.edcdn.com/downloads/South-Essex-Strategic-Green-and-Blue-Infrastructure-Study-Appendix.pdf?v=1608722188
Local Documents and Strategies	
Thurrock Local Flood Risk Management Strategy	http://democracy.thurrock.gov.uk/documents/s6554/Appendix%201%20-%20Thurrock%20Local%20Flood%20Risk%20Management%20Strategy.pdf
Thurrock Borough Council Preliminary Flood Risk Assessment (2011) and Addendum to the PFRA (2017)	https://democracy.thurrock.gov.uk/Data/Cabinet/201106081900/Agenda/$3949%20-%2015328.doc.pdf https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/698721/PFRA_Thurrock_Borough_Council_2017.pdf
Thurrock Water Cycle Study	Under preparation.
Thurrock Green and Blue Infrastructure Strategy 2022/23 Update	https://publishing.thurrock.gov.uk/ObjProxyServices/GetDoc.svc/GetObjDoc?objectID=LN8N8C%2bAIsXQXxjkCF%2fSr0vFgwxUrlHCCRBcCuWCCws%3d
Thurrock Council Climate Change Strategy Update	https://democracy.thurrock.gov.uk/documents/s37351/Climate%20Change%20Strategy%20Presentation.pdf
Thurrock Council Climate Change Action Plan Update Note (November 2021)	https://democracy.thurrock.gov.uk/documents/s33321/Climate%20Change%20Presentation.pdf

Thurrock Core Strategy Policy CSTP27 Management and Reduction of Flood Risk	https://www.thurrock.gov.uk/sites/default/files/assets/documents/core_strategy_adopted_2011_amended_2015.pdf
Thurrock Core Strategy Policy CSTP28 River Thames	https://www.thurrock.gov.uk/sites/default/files/assets/documents/core_strategy_adopted_2011_amended_2015.pdf
Thurrock Core Strategy Policy CSTP25 Addressing Climate Change	https://www.thurrock.gov.uk/sites/default/files/assets/documents/core_strategy_adopted_2011_amended_2015.pdf
Tilbury Integrated Flood Strategy	JBA Consulting: Tilbury Integrated Flood Strategy PS/2015/994 (Jan. 2017)

1.4 User Guide

1.4.1 It is anticipated that the SFRA will have a number of end users, with slightly different requirements. For example strategic planners who may be developing policies, undertaking the Sequential Test and allocating sites; development management officers, emergency planners, and those preparing site specific FRAs. Table 1-2 provides a user guide to summarise the content of the SFRA .

Table 1-2 SFRA Structure

SFRA Section	
Section 2: Methodology	Identifies the datasets and methodologies applied within the SFRA for assessing flood risk.
Section 3: Assessing flood risk in Thurrock	Provides an overview of the different sources of flooding, cumulative impacts of development on flood risk and cross boundary considerations.
Section 4: Avoiding flood risk – Applying the Sequential Test	Provides details of how the Sequential Test should be applied at the Local Plan stage, and for individual planning applications, as well as information on the Exception Test.
Section 5: Measures to control and mitigate flood risk	Identifies existing measures in place to control flooding such as existing flood risk management infrastructure, flood storage areas, and flood alleviation schemes. Identifies opportunities that should be considered when developing strategic plans, and as part of site specific FRAs for future development, to control and mitigate the risk of flooding, such as safeguarding of land for future flood risk management, surface water management measures, property resilience measures.
Section 6: Assessing and managing residual risk	Provides an assessment of the risk of tidal flooding from overtopping or breach in the defences, as well as measures to manage residual risks such as flood warning, emergency planning, provision of safe access/escape and places of safety.
Section 7: Preparing a site-specific FRA	Provides details on when FRAs are required, what they should address and where to go for pre application advice.
Section 8: Next steps	Summary of next steps for Thurrock Council.
Appendix A Flood risk mapping	Thurrock wide mapping of datasets identified in Section 2.
Appendix B Tidal Modelling Methodology	Technical Note detailing tidal modelling methodology, assumptions and limitations.
Appendix C Mapping: Risk from Tidal Overtopping	Mapping of the results of the tidal overtopping modelling.
Appendix D Mapping: Risk from Tidal Breach	Mapping of the results of the tidal breach modelling.
Appendix E Mardyke Sensitivity Analysis	Technical Note describing the sensitivity analysis undertaken on the Mardyke model.
Appendix F West Horndon Integrated Model Technical Note	Technical Note describing the integrated catchment modelling undertaken for West Horndon.
Appendix G Tilbury Integrated Model Technical Note	Technical Note describing the integrated catchment modelling undertaken for Tilbury.
Appendix H Summary of the SFRA recommendations	Recommendations for Thurrock Council to take forward in their Local Plan preparation are provided throughout the SFRA. This Appendix provides a list of all the recommendations in one location.

1.5 Monitoring and Update

1.5.1 SFRAs are living documents that should be reviewed after a significant flood event or when there are changes to:

- The predicted impacts of climate change on flood risk,
- Detailed flood modelling - such as from the Environment Agency or Lead Local Flood Authority,
- Local Plans, spatial development strategies or relevant local development documents,
- Local flood management schemes,
- Flood Risk Management Plans,
- Shoreline Management Plans,
- Local Flood Risk Management Strategies, and,
- National planning policy or guidance.

1.5.2 Thurrock Council prepared their first SFRA in 2009 and subsequently updated it in 2017. This version of the SFRA (prepared in 2022/2023) provides a further update, incorporating the following changes:

- Reference to the latest national and regional policy and guidance documents, including the latest NPPF (July 2021), latest climate change allowances (May 2022) and the updates to the Planning Practice Guidance (PPG) (August 2022).
- Updated tidal flood modelling along the Thames frontage in accordance with the latest Environment Agency guidance (June 2021) to assess the impact of overtopping, and the impact of breach in flood defences at 21 locations.
- Incorporating the outputs from the latest modelling studies for the Thames Estuary (TE211 Extreme Water Level Modelling), Stanford Brook and River Mardyke as provided by the Environment Agency. AECOM have also undertaken a sensitivity analysis on the River Mardyke model to explore the effect of runoff change in the catchment.
- Updates to the Integrated Catchment Model for West Horndon to appraise the potential cumulative impact of development within the catchment.
- Updates to the Integrated Catchment Model for Tilbury to appraise the potential cumulative impact of development in the catchment.

1.5.3 Initial assessment of potential for an Integrated Catchment model for Stanford le Hope/Corringham is also being undertaken but is outside the scope of this version of the SFRA.

2. Methodology

2.1 Overview

2.1.1 Under Section 14 of NPPF, the risk of flooding from all sources must be considered as part of a SFRA, including flooding from the sea (tidal), rivers (fluvial), land (overland flow and surface water), groundwater, sewers and artificial sources.

2.1.2 The methodology for the appraisal of flood risk from these sources is outlined below. Section 2.2 describes the approach to consultation and identifies the stakeholder organisations that have been involved; Section 2.3 provides a description of the datasets and models received. Section 2.4 identifies the modelling tasks that have been completed as part of this SFRA.

2.2 Consultation

Duty to Cooperate

2.2.1 Under the Localism Act 2011[6], there is now a legal duty on LPAs to cooperate with one another. County Councils and other Prescribed Bodies must work together to maximise the effectiveness within which certain activities are undertaken as far as they relate to a 'strategic matter'.

2.2.2 In complying with the duty to cooperate, Government Guidance recommends that LPAs 'scope' the strategic matters of Local Plan documents at the beginning of the preparation process taking account of each matters 'functional geography' and identify those LPAs and Prescribed Bodies that need to be constructively and actively engaged.

2.2.3 The Council prepared a Draft Sustainability Appraisal Scoping Report (2016)[7] as part of the background work required in preparing the Thurrock Local Plan. Flood risk is identified as a strategic matter and specific engagement activities are proposed with a number of adjoining LPAs and Prescribed Bodies both in relation to the preparation of the SFRA and the Local Plan.

[6] HMSO, 2011, *Localism Act 2011.*http://www.legislation.gov.uk/ukpga/2011/20/contents/enacted
[7] Thurrock Council, 2016, *Sustainability Appraisal Scoping Report (DRAFT)*
https://www.thurrock.gov.uk/sites/default/files/assets/documents/localplan_sa_201602_draft_report.pdf

Table 2-1 SFRA Stakeholder Organisations and Roles

Stakeholder Organisation	Role with respect to the Thurrock SFRA
Thurrock Council as LPA	As a LPA Thurrock Council has a responsibility to consider flood risk in their strategic land use planning and the development of their Local Plan. The NPPF requires LPAs to undertake a SFRA and to use their findings, and those of other studies, to inform strategic land use planning including the application of the Sequential Test which seeks to steer development towards areas of lowest flood risk prior to consideration of areas of greater flood risk. During the preparation of the SFRA, Thurrock Council has provided access to available datasets held by the Council. In addition, the SFRA will be used by the Thurrock Council Emergency Planning team to ensure that the findings are incorporated into their understanding of flood risk and the preparation of their flood plan.
Thurrock Council as LLFA and Highways Authority	As the LLFA, under the Flood and Water Management Act (FWMA) Thurrock Council has a duty to take the lead in the coordination of local flood risk management, specifically defined as flooding from surface water, groundwater and ordinary watercourses and to this end has prepared the Thurrock Council Local Flood Risk Management Strategy (LFRMS)[8]. Thurrock Council as LLFA is responsible for regulation and enforcement on ordinary watercourses and is a statutory consultee for future sustainable drainage systems (SuDS) for major developments following changes to the Town and Country Planning (Development Management Procedures) (England) Order 2015. Following the Jenkins review[9], the Government intends to implement Schedule 3 of the FWMA and set up SuDS Approval Bodies (SABs) within Unitary or County Councils. In due course, Thurrock Council will therefore also become a SAB. Thurrock Council is the Highways Authority and therefore has responsibilities for the effectual drainage of surface water from adopted roads insofar as ensuring that drains, including kerbs, road gullies and ditches and the pipe network which connect to the sewers, are maintained.
Environment Agency	The Environment Agency is responsible for managing the risk of flooding from Main Rivers and the sea and has a responsibility to provide a strategic overview for all flooding sources and coastal erosion. Under the FWMA, the Environment Agency has a statutory duty to develop a National Flood and Coastal Risk Management Strategy for England. The Environment Agency is a statutory consultee to the Land Use Planning system for development, other than minor development in an areas of Flood Zones 2 or 3, development within notified areas with critical drainage problems or for development within 20m of a main river watercourse (as set out in Schedule 4 of the Town and Country Planning (Development Management Procedure) (England) Order 2015. The Environment Agency is a prescribed body under the Town and County Planning (Local Planning) (England) Regulations 2012 and has a duty to co-operate with the LPA. The Environment Agency has a role to provide technical advice to LPAs and developers on how best to avoid, manage and reduce the adverse impacts of flooding. Part of this role involves advising on the preparation of spatial plans, sustainability appraisals and evidence base documents, including SFRAs as well as providing advice on higher risk planning applications. The Environment Agency undertakes systematic modelling and mapping of fluvial flood risk associated with all Main Rivers in the study area, as well as supporting Lead Local Flood Authorities (LLFA) with the management of surface water flooding by mapping surface water flood risk across England. The Environment Agency has supplied available datasets for use within the SFRA. The Environment Agency has been involved in the commissioning of the SFRA and has performed a technical review role of the draft project deliverables including the technical breach modelling methodology and positioning of updated breach locations.
Anglian Water	Anglian Water (AW) is responsible for surface water drainage from development in the Anglian Basin District via adopted sewers and for maintaining public sewers into which much of the highway drainage connects. In relation to the SFRA, the main role that AW will play is providing data regarding past sewer flooding.
British Geological Survey (BGS)	BGS hold a number of datasets that have informed the SFRA, including superficial and bedrock geology, groundwater flooding potential and suitability of infiltration SuDS.

2.3 Data collection

2.3.1 A large quantity of information, datasets and models have been made available by the stakeholder organisations to inform the SFRA. The datasets are listed in Table 2-2 and models received are listed in Table 2-3.

[8] Thurrock Council, 2015, Thurrock Local Flood Risk Management Strategy
http://democracy.thurrock.gov.uk/documents/s6554/Appendix%201%20-%20Thurrock%20Local%20Flood%20Risk%20Management%20Strategy.pdf
[9] Defra, January 2023, The review for implementation of Schedule 3 to The Flood and Water Management Act 2010.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1128073/The_review_for_implementation_of_Schedule_3_to_The_Flood_and_Water_Management_Act_2010.pdf

Table 2-2 Datasets obtained to inform the SFRA

Name	Description	Type	Source	SFRA Map
Detailed River Network	Spatial dataset showing main rivers and smaller watercourses.	GIS Shapefile	Environment Agency	Multiple
LiDAR Topographic DTM	Light Detection and Ranging (LIDAR) is an airborne mapping technique, which uses a laser to measure the distance between the aircraft and the ground. The DTM is produced from the last return LiDAR signal and surface objects are removed (such as buildings, vegetation) to provide a ground surface model.	ASCII	Defra Data Services Platform	Map 2
Bedrock and superficial geology	Generalised digital geological map data based on BGS's published poster maps of the UK.	GIS shapefile	British Geological Survey Open Data	Map 3, 4
Historic Flood Map	GIS layer showing areas of land that have previously been subject to flooding from sea, river or groundwater in line with criteria set by the Environment Agency. This excludes flooding from surface water, except in areas where it is impossible to determine whether the source is fluvial or surface water but the dominant source is fluvial.	GIS Shapefile	Defra Data Services Platform	Map 5
Recorded flood incidents	Locations known to Thurrock Council in their role as the LLFA that have experienced flooding and recorded within their LFRMS. These range from minor drain blockages through to flooding of entire roads.	GIS Shapefile	Thurrock Council (LLFA)	Map 5
Records of sewer flooding	Records of internal and external sewer flooding incidents reported by Anglian Water for 5 digit post code areas in Thurrock.	MS Excel Workbook	Anglian Water	Map 6
Postcode Boundary	GIS layer of post code areas. Used to map the Anglian Water sewer flooding records which are reported by 5 digit post code area.	GIS Shapefile	Thurrock Council	Map 6
Flood Map for Planning (rivers and sea) Flood Zones 2	The Environment Agency's best estimate of the areas of land at risk of flooding, from rivers or the sea with a 1 in 1000 (0.1%) chance of flooding each year, when the presence of flood defences are ignored.	GIS Shapefile	Defra Data Services Platform	Map 7
Flood Map for Planning (rivers and sea) Flood Zones 3	The Environment Agency's best estimate of the areas of land at risk of flooding, when the presence of flood defences are ignored and covers land with a 1 in 100 (1%) or greater chance of flooding each year from Rivers; or with a 1 in 200 (0.5%) or greater chance of flooding each year from the Sea.	GIS Shapefile	Defra Data Services Platform	Map 7
Reduction in Risk of Flooding from Rivers and Sea due to Defences	A spatial dataset that indicates where areas have reduced flood risk from rivers and sea due to the presence of flood defences. The dataset has been created to help initiate conversations about the impact our flood defences have on the risk of flooding from the rivers and sea,and as a prompt to find out more about the flood defences in a particular area of interest. It does not replace any local, more detailed information.	GIS Shapefile	Defra Data Services Platform	Map 7
Flood Map for Planning (rivers and sea) Flood Storage Areas	Areas that act as a balancing reservoir, storage basin or balancing pond.	GIS Shapefile	Defra Data Services Platform	Map 7
Risk of flooding from surface water flood extents (3.3% AEP, 1% AEP, 0.1% AEP)	GIS layers showing the extent of flooding from surface water that could result from a flood with a 3.3% (1 in 30 year), 1% (1 in 100 year) and 0.1% (1 in 1000 year) chance of happening in any given year. This is not suitable for identifying whether an individual property will flood but is useful to identifying areas susceptible to surface water flooding and key flow paths.	GIS Shapefile	Defra Data Services Platform	Map 8
Areas of Critical Drainage	GIS layers showing Areas of Critical Drainage as defined in the Thurrock Council Surface Water Management Plan and Local Flood Risk Management Strategy. These are areas with known and modelled surface water flood risk.	GIS Shapefile	Thurrock Council	Map 8

Name	Description	Type	Source	SFRA Map
Susceptibility to groundwater flooding	Dataset which shows where there is the potential for groundwater flooding but does not give any indication of the probability that it will occur. Susceptibility is classified into three categories: Potential for groundwater flooding to occur at surface; Potential for groundwater flooding of property situated below ground level; Limited potential for groundwater flooding to occur.	GIS shapefiles	British Geological Survey	Map 9
Risk of Flooding from Reservoirs mapping	Flood extents for all large raised reservoirs in the event that they were to fail and release the water held on a "dry day" when local rivers are at normal levels, and on a "wet day" when local rivers had already overflowed their banks.	GIS Shapefiles	Defra Data Services Platform	Map 10
Infiltration SuDS Suitability dataset	Dataset which gives a preliminary indication of the suitability of the ground for infiltration SuDS. These are drainage systems that allow surface water to infiltrate to the ground, such as soakaways, infiltration basins, infiltration trenches and permeable pavements. The mapping allows consideration of subsurface permeability, depth to groundwater, presence of geological floodplain deposits, presence of artificial ground, ground stability, potential for pollutant attenuation, and the Environment Agency's source protection zones.	GIS Shapefile	British Geological Survey	Map 11
Flood Warning Areas	Geographical areas where flooding is expected to occur and where the Environment Agency provide a Flood Warning Service. They generally contain properties that are expected to flood from rivers or the sea and in some areas, from groundwater.	GIS Shapefile	Defra Data Services Platform	Map 12
Working with natural processes datasets	A series of spatial datasets identifying best estimate of locations in the country where natural flood management methods can be applied such as: floodplain woodland planting potential, riparian woodland planting potential, wider catchment woodland, floodplain reconnection potential, runoff attenuation features.	GIS Shapefiles	Defra Data Services Platform	Map 13
Spatial Flood Defence Layer	Shows flood defences currently owned, managed or inspected by the Environment Agency. Typically, these are earth banks, stone and concrete walls, or sheet-piling that is used to prevent or control the extent of flooding.	GIS Shapefile	Defra Data Services Platform	Map 14

Table 2-3 Hydraulic Models received and used to inform the SFRA

Model	Details	SFRA Map
Thames Estuary 2100 Extreme Water Level Estuary Modelling	Outputs from the latest TE2100 Modelling were provided to Thurrock Council to inform the tidal overtopping and breach modelling undertaken as part of this SFRA.	SFRA Tidal Modelling (which uses TE2100 inputs) is presented in Appendix C and D. Modelling Note in Appendix B sets out the methodology applied.
PDU4 River Mardyke Hydraulic Model, Mott MacDonald, May 2019.	Model of the **River Mardyke:** 1D-2D hydrodynamic model using Flood Modeller Pro and TUFLOW software. Model of the **Barnards Sewer** tributary. Modelled separately using a 2D only approach for purposes of updating the flood zone maps along this tributary using TUFLOW. Through the village of **West Horndon**, an existing Integrated Catchment Model (ICM) InfoWorks model has been updated to derive the flood extents in this area.	Map 7 – flood extents for the Mardyke and tributaries for the 3.3% AEP event (1 in 30 year) (Flood Zone 3b Functional Floodplain) and the 1% AEP event (1 in 100 year) plus 25%, 35% or 70% climate change allowances. Refer to Section 2.4 for sensitivity analysis completed for the River Mardyke model, and further work undertaken as part of this SFRA for West Horndon using the ICM.
Stanford Brook Hydraulic Model, CH2MHill, May 2017.	Updated 1D-2D model for the fluvial **Stanford Brook** using Flood Modeller Pro and TUFLOW software.	Map 7 – flood extents for the Stanford Brook for the 3.3% AEP event (1 in 30 year) (Flood Zone 3b Functional Floodplain) and the 1% AEP event (1 in 100 year) plus 25%, 35% or 70% climate change allowances.
Tilbury Integrated Flood Strategy PS/2015/994, JBA Consulting, January 2017	Integrated catchment model of the drainage system in **Tilbury** that includes all components of the drainage system and the interaction between them.	Refer to Section 2.4 for further work undertaken as part of this SFRA for using the ICM.

2.4 Hydraulic Modelling Tasks

2.4.1 As part of the SFRA for Thurrock a number of additional hydraulic modelling exercises have been undertaken as described in this section.

Tidal modelling

2.4.2 In order to determine the residual risk of flooding from the Thames Estuary, the scope of this SFRA included updated modelling of overtopping and breach in the tidal defences throughout the study area for the 0.5% (1 in 200 year) and 0.1% (1 in 1000 year) AEP events for the epochs 2025 and 2125.

2.4.3 The methodology is included in Appendix B and the mapping of the results in Appendix C (Overtopping Results) and D (Combined Breach Results).

- Appendix C **Overtopping Results**
  - Map 1: Overtopping 0.5% AEP (1 in 200 year) (2025) – Maximum Depth (m)
  - Map 2: Overtopping 0.5% AEP (1 in 200 year) (2025) – Maximum Hazard Rating
  - Map 3: Overtopping 0.1% AEP (1 in 1000 year) (2025) – Maximum Depth (m)
  - Map 4: Overtopping 0.1% AEP (1 in 1000 year) (2025) – Maximum Hazard Rating
  - Map 5: Overtopping 0.5% AEP (1 in 200 year) (2125) – Maximum Depth (m)
  - Map 6: Overtopping 0.5% AEP (1 in 200 year) (2125) – Maximum Hazard Rating
  - Map 7: Overtopping 0.1% AEP (1 in 1000 year) (2125) – Maximum Depth (m)
  - Map 8: Overtopping 0.1% AEP (1 in 1000 year) (2125) – Maximum Hazard Rating
- Appendix D **Combined Breach Modelling Results**
  - Map 1: Breach Assessment 0.5% AEP (1 in 200 year) (2125) – Maximum Depth (m)
  - Map 2: Breach Assessment 0.5% AEP (1 in 200 year) (2125) – Maximum Hazard Rating
  - Map 3: Breach Assessment 0.1% AEP (1 in 1000 year) (2125) – Maximum Depth (m)
  - Map 4: Breach Assessment 0.1% AEP (1 in 1000 year) (2125) – Maximum Hazard Rating

Future Thames Barrier

2.4.4 Analysis of the Thames Estuary 2100 modelling datasets has been undertaken, to provide an initial understanding of the potential impact of a future flood barrier at Long Reach. This is reported in Appendix B Section 4.

Cumulative Impact of development

2.4.5 SFRAs should consider the cumulative impact of development and land use change on the risk of flooding[10]. At the time of preparation of this version of the SFRA, detailed information about the location of development is unknown due to the change in the level of detail presented for the Regulation 18 consultation. The detail would need to be considered further at a future update of the SFRA. Instead a high level assessment of the levels of growth and distribution of development across the borough has been considered.

2.4.6 In order to further consider the potential for cumulative impact in specific areas at risk of flooding, the scope of this SFRA incorporates three localised assessments of flood risk:

Mardyke – Sensitivity Analysis

2.4.7 Sensitivity analysis has been undertaken using the Environment Agency Mardyke river model, to determine the potential impact should runoff in the contributing catchments change in the future as a result of increased development. Appendix E details the work completed, and a summary of the results is included in Section 3.8.

[10] NPPF paragraph 160.

West Horndon Integrated Catchment Model

2.4.8 An Integrated Catchment Model for this area this area has been developed, (using the ICM model of the upper Mardyke catchment as a basis, Table 2-3) and scenarios undertaken to determine the potential impact of future development in the catchment. Appendix F details the work completed, and a summary of the results is included in Section 3.8.

Tilbury Integrated Catchment Model

2.4.9 The Integrated Catchment Model for this area has been updated and additional scenarios undertaken to determine the potential impact of future development in the catchment. Appendix G details the work completed, and a summary of the results is included in Section 3.8.

Stanford-le Hope Further Assessment

2.4.10 An Initial Assessment for Stanford-le Hope was undertaken in 2018/19 and identified the risk to 42 properties from surface water flooding in a 1.3% AEP (1 in 75 year) event, accounting for a 150mm depth threshold, with up to 4 properties at risk of fluvial flooding in a 1.3% AEP (1 in 75 year) event. There is also an impact on the existing railway infrastructure in this area as a result of fluvial flooding, and therefore both Network Rail and C2C would be the main beneficiaries.

2.4.11 The Initial Assessment identified that due to the relatively low number of properties at risk of flooding from pluvial and fluvial sources a significant contribution from external sources would be required to support the project.

2.4.12 Thurrock Council are seeking to engage with key stakeholders to help progress this project into the next stages. The extent of the scope is still to be agreed and is outside the timescale of this Level 1 SFRA.

3. Assessing Flood Risk in Thurrock

3.1 Study Area

3.1.1 The study area is defined by the administrative boundary of Thurrock Council and covers 163km^2. It is adjacent to Greater London in the West (London Borough of Havering) and the Essex County (Brentwood, Basildon and Castle Point) in the north and east. To the south of Thurrock and the River Thames are the London Borough of Bexley, the Kent authorities of Dartford and Gravesham and Medway unitary authority.

3.1.2 The River Thames forms the southern Borough boundary and Vange Creek flows from north to south along the extent of the eastern boundary before discharging into the River Thames. The River Thames forms 30km of tidally influenced riverfront adjacent to Thurrock. There are two other significant Main Rivers: Mardyke, which flows into the Thames at Purfleet; and Stanford Brook which discharges in the Thames south of Stanford-Le-Hope.

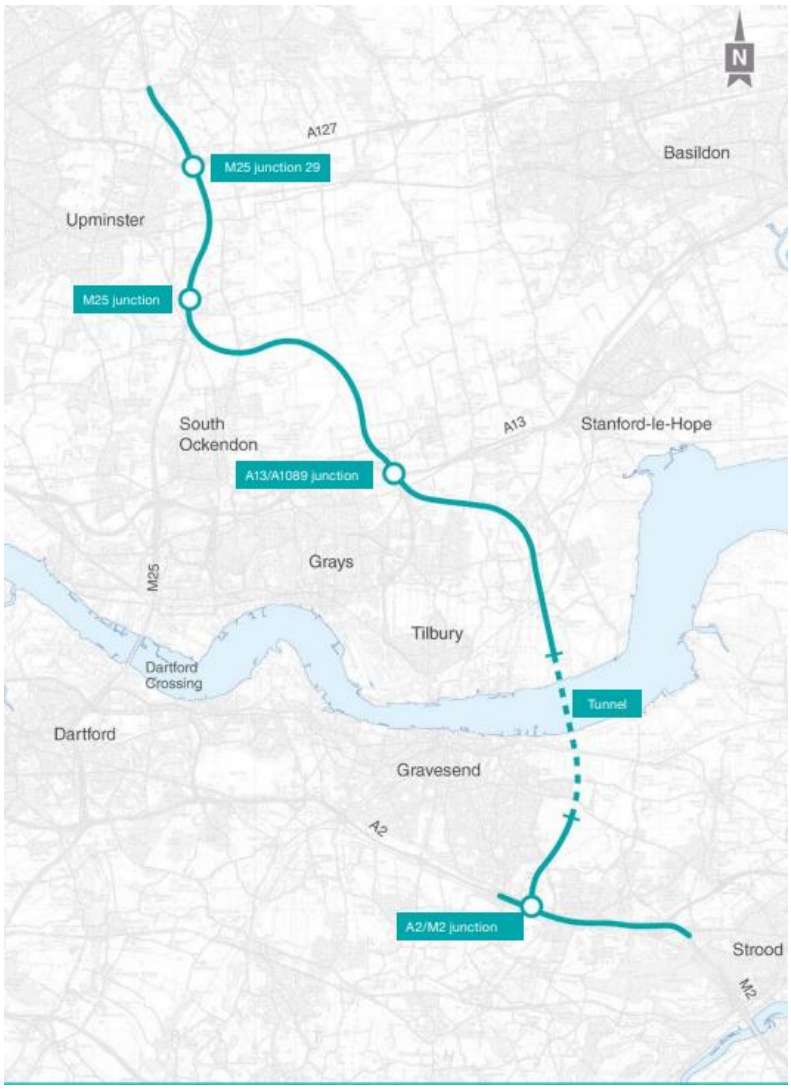
3.1.3 Thurrock's population was 176,000 in 2021[11]. The 2011 census recorded 62,353 households[12]. The Borough forms part of the Thames Gateway regeneration area, which is a corridor of opportunity identified by the government as an area with the greatest development and commercial potential in the country. As such, much of the population and commercial use is centred along the riverfront, this includes the Lakeside Shopping Centre and many industrial and logistic sites, the ports of London Gateway and Tilbury with associated distribution warehousing, a cruise liner terminal (Tilbury) and Purfleet Deep Wharf. There are several large landfill sites located along the eastern extent of the Thames frontage that are coming to the end of operation and the land is being restored.

3.1.4 Thurrock has good transport links due to its proximity to the River Thames and Greater London. The M25 crosses the River Thames by bridge and tunnel between Dartford and Thurrock. Thurrock has good east-west road connections with the A13 and A127 and a railway direct to London Fenchurch Street that provides access to Central London. The Port of London Gateway and Port of Tilbury, nearby connections to HS1 via Ebbsfleet and Stratford International Stations, and the airports of London City and Southend highlight that Thurrock is well placed in terms of international connections.

3.1.5 There are significant targets for new homes and jobs in Thurrock. The Thurrock Core Strategy (adopted 2011 and amended in 2015) sets out a target for the Borough of 23,250 additional homes between 2001 and 2026 and 26,000 additional jobs. The 2022 published South Essex Housing Needs Assessment identifies an annual requirement of 1,181 dwellings per annum for Thurrock. This equates to an identified housing need of at least 23,620new dwellings to 2040 in order to sustain the planned population growth and provide housing to meet forecast job growth[13].

3.1.6 In addition, the government is planning a new road tunnel under the Thames Estuary which will link the M25 near North Ockenden in Essex to the A2 near Shorne in Kent (Figure 3-1). Further description is provided in Section 3.9.

[11] https://www.thurrock.gov.uk/thurrock-facts-and-statistics/population#:~:text=Thurrock%20has%20a%20diverse%20population,the%20population%20to%20be%20176%2C000.
[12] Thurrock Borough Council (2015) Thurrock Joint Strategic Needs Assessment: Demographics and Population Change, Available at: https://www.thurrock.gov.uk/sites/default/files/assets/documents/jsna-demographics-population-v02.pdf
[13] www.thurrock.gov.uk/sites/default/files/assets/documents/southessex-housingneedsassessment-202206-v01.pdf



Source: National Highways (2022) https://highwaysengland.citizenspace.com/cip/ltc-local-refinement-consultation-2022/

Figure 3-1 Lower Thames Crossing Route

3.2 Topography

3.2.1 **Appendix A Map 2** shows the topography of the Borough. The River Thames flows eastwards along the southern Borough boundary where the land is low lying with levels fluctuating around 0m Above Ordnance Datum (mAOD). Lower topography is also located in the eastern Borough boundary, associated with Vange Creek and the western part of the Borough associated with the Mardyke where ground levels vary between 0mAOD and 5mAOD. In the centre of the Borough at South Ockendon, Chafford Hundred and Orsett, the ground rises quickly away from the coast reaching 39mAOD in places. The highest elevation is circa. 109mAOD at Westley Heights.

3.3 Flooding from rivers and sea

3.3.1 As shown in **Appendix A Map 1**, the principal main river-designated watercourses within the Borough include the River Thames and Vange Creek, which are both tidally influenced; and the River Mardyke and Stanford Brook, which are fluvial watercourses. Additionally, there is an extensive network of arterial drainage channels designated as Main River that drain Tilbury, the low-lying agricultural areas and tidal marshes.

3.3.2 The Environment Agency have duties and powers in relation to Main Rivers[14] and Thurrock Council, in their role as the Lead Local Flood Authority (LLFA), have duties and powers in relation to ordinary watercourses including ditches, dykes, rivers, streams and drains (not public sewers).

Flood Zones

3.3.3 The NPPF categorises areas within the tidal and fluvial floodplain into zones of low, medium and high probability, as defined and presented on the Flood Map for Planning (Rivers and Sea)[15]. Flood Zones are shown in **Appendix A Map 7.**

Table 3-1 Flood Zones (PPG Flood Risk and Coastal Change Table 1)

Flood Zone	Flood Zone Definition for River Flooding	Probability of Flooding
Flood Zone 1	Land having a less than 1 in 1,000 probability of river or sea flooding each year (0.1% AEP). Shown as clear on the Flood Map – all land outside Flood Zones 2 and 3.	Low
Flood Zone 2	Land having between a 1 in 100 and 1 in 1,000 probability of river flooding each year (between 1% and 0.1% AEP); or land having between a 1 in 200 and 1 in 1,000 probability of sea flooding (between 0.5% and 0.1% AEP)	Medium
Flood Zone 3a	Land having a 1 in 100 or greater probability of river flooding each year (greater than 1% AEP); or land having a 1 in 200 or greater probability of sea flooding (greater than 0.5% AEP).	High
Flood Zone 3b	Land where water from rivers or the sea has to flow or be stored in times of flood. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. Functional floodplain will normally comprise: • Land having an annual probability of 1 in 30 (greater than 3.3% AEP) of flooding, with existing flood risk management features and structures operating effectively, • Land that is designed to flood (such as a flood attenuation scheme), even if it would only flood in more extreme events (such as 0.1% annual probability of flooding). LPAs should define Flood Zone 3b within their SFRA in agreement with the Environment Agency. It is not separately distinguished from Flood Zone 3a on the Flood Map for Planning (Rivers and Sea).	Functional Floodplain

3.3.4 **Appendix A Map 7** shows that large parts of the Borough are defined as Flood Zone 3, i.e. high probability of flooding ignoring the presence of defences. The areas at greatest risk of tidal flooding in Thurrock (assuming no defences are present) include the London Gateway Port, Tilbury and Grays.

Tidal flooding – River Thames and Vange Creek

3.3.5 The Thames drains the whole of Greater London before discharging into the North Sea via the Thames Estuary. It is tidally influenced for approximately 90km of its length up to Teddington in London Borough of Richmond upon Thames. The southern boundary of the Thurrock study area is formed by the River Thames which has been heavily modified over time to include the construction of raised defences along its frontage. The defences are predominantly defined as 'hard defences' and largely provide a high standard of defence, offering protection up to and in excess of 0.1% AEP (1 in 1000 year) level. Tidal barriers have been constructed at the mouth of Tilbury Docks to protect this area, much of which is below sea level.

3.3.6 The eastern border of the Borough includes the marshes of Fobbing and Vange which drain into the Vange Creek and Holehaven Creek, which are both Sites of Scientific Interest (SSSI). These creeks then flow to join the Thames at the Sea Reach section. Prior to the 1953 flood event, the Vange Creek was navigable by sea. The Fobbing Horse tidal flood barrier was built on Vange Creek in the early 1980s as part of the wider Thames Tidal Defence Scheme to continue the primary defence line across the creek from Fobbing to Bowers Marsh by limiting the passage of flood water up the creek. Three gates

[14] All watercourses in England and Wales are classified as either 'Main Rivers' or 'Ordinary Watercourses'. The difference between the two classifications is based largely on the perceived 'importance' of the watercourse with particular reference to its potential to cause significant and widespread flooding. However, the watercourses classed as ordinary watercourses can still cause significant localised flooding.
[15] Flood Map for Planning https://flood-map-for-planning.service.gov.uk/

drop from the roof of the structure into the channel to prevent water ingress when in operation, but also to retain a navigation function further up the creek (refer to Section 5).

3.3.7 The primary flood mechanisms associated with these tidally influenced watercourses are:

- Daily tidal fluctuation, occurring when the freshwater Thames is met by the incoming tide from the North Sea;
- Surge tides, which occur due to climatic conditions creating bands of low pressure in the Atlantic and North Sea. This causes a surge of water to move across the Atlantic, travelling southwards into the North Sea and becoming compressed as it travels towards and through the narrow English Channel, between Great Britain and mainland Europe. This causes a rapid rise in sea levels, which can be exacerbated by strong northerly winds.

3.3.8 The greatest overall flood risk from the Thames Estuary occurs when tidal surges coincide with particularly high tide levels and/or fluvial flooding in the upper reaches of the catchment. As the flood risk associated with fluvial mechanisms is relatively minor, compared to the tidal influence, the risk from the River Thames is defined as tidal and addressed as such within this SFRA.

Historic records of tidal flooding

3.3.9 Historically South Essex and Thurrock has experienced tidal flooding on a large scale, due to its location on the Thames Estuary. The largest of these flood events were in 1897[16], 1928[17], 1938[18] and 1953.

Flood defences and further assessment of tidal flooding

3.3.10 Following the 1953 tidal surge, and subsequent local repairs and minor raising works, the 1972 Thames Barrier and Flood Protection Act was passed to construct the Thames Barrier - originally designed to give a 0.1% AEP (1 in 1000 year) standard of protection to central London until 2030. Local works were commissioned based upon the provisions of this Act, which resulted in the raising of tidal defences within the Borough (and the rest of the Thames estuary) from Purfleet to Vange Creek. Tidal barriers were also built at the entrance to Tilbury Docks and across Vange Creek. All major works were completed to give an effective defence line for the winter of 1982/83.

3.3.11 In addition, the Storm Tides Warning Services was established within the Met Office which provides a forecast for the development and progression of Atlantic storms up to five days ahead and detailed, accurate information on the height of the surge and wave overtopping predictions two days ahead.

3.3.12 Large parts of Thurrock are currently protected against tidal flooding from the Thames. The Thames Tidal Defence system and Thames River Walls provide the Borough with a significant Standard of Protection (SoP) against tidal flooding; up to the 1 in 1000 year event (0.1% AEP). Further details about flood defence measures to control flood risk are included in **Section 5**.

3.3.13 The risk of flooding from the River Thames is therefore the residual risk should the flood defences overtop or fail (breach). As part of this SFRA, updated tidal modelling has been undertaken to assess the impact from overtopping or a breach in the flood defences along the River Thames frontage. This is further described in **Section 7** and **Appendix B Modelling Methodology.** The modelling was undertaken in accordance with the latest Breach Modelling Guidance[19] and in consultation with the Environment Agency.

Fluvial flooding

3.3.14 Flooding from rivers occurs when water levels rise higher than bank levels causing floodwater to spill across adjacent land (floodplain). The main reasons for water levels rising in rivers are:

- Intense or prolonged rainfall causing runoff rates and flows to increase in rivers, exceeding the capacity of the channel. This can be exacerbated by wet conditions and where there is significant groundwater base flow;
- Constrictions in the river channel causing flood water to back up; and,

[16] British History Website https://www.british-history.ac.uk/vch/essex/vol8/pp35-56#anchorn249
[17] BBC News Article about 1928 Flood of London https://www.bbc.co.uk/news/magazine-26153241
[18] Surge Watch Website, Coastal Flooding in 1938 https://www.surgewatch.org/the-sea-is-in-sir-coastal-flooding-on-the-east-coast-of-the-uk-on-12th-february-1938/
[19] Environment Agency, 29 June 2021 LIT 56413 Breach of defences guidance.

- Constrictions preventing discharge at the outlet of the river, e.g. locked flood gates, or tide locking.

River Mardyke

3.3.15 The River Mardyke flows from the north to the west of the Borough, before discharging into the River Thames at Purfleet. The river rises in the Brentwood Hills, north of the Borough border in the neighbouring Borough of Brentwood. It drains a semi-rural catchment of ~112km^2 and has an approximate length of 18km from its source to the tideway of the Thames. There are two significant tributaries, one of which flows east from Upminster and the other west from Langdon Hills. The northern catchment is predominantly agricultural with clay soils giving a flashy flow regime with low baseline flows.

3.3.16 The south of the Mardyke catchment is more urbanised with residential and industrial uses. The closest settlements are South Ockendon, North Stifford and Chafford Hundred. Downstream of Orsett Fen the higher topography restricts the floodplain resulting in a greater risk of flooding to residents in Purfleet.

3.3.17 Modification of the Mardyke was undertaken as part of the 1980s land drainage scheme by the Essex Rivers Authority. This included channel improvements, wash land storage and improved sluice capacity to enhance land drainage within the catchment. The Mardyke discharges into the Thames at Purfleet via Mardyke Sluice which prevents the tidal Thames from flowing up the Mardyke. The Mardyke Sluice consists of double mitre gates and a guillotine gate set within concrete and masonry abutments. There is an oval bypass culvert through the right hand abutment with two lines of defence formed by flap valves; there is a penstock at the upstream end.

Stanford Brook

3.3.18 Stanford Brook has a small catchment which drains south through Stanford-le-Hope and Mucking Marshes before discharging into the Thames Estuary via Mucking Sluice. Victoria Road Brook joins Stanford Brook in Stanford-le-Hope. Due to the steep surrounding topography and urbanised areas the rivers responds rapidly during a rain event putting the surrounding population at risk of fluvial and surface water flooding.

Arterial Drainage Networks

3.3.19 A network of drainage channels drain large areas of West Thurrock, Tilbury as well as northern areas in the Mardyke catchment. Urban areas on the edge of the Thames Estuary generally have a combination of gravity outfalls and pumps and low-lying areas around Tilbury have numerous pumping stations to drain the marshlands which are below sea-level in places. The grazing marshes have a system of irrigation channels to provide storage when gravitational outfalls are tide locked; this control of water level has an important influence on their habitat and landscape value.

3.3.20 The arterial drainage network may experience flooding as a result of several mechanisms, including:

- High rainfall events in the local catchment,
- Blocked channels,
- Rainfall exceeding pump capacity at channel outlets, or
- Pump failure are the downstream end of drainage channels which can cause out of bank flows or the backing up of water behind defences at channel outlets

3.3.21 The responsibility for the maintenance of these Ordinary Watercourses falls to riparian owners who own the land on either bank. Thurrock Council is only responsible for Ordinary Watercourses where land on either bank is in Council ownership or where historical agreements have been made.

Historic records of fluvial flooding

3.3.22 There have been two significant fluvial flood events associated with Stanford Brook (September 1958) and the River Mardyke (September 1968). During the 1958 Stanford Brook flood event 76mm of rainfall fell in 2 hours resulting in 500 houses flooded above floorboard level in Stanford-le-Hope. The 1968 Mardyke affected the Fenchurch Street rail line and 2,400 acres of farmland flooded.

3.3.23 Since these events, conveyance/storage systems controlled by gravity outfalls subject to tide-locking have been implemented and recent modelling studies have shown the benefit they have during a 1%

AEP (1 in 100 year) flood event for both the River Mardyke and Stanford Brook (**Appendix A Map 7**). The presence of these defences decreases the likelihood of similar flood events occurring in the future. However, the modelling shows the protection up to the 1% AEP (1 in 100 year) only, therefore it is possible that flooding would occur in these areas during the 0.1% AEP (1 in 1000 year) flood event.

Climate change

3.3.24 The Environment Agency's online guidance 'Flood risk assessments: climate change allowances'[20] sets out the climate change allowances for peak river flows for specific 'management catchments' and provides advice on applying climate change projections when preparing flood risk assessments. The allowances for the management catchments of relevance to Thurrock are set out in Table 3-2. SFRAs should consider the central and higher central allowances (shaded in grey).

Table 3-2 Peak River Flow Allowances for management catchments in Thurrock

Management Catchment	Allowance Category	Total potential change anticipated for the '2020's (2015 to 2039)	Total potential change anticipated for the '2050's (2040 to 2069)	Total potential change anticipated for the '2080's (2070 to 2125)
South Essex	Upper end (95th)	22%	27%	48%
	Higher central (70th)	11%	11%	**26%**
	Central (50th)	6%	5%	**17%**
Roding, Beam and Ingrebourne*	Upper end (95th)	31%	38%	64%
	Higher central (70th)	20%	21%	**36%**
	Central (50th)	15%	14%	**26%**

* only a small portion of the study area, (to the north and west of Aveley), is in this management catchment. The large majority of Thurrock is in the South Essex management catchment.

3.3.25 Hydraulic modelling of the River Mardyke and Stanford Brook (refer to **Section 2 Table 2-3**) includes increases in peak river flow due to the impacts of climate change. Scenarios have been undertaken to consider the change to the 1% AEP (1 in 100 year) flood extent (including the presence of defences) when applying increases of 25%, 35% and 70% to peak river flow. These are mapped in **Appendix A Map 7**. These provide a suitable indication of the central and higher central allowances for the 2080s. The mapping shows that the floodplain of the Mardyke and in particular its tributaries in the north of the borough will increase significantly in the future.

Flood Zone 3b Functional Floodplain

3.3.26 The following areas are defined as Flood Zone 3b in Thurrock, as shown in **Appendix A Map 7**:

- Tilbury Flood Storage Area extent was engineered to store water in times of a flood and is therefore defined as Flood Zone 3b functional floodplain.
- Flood extents from the River Mardyke modelling study (Mott MacDonald 2019) for the 3.3% AEP (1 in 30 annual probability) event have been used to define Flood Zone 3b. In the lower reaches of the watercourse the river remains within the defended channel, however once north of the A13 the catchment becomes increasingly rural and the standard of protection of the defences is lower, therefore the extent of Flood Zone 3b is more extensive.
- The Stanford Brook is largely constrained as it flows through Stanford-le-Hope, however, flood extents from the Stanford Brook modelling study (CH2MHill 2017) for the 3.3% AEP scenario (1 in 30 annual probability) have been used to define Flood Zone 3b. And to the south of the A13 and south of the urban envelope towards Mucking Marshes there are areas of Flood Zone 3b. Due to the steeper topography to the north, the watercourse is more restricted and hence has smaller floodplains.
- Flood Zone 3b associated with the River Thames is limited to the river channel. Due to the presence of formal flood defences providing protection to 1 in 1000 year (0.1% AEP) there is no Flood Zone 3b on the landward side of the defences.

[20] Environment Agency (published 2016 and updated May 2022) Flood risk assessments: climate change allowances. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

- Downstream of Fobbing Horse Barrier Vange Creek is protected by the Thames Tidal Defence System (TTD). Due to the presence of these formal defences the Standard of Protect is 1 in 1000 year (0.1% AEP) and therefore there is no Flood Zone 3b on the landward side of the defences at this location.
- Upstream of Fobbing Horse Barrier on Vange Creek there are no flood defences therefore it is possible that the surrounding marshland would flood in the 3.3% AEP (1 in 30 year) scenario. There has been no hydraulic modelling of Flood Zone 3b here, primarily due to its rural location and therefore it not currently included in the definition of Flood Zone 3b. Should development be proposed in this area further delineation of the functional floodplain would be required.

3.4 Flooding from surface water

3.4.1 Overland flow and surface water flooding typically arise following periods of intense rainfall, often of short duration, that is unable to soak into the ground or enter drainage systems. It can run quickly off land and result in localised flooding. This source of flooding can be compounded when combined with impermeable sub-soils, significant areas of development with associated hard standing areas or areas of open grassland.

Historic records

3.4.2 There have been numerous surface water flood events across the Borough, mainly in the urban parts of Thurrock where impermeable surfaces dominate, including Grays, Tilbury, Stanford-le-Hope and South Ockendon. Thurrock Council Highways Team has provided maps showing areas of previous surface water flooding. The incidents have been digitalised and added to a GIS layer and displayed in **Appendix A Map 8**.

3.4.3 An Initial Assessment (IA) was undertaken for Stanford-le-Hope in 2018/19. The IA identified the risk for 42 properties from surface water flooding in a 1.3% AEP (1 in 75 year) event, accounting for a 150mm depth threshold, with up to 4 properties at risk of fluvial flooding in a 1.3% AEP (1 in 75 year) event. There is also an impact on the existing railway infrastructure in this area as a result of fluvial flooding.

3.4.4 In its capacity as LLFA, Thurrock Council has undertaken a formal s19 Flood Investigation[21] in response to the flooding of properties on Quebec Road, Tilbury, on numerous occasions in 2012/13. Flooding occurs shortly after the onset of moderate rainfall. Surface water is the main source of flooding as the local drainage system is surcharged.

3.4.5 Short term measures are due to be implemented to ensure the drainage system is working effectively such as desilting of the East Dock Sewer and cleansing the sewer networks. These measures are to be complemented with more long term actions including clarifying riparian responsibilities, introducing a maintenance schedule, and pooling of flood modelling information to identify potential long term solutions to reduce flood risk in the area.

Areas of Critical Drainage

3.4.6 The Thurrock LFRMS[8] identifies 14 'Areas of Critical Drainage' (AoCD), which are defined as being *'A discrete geographic area where multiple and/or interlinked sources of flood risk (surface water, groundwater, sewer, main rivers and/or tidal) cause flooding in one or more Local Flood Risk Zones (LFRZ) during severe weather thereby affecting people, property or local infrastructure.'*

3.4.7 The 14 AoCDs are spread across the Borough but mainly within urban areas. The locations covered by AoCDs are shown in **Appendix A Map 8** and include:

- Purfleet
- West Purfleet
- West Thurrock
- Lakeside
- South Ockendon
- Grays
- Little Thurrock
- Tilbury
- East Tilbury
- Orsett
- Aveley
- West Thurrock
- Stanford-le-Hope
- Bulphan

[21] Thurrock Council, November 2013, Section 19 FWMA Flood Investigation Report. Quebec Road, Tilbury. https://www.thurrock.gov.uk/flood-risks/flood-investigations

3.4.8 Information generated in the LFRMS has been used to create an action plan to reduce the risk and/or effects of surface water flooding, assisting Thurrock Council in their role as LLFA. For further detail on each AoCD refer to the Thurrock Council LFRMS.

3.4.9 It should be noted that the NPPF also refers to areas with 'critical drainage problems' as notified by the Environment Agency. However, these are not the same as critical drainage areas referred to within the LFRMS and at the time of writing, the Environment Agency has confirmed that there are no *'areas with critical drainage problems for the purposes of the Development Management Procedure Order'* within Thurrock.

Risk of flooding from surface water mapping

3.4.10 The Environment Agency has undertaken detailed modelling of surface water flood risk at a national scale and produced mapping identifying those areas at risk of surface water flooding during three probability events:

- 3.33% annual probability (1 in 30 year),
- 1% annual probability (1 in 100 year), and
- 0.1% annual probability (1 in 1,000 year).

3.4.11 The latest version of the mapping is referred to as the 'Risk of Flooding from Surface Water' (RoFSW) and the extents are mapped in **Appendix A Map 8.**

Climate Change

3.4.12 The RoFSW mapping does not include a specific scenario to determine the impact of climate change on the risk of surface water flooding. However, a range of three annual probability events have been undertaken, 3.3% (1 in 30 year), 1% (1 in 100 year) and 0.1% (1 in 1000 year) and therefore it is possible to use with caution the 0.1% outline as a substitute dataset to provide an indication of the implications of climate change.

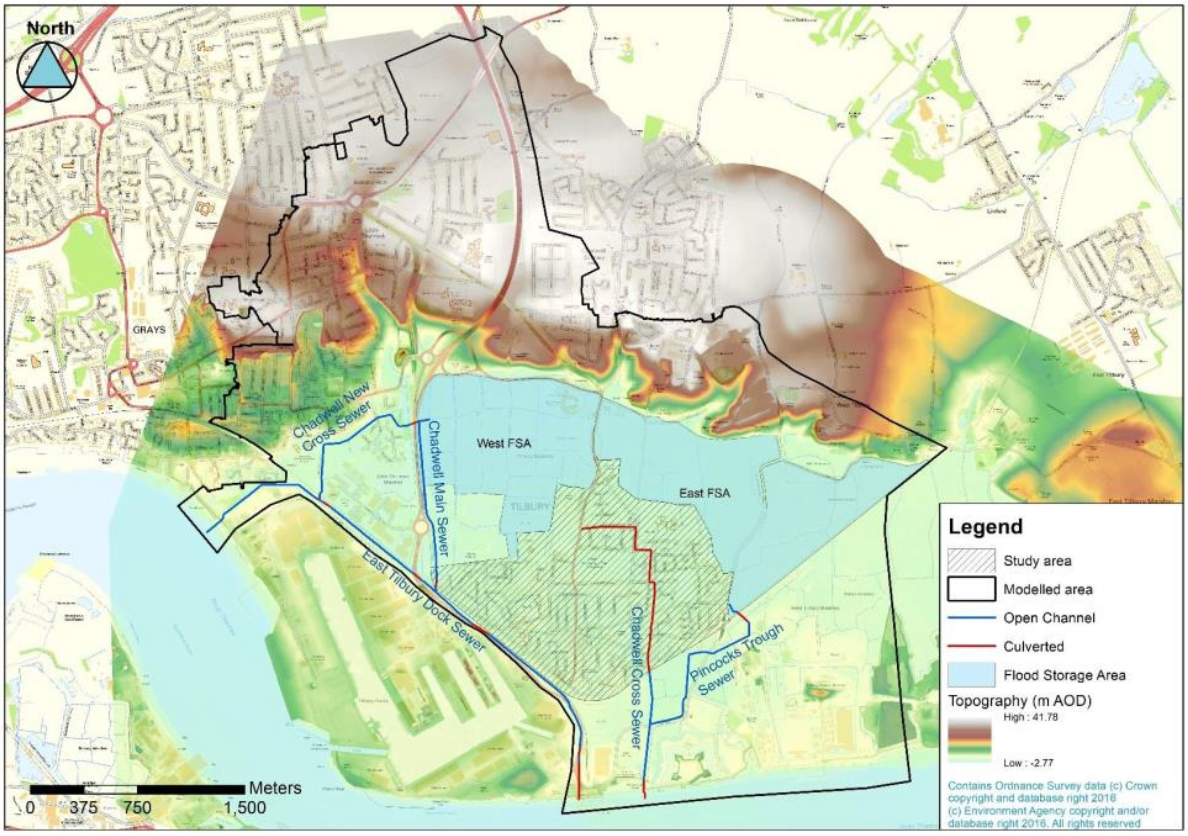
Tilbury Integrated Flood Strategy

3.4.13 Tilbury is at risk of flooding from surface water through a number of routes including surface water runoff collecting in the low lying marshland, pumped outfalls, gravity systems and their tidal interaction and the underground sewer network.

3.4.14 Thurrock Council undertook the Tilbury Integrated Flood Strategy (JBA 2017, described in Table 2-3) which included hydraulic modelling designed to better understand the relationship between the different sources and mechanisms of flooding and their response to different rainfall events. The aim of the study is to inform the understanding of asset performance amongst project partners particularly where flooding is shown to be caused by their interaction of assets owned by multiple partners. The study area of the Strategy is shown in Figure 3-2.

3.4.15 The output from the study includes mapped deliverables as well as an Action Plan for project partners to implement over time. The Action Plan outlines where action is required and who is responsible, tying into the Thurrock LFRMS.

Figure 3-2 Tilbury Integrated Flood Strategy Modelled Area



Source: Tilbury Integrated Flood Strategy, January 2017

3.5 Flooding from groundwater

Groundwater Flooding

3.5.1 Groundwater flooding occurs when water levels in the ground rise above surface elevations. Groundwater flooding may take weeks or months to dissipate, as groundwater flow is much slower than surface water flow therefore water levels take much longer to recede.

3.5.2 Information regarding the Solid and Drift geology within the Borough has been obtained from BGS datasets and mapped in **Appendix A Maps 3 and 4**. Local geology adjacent to the Thames Estuary is Solid Chalk; to the north there is a band of geology comprising the Solid Thanet Group and Lambeth Group, beyond this to the north of the A13 is the Thames Group (clay, silt, sand and gravel).

3.5.3 The Drift geology consists of Alluvium in the south of the Borough adjacent to the Thames Estuary. Alluvium is also present within the floodplain of the River Mardyke in the northern part of the study area. Alluvium consists of clays, silts, sands and gravels of which the permeability can be highly variable depending on the exact composition of the material. Since this material has been deposited in riverbeds, it tends to be relatively impermeable. In between these two areas of Alluvium, there runs a band of undifferentiated river terrace deposits.

3.5.4 Within the Thurrock study area, groundwater is held within a chalk aquifer to the south and a gravel aquifer to the north.

3.5.5 The BGS dataset 'Susceptibility to Groundwater Flooding' has been obtained by Thurrock Council and mapped within this SFRA in **Appendix A Map 9.** This dataset shows where there is the potential for groundwater flooding but does not give any indication of the probability that it will occur. Susceptibility is classified into three categories: Potential for groundwater flooding to occur at surface; Potential for groundwater flooding of property situated below ground level; Limited potential for groundwater flooding to occur. The mapping shows that throughout the north part of the Borough across the catchments of the Mardyke and Stanford Brook, there is 'potential for groundwater flooding to occur at surface'. Across the

southern parts of the Borough there is 'limited potential for groundwater flooding to occur', or 'potential for groundwater flooding of property below ground level'.

3.5.6 The South Essex CFMP[22] draws attention to the impact commercial chalk quarrying may have on groundwater levels within Thurrock. During extraction of the chalk, the quarried areas become de-watered. Since manufacturing came to an end and with it the de-watering activities, groundwater levels have risen by approximately 60mm a year. Continued increases in groundwater levels could lead to local flooding or structural problems for development located in close proximity to former quarries where restored ground levels may be lower than natural ground levels.

3.5.7 Groundwater investigations should be carried out as part of site-specific FRAs. This is particularly important for potential development sites near former quarried areas and developments in which basement areas are proposed; it must be demonstrated that the site does not lie on a key groundwater flow route such that introducing a flow barrier within the system would increase the risk of groundwater flooding elsewhere.

3.6 Sewer flooding

3.6.1 During heavy rainfall, flooding from the sewer system may occur if:

1) The rainfall event exceeds the capacity of the sewer system/drainage system:

Sewer systems are typically designed and constructed to accommodate rainfall events with an annual probability of 3.3% (1 in 30 chance each year) or greater. Therefore, rainfall events with an annual probability less than 3.3% (1 in 30 year) would be expected to result in surcharging of some of the sewer system. While AW, as the sewerage undertaker recognises the impact that more extreme rainfall events may have, it is not cost beneficial to construct sewers that could accommodate every extreme rainfall event.

Furthermore, as urban areas expand to accommodate growth, the original sewer system is rarely upgraded proportionately and so becomes overloaded. This problem is compounded by climate change which is forecast to result in milder wetter winters and increased rainfall intensity in summer months.

2) The system becomes blocked by debris or sediment:

Over time there is potential that road gullies and drains become blocked from fallen leaves, build-up of sediment and debris (e.g. litter).

3) The system surcharges due to high water levels in receiving watercourses:

Within the study area there is potential for surface water outlets to become submerged due to high river levels. When this happens, water is unable to discharge. Once storage capacity within the sewer system itself is exceeded, the water may overflow into streets and potentially into houses. Where the local area is served by 'combined' sewers i.e. containing both foul and storm water, if rainfall entering the sewer exceeds the capacity of the combined sewer and storm overflows are blocked by high water levels in receiving watercourses, surcharging and surface flooding may again occur but in this instance floodwaters will contain untreated sewage.

3.6.2 During the September 1968 event the East Dock Sewer in Tilbury caused significant flooding to the area. In Tilbury alone the flooding affected 1km^2 of the marshes and 1.25km^2 of agricultural land. 1,750 houses were flooded and a further 950 affected by the event and Dock Road was closed for 4 days.

3.6.3 Historically, sewer flooding has been a particular problem in Stanford-le-Hope, Purfleet and Tilbury due to inadequate maintenance of the sewer infrastructure which leads to blockages or systems being overwhelmed by the quantity of discharge[23]. Anglian Water was involved in investigating schemes to reduce the number and frequency of sewer floods and surface water drainage incidents.

[22] Environment Agency, 2009, South Essex Catchment Flood Management Plan https://www.gov.uk/government/publications/south-essex-catchment-flood-management-plan
[23] Thurrock Borough Council (2009) Strategic Flood Risk Assessment

3.6.4 Anglian Water (AW) has provided data regarding records of flooding to inform this study (December 2022). This information is provided by post code area and is included in **Appendix A Map 6**. The data shows that Tilbury and Grays have a history of sewer flooding incidents.

3.7 Flooding from reservoirs

3.7.1 The failure of a reservoir or artificial source has the potential to cause catastrophic damage due to the sudden release of large volumes of water. The PPG encourages LPAs to identify any reservoirs and evaluate how they might modify the existing flood risk in the event of a flood in the catchment is located within, and/or whether emergency draw-down of the reservoir will add to the extent of flooding.

3.7.2 The Environment Agency dataset 'Risk of Flooding from Reservoirs' identifies areas that could be flooded if a large[24] reservoir was to fail and release the water it holds. The mapping shows the flood extent when local rivers are at normal levels (a 'dry day') or when local rivers are already in flood (a 'wet day'). This mapping reproduced in **Appendix A Map 10** identifies that areas around Tilbury could be at risk of reservoir flooding if the Tilbury Flood Storage Area were to fail. The mapping also shows areas along the River Mardyke at risk from reservoir flooding associated which, from the mapping, is assumed to be associated with a reservoir located off Green Lane near Orsett in Thurrock and a lake off Childerditch Lane, just north of the A217 in Brentwood.

3.7.3 Reservoirs in the UK have an extremely good safety record. The Environment Agency is the enforcement authority for the Reservoirs Act 1975 in England and Wales. All large reservoirs must be inspected and supervised by reservoir panel engineers. It is assumed that these reservoirs are regularly inspected, and essential safety work is carried out. These reservoirs therefore present a minimal risk.

3.7.4 Thurrock Council is responsible for working with members of the Thames Valley Local Resilience Forum (LRF)[25] to develop emergency plans for reservoir flooding and ensuring communities are well prepared.

3.7.5 Any development plans within the risk of flooding from reservoirs will need to confirm with the Environment Agency the source of this reservoir flood risk.

Tilbury Flood Storage Area

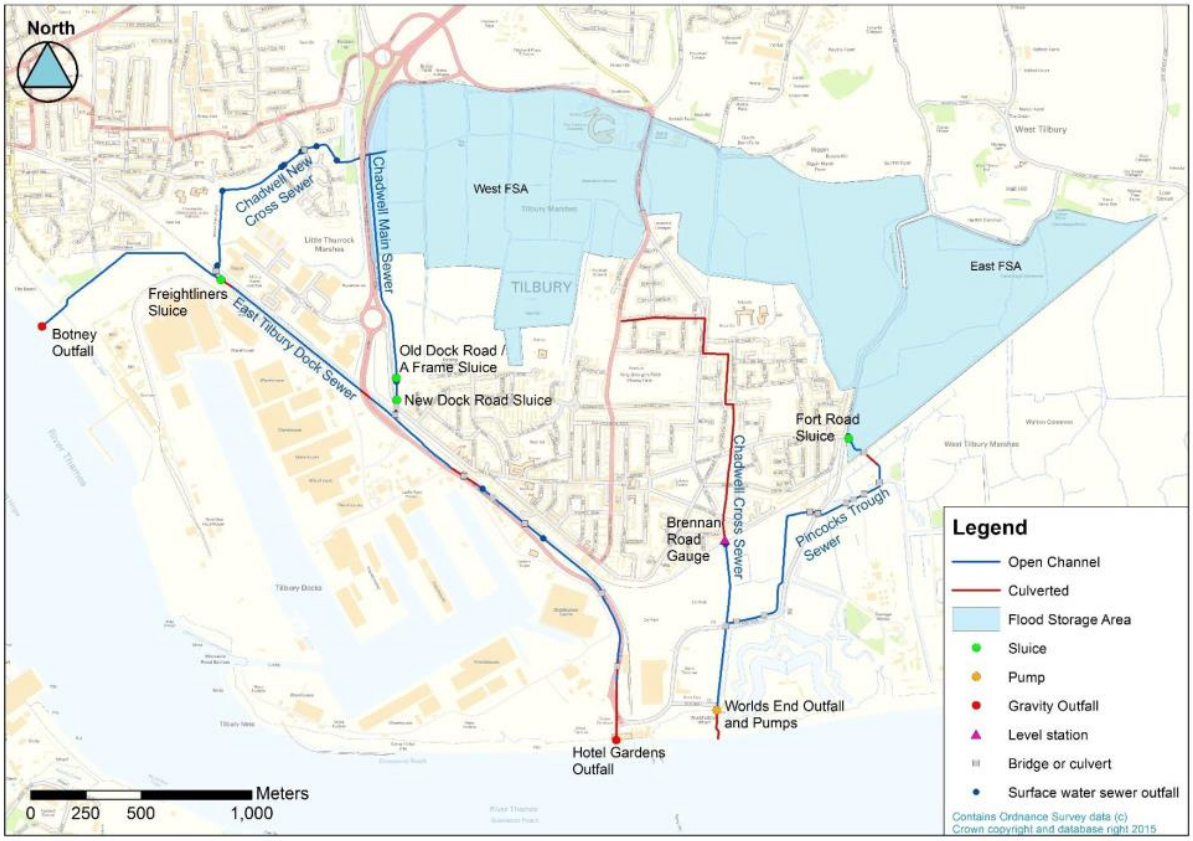
3.7.6 The area north of Tilbury is classified as washlands and has been defined by the Environment Agency as a Flood Storage Area. It is also registered under the Reservoirs Act (1975) and will be maintained and operated as a category C Reservoir and Flood Storage Area (FSA) with capacity to store surface water floodwaters during a 0.1% AEP (1 in 1000 year) event. In 2012 the Environment Agency ran a scheme to ensure that the FSA was compliant with the Matters for Safety outlined by the Inspecting Engineer under the Reservoirs Act 1975. This involved the raising of embankments along sections of the eastern and western parts of the FSA to ensure that it can withstand a 0.1% AEP (1 in 1000 year) flood event.

3.7.7 For the purpose of planning, this area is designated as functional floodplain (Flood Zone 3b) and therefore nearly all types of development are inappropriate at this location. Only developments which are classified by Annex 3 of the NPPF as "Essential Infrastructure" or "Water Compatible" are appropriate for consideration within Flood Zone 3b and that these uses must (1) be designed and constructed to remain operational and safe for users in times of flood; (2) result in no net loss of floodplain storage; and, (3) not impede water flows and not increase flood risk elsewhere. Essential Infrastructure must also pass the Exception Test if located in Flood Zone 3b. Housing and commercial or industrial development should not be permitted.

3.7.8 It is essential that the Environment Agency is consulted before development plans are planned for sites within this area. Figure 3-3 is an extract from the Tilbury Integrated Flood Strategy[26] showing the surface water drainage outfalls from the Tilbury Flood Storage Area.

[24] A large reservoir is one that holds over 25,000 cubic metres of water, equivalent to approximately 10 Olympic sized swimming pools.
[25] http://thamesvalleylrf.org.uk/
[26] Tilbury Integrated Flood Strategy, JBA for Thurrock Council, January 2017

Figure 3-3 Tilbury Integrated Flood Storage Area – Drainage Outfalls



Source: Tilbury Integrated Flood Strategy, January 2017

3.8 Assessing the cumulative impact of development

3.8.1 The NPPF states that strategic policies should be informed by a strategic flood risk assessment, and should consider cumulative impacts in, or affecting, local areas susceptible to flooding (paragraph 160).

3.8.2 Development or the cumulative impacts of development may result in an increase in flood risk elsewhere as a result of impacts such as the loss of floodplain storage, the deflection or constriction of flood flow routes or through inadequate management of surface water. The loss of floodplain storage is less likely to be a concern in areas benefitting from appropriate flood risk management infrastructure, however assessment will still need to be made (refer to Section 5.6).

3.8.3 Where flood storage from any source of flooding is to be lost as a result of development, on-site level-for-level compensatory storage, accounting for the predicted impacts of climate change over the lifetime of the development, should be provided. Where it is not possible to provide compensatory storage on site, it may be acceptable to provide it off-site if it is hydraulically and hydrologically linked. Whilst the use of stilts and voids below buildings may be an appropriate approach to mitigating flood risk to the buildings themselves, such techniques should not normally be relied upon for compensating for any loss of floodplain storage. This is because voids do not allow water to freely flow through them, trash screens get blocked, voids get silted up, they have limited capacity, and it is difficult to stop them being used for storing belongings or other materials.

3.8.4 Identification of those areas where changes in land use could potentially increase surface water runoff rates and volumes can strategically aid spatial planning in avoiding areas where significant mitigation of surface water runoff following development may be required. The provision of multifunctional sustainable drainage systems, natural flood management and green infrastructure can also make a valuable contribution to mitigating the cumulative impacts of development on flood risk.

3.8.5 Whilst individual development with appropriate site mitigation measures should not result in measurable local effects with respect to hydrology and flood risk, the cumulative effect of multiple development may

be more severe at downstream locations in the catchment. Locations where there are existing flood risk issues will be particularly sensitive to cumulative effects.

3.8.6 The cumulative impact should be considered throughout the planning process, from the allocation of sites within the Local Plan, to the planning application and development design stages.

3.8.7 At the time of preparation of this version of the SFRA, detailed information about the location of development is unknown due to the change in the level of detail presented for the Regulation 18 consultation. The detail would need to be considered further at a future update of the SFRA. Instead a high level assessment of the levels of growth and distribution of development across the borough has been considered.

3.8.8 This high level assessment identifies that, *without appropriate mitigation and infrastructure improvements*, there is potential for existing surface water and sewer flood risk to be exacerbated within the existing urban areas. Furthermore, development of surrounding rural areas, *without appropriate mitigation*, has the potential to increase the rates and volumes of surface water runoff. However, the scale of development proposed in some locations also offers significant opportunity to deliver improvements to alleviate flood risk. Further assessment is required to determine the scale of benefits that could be delivered.

3.8.9 In order to further consider the potential for cumulative impact in specific areas at risk of flooding, the scope of this SFRA incorporates three localised assessments of flood risk in the Mardyke catchment, in West Horndon and in Tilbury.

Cumulative impact in the Mardyke catchment

3.8.10 Sensitivity analysis has been undertaken using the Mardyke river model (Table 2-3), to determine the potential impact should runoff in the contributing catchments change in the future as a result of increased development. Appendix E details the work completed.

3.8.11 The results of the sensitivity testing undertaken for the River Mardyke catchment indicate that if runoff is increased, the upper part of the catchment is more likely to show an increase in flood risk (flood levels and flow) than the lower part of the catchment. Further down in the catchment, the changes in hydrograph volume do not have such a noticeable effect on flood level and flow. This may be because flood risk in the lower part of the catchment is more strongly influenced by conditions in the River Thames than by conditions in the upper catchment.

Cumulative impact in West Horndon

3.8.12 An Integrated Catchment Model for this area this area has been developed, (using the ICM model of the upper Mardyke catchment as a basis, Table 2-3) and scenarios undertaken to determine the impact of potential future development around West Horndon and Bulphan. Appendix F details the work completed.

3.8.13 The modelling undertaken demonstrates that cumulatively, development on the potential development sites identified which results in an increase in impermeable surfaces could increase flood risk. The areas that seem most susceptible to an increase in flood depth as a consequence of more runoff from development are the rural area between West Horndon and Bulphan and South Ockendon where multiple flow routes converge.

3.8.14 It is therefore recommended that Thurrock Council consider policies in the Local Plan, supported by this SFRA evidence base, that would reduce runoff from new development sites to avoid an increase in flood risk compared to baseline conditions and where possible provides a reduction in the risk of flooding. If this is sufficiently managed on each development site, the potential cumulative impacts shown in this assessment could be avoided.

Cumulative impact in Tilbury

3.8.15 The Integrated Catchment Model for this area (Table 2-3) has been updated and additional scenarios undertaken to determine the potential impact of future development in the catchment. Appendix G details the work completed.

3.8.16 Three sensitivity tests have been undertaken to represent different scenarios:

- Scenario 1: 50% of the potential development site areas are assumed to be covered by impermeable surfaces.

- Scenario 2: 90% of the potential development site areas are assumed to be covered by impermeable surfaces.
- Scenario 3: One selected development site area is assumed to be raised by 700mm above existing ground level.

3.8.17 The modelling results of Scenarios 1 and 2, identify that development which increases impermeable surfacing will result in increased flood depths within the FSR. The greater runoff generated could increase the depth of flooding in the FSRs by more than 0.1m which reduces the capacity of flood protection offered by the FSR.

3.8.18 Results for Scenario 3, demonstrate that development that includes land raising has the potential to displace floodwater and increase flood risk to existing neighbouring development.

3.8.19 It is therefore recommended that Thurrock Council implement policies that prevent land raising within the FSR. It is recommended that Thurrock Council retain the Flood Zone 3b designation in this area.

3.8.20 It is also recommended that Thurrock Council ensure that existing policies to restrict surface water runoff (to existing runoff rates and volumes) continue to be enforced for all potential development sites in the catchment and where possible opportunities are taken to reduce the surface water runoff.

3.9 Lower Thames Crossing

3.9.1 The government is planning a new road tunnel under the Thames Estuary which will link the M25 near North Ockenden in Essex to the A2 near Shorne in Kent (Figure 3-1). The Lower Thames Crossing aims to reduce the burden on the Dartford Crossing to the west and may lead to further growth across the study area.

3.9.2 The application for a Development Consent Order for the Lower Thames was submitted on 31 October 2022, and it was accepted for examination by the Planning Inspectorate on 28 November. The DCO process is expected to run until 2024. The accompanying FRA demonstrates how the Project meets the criteria by being designed to:

a) Remain operational and safe for users in times of flood.

b) Result in no net loss of floodplain storage.

c) Not impede water flows and not increase flood risk elsewhere.

d) Include for resilience to future climate change.

3.9.3 To achieve the above, a series of flood mitigation and protection measures would be put in place. Flood resilience measures, which aim to make the Project less vulnerable to the effects of flooding, are also set out in the FRA alongside an assessment of the remaining (residual risk) after any proposed flood mitigation, protection and resilience measures have been implemented.

3.9.4 Flood mitigation measures for the catchment between North Portal to Chadwell St Mary Catchment (EFR-2) would comprise alteration of watercourse channels, provision of a CFSA, incorporating a hydraulic structure in West Tilbury Main and inclusion of a highway drainage system. West Tilbury Main channel alterations would comprise removal of two culvert crossings and enlargement of one existing culvert crossing.

3.9.5 There are no flood protection measures in the A13 Junction Catchment (EFR-3). Surface water flood risk caused by highway runoff would be mitigated by inclusion of highway drainage provisions; these provisions would apply to all new and realigned roads in the catchment. The drainage system would include upgrading parts of the existing drainage network and the addition of new drainage elements.

3.9.6 Flood mitigation measures for the Ockendon Link Catchment (EFR-4) would include provision of a flood relief channel under the Project road to maintain connectivity through the Mardyke floodplain, altering the floodplain locally to prevent the creation of a new flow path (ground raising); and provision of floodplain compensation areas to replace floodplain displaced by the Project road embankment, bridge piers and ground raising.

3.9.7 Although residual risk[27] generally have a low probability of occurrence, their impacts can be severe. A summary of residual risk by catchment is presented in Table 3-3 along with appropriate mitigation measures.

Table 3-3 Residual Risk by Catchment

Risk	ERF-2	EFR-3	EFR-4	Mitigation and Project response
Inundation of the highway drainage system	✓	✓	✓	Implementation of an appropriate maintenance programme.
Overtopping of the infiltration basin		✓		Implementation of an appropriate maintenance programme.
Overtopping of the retention ponds	✓	✓	✓	Implementation of an appropriate maintenance programme.
Inundation of flood storage areas	✓		✓	Implementation of an appropriate maintenance programme.
Potential seepage of perched groundwater in cuttings	✓	✓	✓	Inclusion of an appropriate edge of pavement detail.
Groundwater mounding		✓		The risk of groundwater mounding to unacceptably shallow depths is negligible.
Breach of tidal defences at Bowaters Sluice	✓			The risk of a breach of River Thames tidal flood defences at Bowaters Sluice is considered to be negligible.
Blockage of Bowaters Sluice	✓			The hydraulic modelling was undertaken on the basis that risk of failure of Bowaters Sluice has been realised.
Cuttings have the potential to alter the groundwater flow regime		✓		The risk that cuttings may alter groundwater flow regime is negligible.
Failure of flow relief channel			✓	Implementation of an appropriate maintenance programme.
Reservoir breach			✓	Regulatory inspection requirements.
Failure of Mardyke Sluice gate			✓	Flood risk due to failure of Mardyke Sluice would be low.
Breach of tidal flood defences at Mardyke Sluice			✓	Flood flows resulting from a breach would remain in channel at the Project location.

Source: Lower Thames Crossing 6.3 Environmental Statement Appendices Appendix 14.6 - Flood Risk Assessment - Part 6. Volume 6

3.10 Future Thames Barrier

3.10.1 One of the future conditions that could impact the risk of tidal flooding from the Thames Estuary in Thurrock is the potential option to locate a new flood barrier on the River Thames at Long Reach. This is just one of a range of possible options for the future of the Thames Barrier, which are described in Section 5.2.

3.10.2 The impact of a future flood barrier at Long Reach would be to control water levels upstream of the Barrier by reducing tidal ingress up the Thames Estuary. However, immediately downstream of a new barrier, water levels would be elevated. There is therefore potential that the risk of tidal flooding to Grays and Tilbury could increase.

[27] Residual risk is the risk that remains after the flood risk management strategy has been implemented.

3.10.3 Analysis of the Thames Estuary 2100 modelling datasets has been undertaken, to provide an initial understanding of the potential impact of a future flood barrier at Long Reach. This is reported in Appendix B Section 4.

3.10.4 The comparison identifies that for much of the Thurrock frontage, the peak water levels for *design* event (0.5% AEP) with the *Long Reach barrier* in place, matches closely with the *extreme* event (0.1% AEP) for the *current barrier location*. Further downstream (east of Tilbury), the water levels for the Long Reach barrier location reduce and are less than the extreme event (0.1% AEP) for the current barrier location.

3.10.5 The mapping of the *extreme* event (0.1% AEP) for the current barrier location that is presented within the Level 1 SFRA (Appendix C and Appendix D) can therefore be used as a useful approximation of how the *design* event (0.5% AEP) would change with the Long Reach barrier in place. Noting that downstream from Tilbury this provides a conservative approach.

3.11 Assessing cross boundary considerations

3.11.1 Thurrock Council is adjacent to Greater London in the West (London Borough of Havering) and the Essex County (Brentwood, Basildon and Castle Point) in the north and east. The natural catchments within Thurrock area cross borders between LPA administrative areas. Watercourses, overland flowpaths and groundwater flow routes pass from one LPA to a neighbouring one. Therefore, future development in one LPA has the potential to affect flood risk to existing development and surrounding areas in another LPA area.

Recommendation 3-1 *Thurrock Council should ensure communication between LPAs to make sure that action in one does not negatively impact upon another.*

3.11.2 It is important that LPAs work together and take a catchment approach to consider the wider impacts of any proposed development. This is particularly important in relation to the Mardyke catchment which crosses the Thurrock and Brentwood boundary and where there is potential for further development in the future.

Recommendation 3-2 *Thurrock Council should work with Brentwood Council to manage the flood risk in the upper Mardyke catchment.*

4. Avoiding flood risk – Applying the Sequential Test

4.1 Overview

4.1.1 The sequential approach is a decision-making tool designed to select sites so that development is, as far as reasonably possible, located where the risk of flooding from all sources is lowest, taking account of climate change and the vulnerability of future users to flood risk. This will help avoid the development of sites that are inappropriate on flood risk grounds. The subsequent application of the Exception Test where required (as determined by Table 4-2) will ensure that new developments in flood risk areas will only occur where flood risk is clearly outweighed by other sustainability and safety drivers.

4.1.2 The sequential approach can be applied at all levels and scales of the planning process, both between and within Flood Zones. All opportunities to locate new developments (except Water Compatible) in reasonably available areas of little or no flood risk should be explored, prior to any decision to locate them in areas of higher risk.

4.2 Applying Sequential Test for the Local Plan

4.2.1 Figure 4-1 illustrates the approach for applying the Sequential Test that Thurrock Council should adopt in the allocation of sites as part of the preparation of the Thurrock Local Plan. The Sequential Test should be undertaken by Thurrock Council and accurately documented to ensure decision processes are consistent and transparent. The Sequential Test requires an understanding of the risk of flooding in the study area from all sources (as provided within this SFRA) and the vulnerability classification of the proposed developments (as defined in the NPPF are presented in Table 4-1).

4.2.2 As part of this SFRA support package, Thurrock Council have identified a long list of potential allocation sites. AECOM have analysed these sites against the flood risk information within this SFRA and provided a site assessment database to Thurrock Council to enable them to undertake the Sequential Test process.

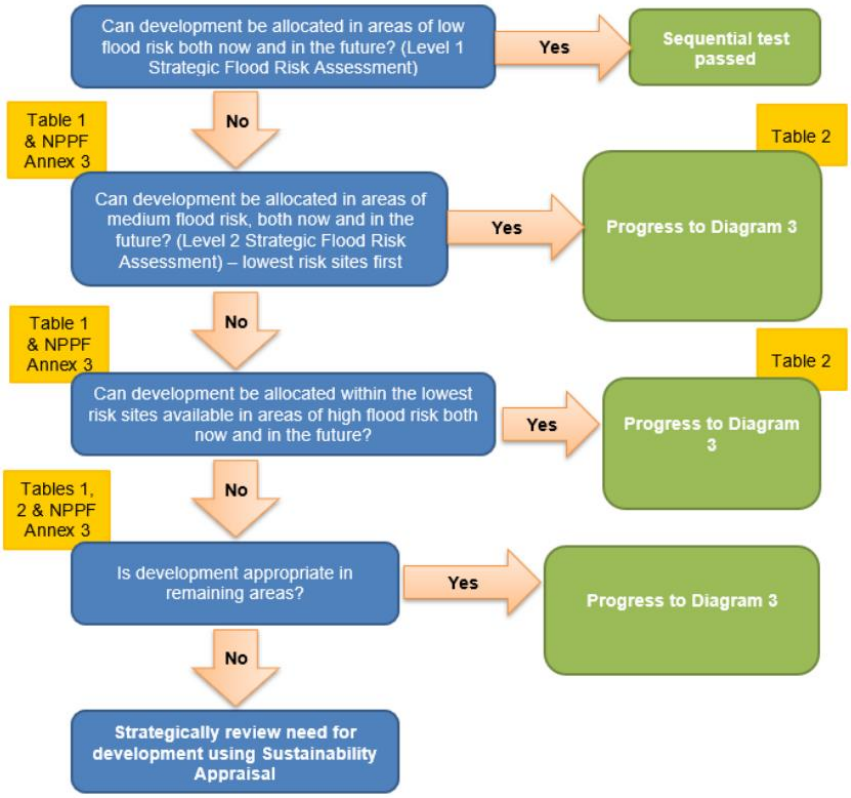


Figure 4-1 Applying the sequential test in the preparation of a Local Plan (PPG Diagram 2)

Table 4-1 Flood Risk Vulnerability Classification (NPPF Annex 3)

Vulnerability Classification	Development Uses
Essential Infrastructure	Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk. Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including infrastructure for electricity supply including generation, storage and distribution systems; including electricity generating power stations, grid and primary substations storage; and water treatment works that need to remain operational in times of flood. Wind turbines. Solar farms.
Highly Vulnerable	Police stations, ambulance stations and fire stations and command centres and telecommunications installations required to be operational during flooding. Emergency dispersal points. Basement dwellings. Caravans, mobile homes and park homes intended for permanent residential use. Installations requiring hazardous substances consent. (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as “essential infrastructure”).
More Vulnerable	Hospitals. Residential institutions such as residential care homes, children’s homes, social services homes, prisons and hostels. Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels. Non–residential uses for health services, nurseries and educational establishments. Landfill and sites used for waste management facilities for hazardous waste. Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.
Less Vulnerable	Police, ambulance and fire stations which are not required to be operational during flooding. Buildings used for shops, financial, professional and other services, restaurants and cafes, hot food takeaways, offices, general industry, storage and distribution, non–residential institutions not included in “more vulnerable”, and assembly and leisure. Land and buildings used for agriculture and forestry. Waste treatment (except landfill and hazardous waste facilities). Minerals working and processing (except for sand and gravel working). Water treatment works which do not need to remain operational during times of flood. Sewage treatment works (if adequate measures to control pollution and manage sewage during flooding events are in place). Car parks.
Water-Compatible Development	Flood control infrastructure. Water transmission infrastructure and pumping stations. Sewage transmission infrastructure and pumping stations. Sand and gravel working. Docks, marinas and wharves. Navigation facilities. MOD defence installations. Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. Water-based recreation (excluding sleeping accommodation). Lifeguard and coastguard stations. Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

Table 4-2 Flood Risk Vulnerability and Flood Zone 'Incompatibility' (PPG Table 2)

Flood Risk Vulnerability Classification		Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone	1	✓	✓	✓	✓	✓
	2	✓	✓	Exception Test Required	✓	✓
	3a †	Exception Test Required †	✓	✗	Exception Test Required	✓
	3b *	Exception Test Required *	✓*	✗	✗	✗

✓ – Exception Test is not required ✗ – Development should not be permitted

† – In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.

* – In Flood Zone 3b (functional floodplain) essential infrastructure that has to be there and has passed the Exception Test, and water-compatible uses, should be designed and constructed to:

- remain operational and safe for users in times of flood
- result in no net loss of floodplain storage
- not impede water flows and not increase flood risk elsewhere

Recommendation 4-1 *Thurrock should ensure the Sequential Test is undertaken for all strategic land allocations and check that the vulnerability classification of the proposed land use is appropriate to the Flood Zone classification.*

Recommendation 4-2 *Thurrock Council should pursue opportunities to move existing development from within the floodplain to areas with a lower risk of flooding. This should include consideration of the vulnerability of existing developments and whether there is potential for land swap with lower vulnerability uses.*

4.3 Applying Sequential Test for planning applications

4.3.1 The Sequential Test should be applied to 'Major' and 'Non-major development' proposed in areas at risk of flooding. The Environment Agency publication 'Demonstrating the flood risk Sequential Test for Planning Applications[28]' sets out the procedure for applying the sequential test to individual applications as follows:

- Identify the geographical area of search over which the test is to be applied; this could be the Borough area, or a specific catchment if this is appropriate and justification is provided (e.g. school catchment area or the need for affordable housing within a specific area). For individual planning applications subject to the Sequential Test, the area to apply the test will be defined by local circumstances relating to the catchment area for the type of development proposed. For nationally or regionally important infrastructure the area of search to which the Sequential Test could be applied will be wider than the local planning authority boundary.
- Identify the source of 'reasonably available' alternative sites; usually drawn from evidence base / background documents produced to inform the Local Plan. The definition of 'reasonably available sites' is defined within the PPG as sites in a suitable location for the type of development with a reasonable prospect that the site is available to be developed at the point in time envisaged for the development.
- State the method used for comparing flood risk between sites; for example the Environment Agency Flood Map for Planning, the SFRA mapping, site-specific FRAs if appropriate, other mapping of flood sources.

[28] Environment Agency (2012) Demonstrating the flood risk Sequential Test for Planning Applications, Version 3.1. Available from: http://www.gwfoe.org.uk/wp-content/uploads/2014/01/EA-Sequential-Test-Process-v3.1-April-2012.pdf https://www.gov.uk/guidance/flood-risk-assessment-the-sequential-test-for-applicants

- Apply the Sequential Test; systematically consider each of the available sites, indicate whether the flood risk is higher or lower than the application site, state whether the alternative option being considered is allocated in the Local Plan, identify the capacity of each alternative site, and detail any constraints to the delivery of the alternative site(s).
- Conclude whether there are any reasonably available sites in areas with a lower probability of flooding that would be appropriate to the type of development or land use proposed.
- Where necessary, as indicated by Table 4-2, apply the Exception Test.
- Apply the sequential approach to locating development *within* the site.

4.3.2 It is for Thurrock Council, taking advice from the Environment Agency as appropriate, to consider the extent to which Sequential Test considerations have been satisfied, taking into account the particular circumstances in any given case. The developer should justify with evidence what area of search has been used when making the application.

4.3.3 Ultimately, after applying the Sequential Test, Thurrock Council needs to be satisfied in all cases that the proposed development would be safe and not lead to increased flood risk elsewhere. This needs to be demonstrated within a FRA and is necessary regardless of whether the Exception Test is required.

Recommendation 4-3 *Thurrock Council should keep an up-to-date register of 'reasonably available' sites (for example as part of their housing and/or economic land availability assessments), clearly ranked in flood risk preference, and prepare guidance on the appropriate area of search for common development types.*

4.3.4 The Sequential Test does not need to be applied in the following circumstances:

- The site has been allocated for development and subject to the test at the plan making stage (provided the proposed development is consistent with the use for which the site was allocated and provided there have been no significant changes to the known level of flood risk to the site, now or in the future which would have affected the outcome of the test).
- The site is in an area at low risk from all sources of flooding, unless the Strategic Flood Risk Assessment, or other information, indicates there may be a risk of flooding in the future.
- The application is for a development type that is exempt from the test, as specified in footnote 56 of the NPPF. This includes:
    - Householder development,
    - Small non-residential extensions (with a footprint of less than 250m^2),
    - Changes of use; except for changes of use to a caravan, camping or chalet site, or to a mobile home or park home site, where the Sequential and Exception tests should be applied as appropriate.

Applying sequential approach *within* a site

Recommendation 4-4 *Apply a sequential approach to the layout and design of individual development sites.*

4.3.5 Flood risk should be considered at an early stage in deciding the layout and design of a site to provide an opportunity to reduce flood risk within the development. Most large development proposals include a variety of land uses of varying vulnerability to flooding. The sequential approach should be applied within development sites to locate the most vulnerable elements of a development in the lowest risk areas (considering all sources of flooding) e.g. residential elements should be restricted to areas at lower probability of flooding whereas parking, open space or proposed landscaped areas can be placed on lower ground with a higher probability of flooding. Reference should be made to tidal modelling included within this study (Section 6) to provide further detail on the varying level of tidal flooding *within* the Flood Zone.

4.4 Exception Test

4.4.1 Following the application of the Sequential Test it may be concluded that there are no reasonable available alternative sites in areas of lower risk, and in some cases the Exception Test may be required. Figure 4-2 shows the decision making process and Table 4-2 identifies when the Exception Test is required, based on the flood zone and the vulnerability classification of the proposed development. The Exception Test should only be applied as set out in Figure 4-2 i.e. only if the Sequential Test has shown that there are no reasonably available, lower-risk sites, suitable for the proposed development, to which the development could be steered.

4.4.2 For the Exception Test to be passed:

- Part 1 - It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by the SFRA where one has been prepared; and
- Part 2 - A site-specific Flood Risk Assessment must demonstrate that 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. If the risk of flooding is not reduced overall, the SFRA must also demonstrate why measures to reduce flood risk overall have not been secured, for example if such measures cannot be identified or are unfeasible.

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

4.4.4 In order to satisfy the **first part** of the Exception Test, the objectives of the Sustainability Appraisal (SA) can be used to assess each potential development site. Typical examples may include:

- The re-use of suitable brownfield land as part of a local regeneration scheme;
- An overall reduction in flood risk to the wider community through the provision of, or financial contribution to, flood risk management infrastructure;
- The provision of multifunctional SuDS that integrate with green infrastructure, significantly exceeding NPPF policy requirements for SuDS.

4.4.5 With respect to the **second part** of the Exception Test, there are a number of ways a new development can be made safe:

- Avoiding flood risk by not developing in areas at risk of flooding.
- Substituting higher vulnerability land uses for lower vulnerability uses in higher flood risk locations and locating higher vulnerability uses in areas of lower risk on a strategic scale, or on a site basis.
- Providing adequate flood risk management infrastructure which will be maintained for the lifetime of the development.
- Mitigating the potential impacts of flooding through design and resilient construction.
- Managing the remaining residual risk through flood warning and emergency planning measures.

4.4.6 Consideration must also be made to ensure that the risk of flooding elsewhere is not increased and where possible is reduced. Further guidance on how development could satisfy the second part of the Exception Test is provided in Sections 5 and 6.

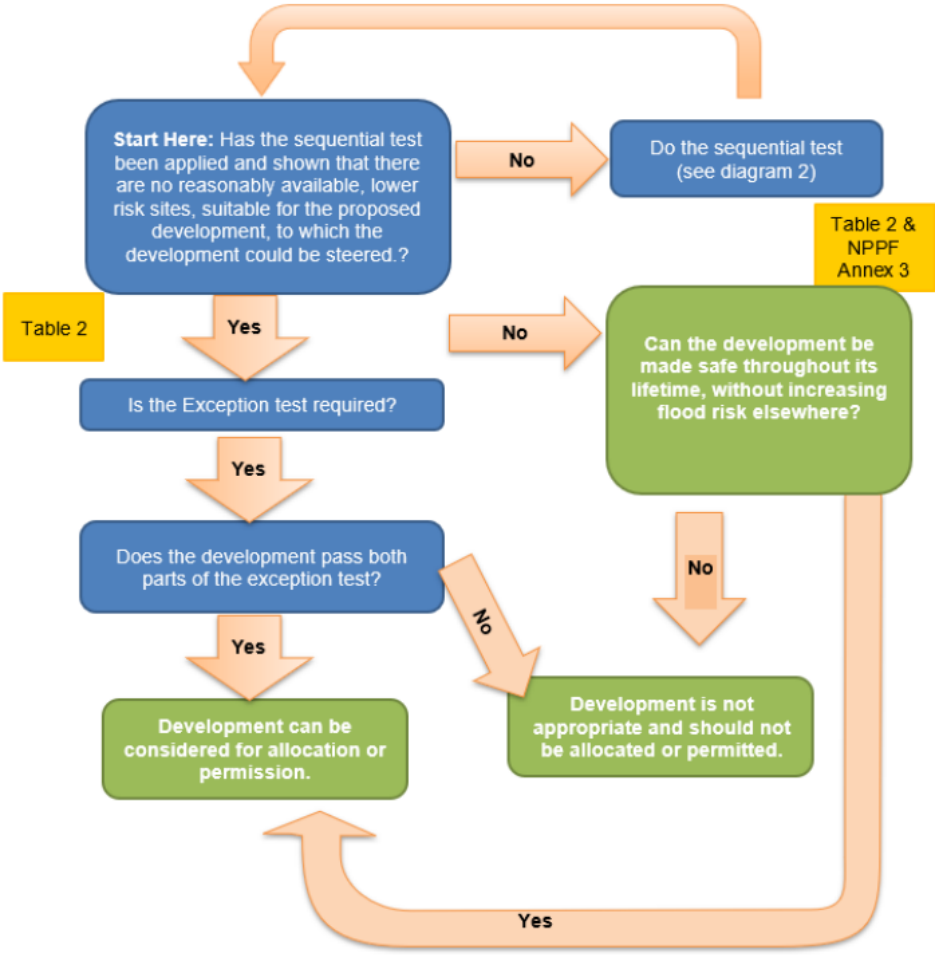


Figure 4-2 Application of the Exception Test in the preparation of a Local Plan (PPG Diagram 3)

5. Measures to control and mitigate flood risk

The NPPF recognises that it is not always possible to **avoid** locating development in areas at risk of flooding, and the next steps are to **control** and **mitigate** the risks. This section identifies measures already in place, as well as measures that should be considered when developing strategic plans and as part of site specific FRAs for future development to control and mitigate the risk of flooding.

5.1 Existing flood risk management infrastructure

Flood defences

5.1.1 There are two main categories of flood defences, formal and informal (de facto). Formal defences are specifically constructed to control floodwater. Informal defences include structures that have not necessarily been constructed for this purpose but do have an impact on retaining flood water, such as railway and road embankments or other linear infrastructure such as boundary walls and buildings.

5.1.2 Information on flood defences has been provided by the Environment Agency from the Asset Information Management System (AIMS). The AIMS provides details of the asset reference, location, type of defence, level of protection provided by the structure and the geographical extent of the defence or structure. Details of all AIMS flood defences in the study area are presented as a GIS layer. The defences are shown in **Appendix A Map 15.**

5.1.3 Almost all the flood defences in Thurrock are maintained by the Environment Agency aside a few privately owned defences, including: the raised defence at the pumping station at Aveley Marsh in Purfleet, a culverted channel owned by Network Rail north of Tilbury and an earth embankment in Fobbing Marsh, which is not officially classified as a flood defence structure. The majority of flood defences are Grade 2 or 3 (Grade 1 being the best classification and Grade 5 being the worst).

Thames Tidal Defences (River Walls)

5.1.4 The primary flood defences within the Borough are the River Thames defences, which in Thurrock are mainly raised reinforced concrete walls, steel walls, or earth embankments which are recorded as providing protection up to a 0.1% AEP (1 in 1000 year) tidal flood event. The Environment Agency state that the defence height along the Thames Estuary in Thurrock varies between 6.9m AOD and 7.2m AOD.

River Mardyke Defence System

5.1.5 Along the River Mardyke there are approximately 10km of maintained channels, including the channels in close proximity to the Mardyke sluice and Stifford gauging station. These provide a standard of protection in the upper catchment to South Ockenden to the 5% AEP (1 in 20 year) fluvial flood event. In the lower catchment, between Purfleet and South Ockenden defences largely offer a 0.1% (1 in 1000 year) standard of protection. Defences along the fluvial channel are maintained by the Environment Agency.

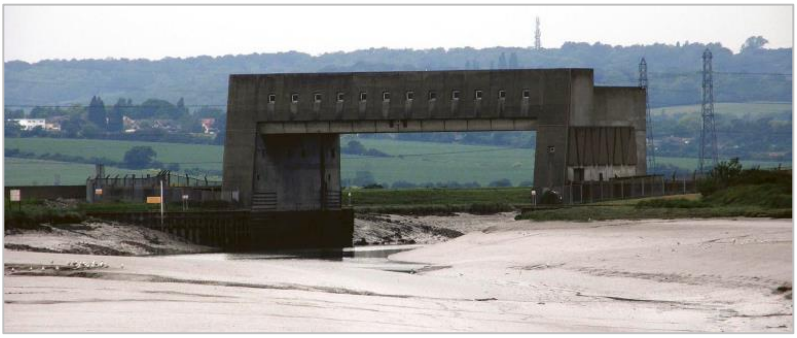
Sluices

5.1.6 There are multiple sluice gates in the Borough which act to prevent tidal waters propagating up connecting rivers. These include: Botney, Gobians, Mardyke, Mucking, St. Cleres, Stonehouse, West Thurrock and Worlds End Sluices.

Flood Barriers

5.1.7 Flood Barriers are further important flood infrastructure reducing the flood risk in Thurrock. There is a flood gate at the entrance of Tilbury Docks. Fobbing Horse Flood Barrier controls water levels on Vange Creek and protects the surrounding area from a 0.1% AEP (1 in 1000 year) tidal flood event. Upriver of the Fobbing Horse Barrier are embankments along Vange Creek.

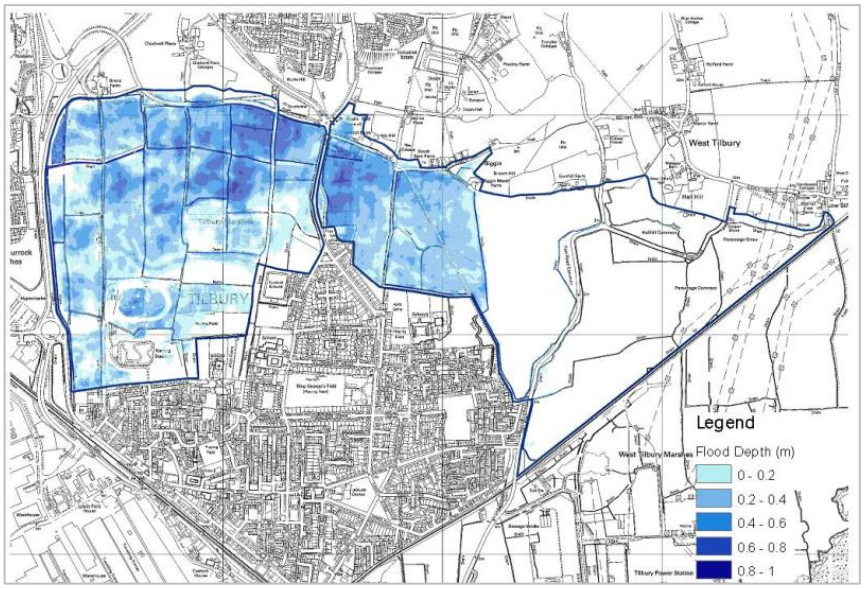
Figure 5-1 Fobbing Horse Tidal Barrier (Source: South Essex CFMP)[29]



Tilbury Flood Storage Area

5.1.8 The purpose of the Tilbury Flood Storage Area, as described in Section 3.7 and shown in Figure 5-2, is to store surface water during the 0.1% AEP (1 in 1000 year) event. Its function is to ensure that surface water runoff from the north does not overwhelm the urban drainage system of Tilbury during major storm events, such as the 1968 floods[30].

Figure 5-2 Tilbury Flood Storage Area (source: Environment Agency 2009)



Recommendation 5-1 *Safeguard the Tilbury Flood Storage Area and prevent loss through redevelopment.*

[29] Environment Agency (2009) South Essex Catchment Flood Management Plan https://www.gov.uk/government/publications/south-essex-catchment-flood-management-plan
[30] Tilbury Riverside Project Website https://www.tilburyandchadwellmemories.org.uk/content/past-events/1968-smaller-flood Weather Online Website https://www.weatheronline.co.uk/reports/philip-eden/September-1968-Floods.htm

TEAM2100 Programme of Work

5.1.9 TEAM2100 will carry out the first part of the Environment Agency's Thames Estuary 2100 Plan, which sets out how to manage tidal flood risk in the Thames estuary throughout the 21st century. TEAM2100 will improve tidal flood defences in London, Kent and Essex from 2015 to 2025.

5.1.10 Table 5-1 provides a summary of the current, planned and delivered flood risk management schemes in Thurrock under the TEAM2100 programme.

Table 5-1 Flood risk management schemes, Thurrock

Scheme	Description	Status
Tilbury Dual Function Lock Gates and existing Tilbury Barrier decommissioning	The Tilbury Tidal Barrier is located at the entrance to the Port of Tilbury London Ltd (PoTLL), immediately in front of the Port's outer lock gates. The barrier is closed on high spring and surge tides to complete the system of flood defences and it protects the Port and over 5000 properties in Tilbury from tidal flood risk. The barrier was constructed in the late 1970s/80s and is nearing the end of its operational life. The Tilbury Dual Function Lock Gates (DFLG) project is to replace the current barrier and outer lock gates with a new pair of reverse head mitre gates, serving both the lock and as a tidal flood defence. The project includes the replacement of all three pairs of mitre gates within the entrance lock to the Port of Tilbury. This provides the Port and the Environment Agency (EA) with full interchangeability, which is both a requirement of the PoTLL and the Environment Agency Area teams should any of the gates require replacing. This is a joint project between PoTLL and the Environment Agency, with each party financially contributing and the EA taking the lead. The project also includes the removal of the existing Tilbury barrier, which will become redundant when the new DFLG are commissioned. The projects are being delivered by the TEAM2100 programme. Construction started in early January 2021 and is due for completion in early summer 2023. The project value is £56M, funded by Grant-in-Aid (GiA), which includes the decommissioning of the existing barrier.	On Site
Purfleet and Grays: Ground anchor inspection and testing	236 ground anchors, covering a frontage of about 1.2 km within the Thames Estuary (TE) 2100 Plan's Purfleet, Grays and Tilbury Policy Unit, were installed in the late 1970s along the Purfleet & Grays frontage. All but 12 of these ground anchors are to stabilise the cantilevered steel sheet pile (SSP) flood walls. The ground anchors extend out under the river with the anchor heads located on the landside of the walls in anchor pits protected by heavy concrete covers. The flood wall stabilising anchors are passive during normal operation so will not show any obvious signs of distress prior to a flood event. Hence, adequate inspection, testing, and other maintenance activities are required to assure their serviceability. The remaining 12 anchors are located where jetties intersect flood walls to control movement of the jetty structures under flood loading. We are currently investing just under £2.5M GiA to inspect and test the loading of all the ground anchor elements and to record the current condition. This will provide a benchmark for the future inspection, maintenance and testing. We mobilised to site in late November 2022 and began inspection and load testing activities prior to Christmas 2022. As of w/c 20 March 2023 59% of the anchors have been inspected and tested with 97 anchors remaining to be inspected. The Environment Agency currently plan to complete these inspection and testing works by summer 2023.	On Site
Tilbury Docks remedial works	The Environment Agency are working to deliver localised repairs to the existing waling beam that forms part of the steel sheet pile (SSP) tidal defence at Tilbury Riverside Arts and Craft (TRAAC) centre. These works aim to deliver a cost-effective solution lasting to 2040 when the current defences will need replacing and raising under the current aspirations of the TE2100 Plan. Targeted site investigation will be required to confirm this approach is suitable and to understand any constraint in advance of preceding with design activities. This same site investigation will also see a trial application of the preferred coating treatment to mitigate corrosion to the SSP itself. The necessary site investigations are planned for mid Q1 2024/25. This site work will influence the subsequent design and delivery is anticipated in spring 2024 although opportunities to bring this forward are in consideration.	In design
Tilbury Fort Sheet Piling Repairs	Tilbury Fort defence wall (within the TE2100 Plan's Purfleet, Grays and Tilbury policy unit) is a 750m frontage installed in 1982 consisting of a steel sheet pile (SSP) embedded retaining wall, including sections with ground anchors and sections with tie rods and capped with precast reinforced concrete (RC) units. The wall supports a high level concrete walkway that forms the public footpath. Detailed engineering inspections (2019 & 2020) identified a number of perforations to the SSP wall. Thickness testing of the SSP wall also identified a number of other areas where the piles were now below their minimum required section thickness. The overall structural assessment of residual life of both the anchored and cantilevered wall sections indicate the SSP defence wall could remain in operation as a flood defence until 2040 subject to remedial works to the perforated areas of locally high corrosion rates. From summer to winter 2021 just under £2M GiA was invested to carry out re-plating of the most heavily corroded areas of the SSPs and carried out inspection and testing of the landward ground anchors to ensure their continual 1:1000yr standard of protection. It is currently envisaged that these defences will need to be replaced to a higher crest level by 2040, rather than raising the existing assets, owing to the structural limitations.	Completed 2021
Tilbury Barrier Maintenance	Works to inspect, and refurbish where required, the spare hydraulic motors and barrier rollers at Tilbury Barrier were completed in early March 2020. This work ensures continued reliability of the existing barrier until the new Tilbury Dual Function Lock Gates (DFLG) project is complete, at which time the existing barrier can be decommissioned once six-months have passed following the commissioning the DFLG.	Complete 2020
Floodgate work	In August 2018 we completed decommissioning, replacement and refurbishment work on 22 floodgates across Purfleet, Grays and Tilbury	Complete 2018
Coryton Drop boards	We delivered minor refurbishment works to a series of access crossing drop boards in the crest of the tidal defences at Coryton in October 2018.	Complete 2018

Flood Alleviation Schemes

5.1.11 In addition to fluvial and tidal flood defences, a number of flood alleviation schemes have been completed or are in the appraisal process. These range from localised SuDS schemes to more strategic regional infrastructure solutions, as listed in Table 5-2.

Table 5-2 Thurrock Flood Alleviation Schemes

Flood Alleviation Schemes	Description	Status
Stanford-le-Hope Integrated Urban Drainage Study	The Stanford le Hope Surface Water Flood Alleviation scheme is a joint partnership project between the Environment Agency and Thurrock Council to help lower the risk of flooding from pluvial and fluvial sources in Stanford le Hope, in east Thurrock. An Initial Assessment undertaken in 2018/19 identified the risk of 42 properties from surface water flooding in a 1.3% AEP (1 in 75 year) event, accounting for a 150mm depth threshold, with up to 4 properties at risk of fluvial flooding in a 1.3% AEP (1 in 75 year) event. There is also an impact on the existing railway infrastructure in this area as a result of fluvial flooding, and therefore both Network Rail and C2C would be the main beneficiaries. Due to the low number of properties at risk of flooding from pluvial and fluvial sources a significant contribution from external sources would be required to support the project. Thurrock Council, as the LLFA will seek to engage with key stakeholders to help progress this project into the next stages, to develop the necessary measures, and business case to help bring the risk to a low-medium level. The next step identified is to develop an Integrated Urban Drainage (IUD) study, working alongside the Environment Agency and Anglian Water, before developing a Business Case. The large level of funding required may place a risk on the ability for this scheme to be progressed.	Ongoing
Bull Meadow Integrated Water Management Scheme, Grays	Thurrock Council has identified an area of land in Grays (NGR NGR TQ 63009 78070) which could provide environmental benefit as well as flood risk benefits. The area upstream is highly urbanised and has suffered from repeated surface water flooding over the years. This project is envisaged to improve the flood risk faced by the community. Thurrock Council will be working in partnership with the local community, Thames Estuary 2100, Environment Agency and Anglian Water.	Ongoing
Catchment to Coast Project, Flood and Coastal Resilience Innovation Programme	As part of the Environment Agency Flood and Coastal Resilience Innovation Programme, the 'Catchment to Coast' project includes measures to improve flood and erosion resilience within Thurrock and Southend-on-Sea. In Thurrock, measures to improve flood resilience will include: - Installing nature-based water management and land management solutions in the upper catchment (above Stanford-le-Hope). - In the mid catchment (Stanford-le-Hope) installing rainwater harvesting in individual homes near pinch points in the sewer system, and storm-water harvesting for greywater purposes in the community, (e.g. allotments); and installing local monitoring and early warning systems. In the lower catchment (Thurrock Thameside Nature Park, Fobbing Marsh), installing bioblocks for patch and repair works to maintain or improve existing and increase biodiversity.	Ongoing
Tilbury Integrated Flood Strategy	The project was led by Thurrock Council who worked in partnership with AW and the Environment Agency to carry out this study. Tilbury, Essex, is at risk of flooding thought to be a result of surface water runoff that is unable to drain away adequately. Tilbury is served by separate sewer system with the surface water discharging to the designated 'Main River' watercourses which themselves drain into the Thames Estuary either by gravity outfalls or pumps. Consequently, the surface water drainage is vulnerable to flooding when water levels in the designated 'Main River' watercourses are elevated. Previous studies have investigated flood risk for the fluvial, surface water and sewer systems, with different parts of the system coming under different ownership, but they interact and affect each other. As a result, the Tilbury catchment required a modelling approach that considered the interaction and interdependencies of the full drainage arrangement to understand the relationship between the different sources of flooding and their response to different rainfall events. The study objectives were as follows: – construct and verify an integrated catchment model of the entire piped and open-channel drainage system in Tilbury; – produce flood risk maps for Tilbury for a range of design storms, including an allowance for climate change; – produce an operational plan highlighting local drainage problems and concerns; – consider outline options appraisal of flood mitigation options for Tilbury in the short, medium and long term; and, – produce an action plan setting out the maintenance activities and the flood mitigation options investigated, with timescales and owners for implementation. This project was completed in 2017. The report identified there was a lack of capacity in the AW sewer system and there was a need to address this. The key recommendation was to link the eastern and the western sewer network to create additional capacity, helping to reduce surface water flooding at key locations. Flooding has been reported in the areas within Tilbury which triggered the modelling work, and Thurrock Council are working with Essex County Council to deliver a pilot Property Level Resilience scheme to select properties in the town.	Complete

Pump Street Flood Alleviation Scheme	Properties on Pump St, Horndon on the Hill, had previously recorded internal flooding to 3 properties in 2002/03. After this event significant local drainage and maintenance was undertaken which appeared to alleviate the flooding with only minor recurrences thereafter. Unfortunately in December 2013 and January 2014 internal flooding to 4 properties occurred and persistent garden flooding has occurred on numerous occasions since. Results of an interim s19 flood investigation report into the flooding identified that recent flooding has been caused by out of bank flows from the Pump Street Brook. In times of heavy rainfall the watercourse is unable to get beyond Pump Street due to an undersized culvert, intensified by lack of maintenance to the watercourse downstream, causing an obstruction to flow. A project was delivered and completed in 2015 by Thurrock Council to alleviate surface water flood risk to 4 cottages located along Pump Street at a cost of £4k, £20k of which was contributed from the Anglian Eastern RFCC Local Levy. The 96m-long culvert on Pump Street Brook was upsized to a 300 x 1000mm box culvert and a flood wall installed to the rear curtilage of the properties. The combination of the measures manages flood risk to the properties from a flood with a 1% chance of occurring in any one year including an allowance for an increase in peak flows anticipated due to climate change.	Complete
Linford, Gobians Sewer Surface Water Study	The study, led by Thurrock Council, has been included in the Environment Agency's Business Case Package. Linford is identified as an area at potential risk from surface water flooding in Thurrock Council's Surface Water Management Plan (SWMP). On behalf of Thurrock Council, CH2M have carried out an Initial Assessment stage to identify outline flood alleviation options and confirm if there is viability to progress the study into a project. The study is considered multiple sources of potential flood risk, including surface water, fluvial and other contributing factors. This project was completed in Autumn 2017. The outcome of the Initial Assessment stated a low Benefit to Cost ratio, and further work will need to be undertaken to determine the viability of the scheme.	Complete
Grays Park Surface Water Study	The study, led by Thurrock Council, has been included in the Environment Agency's Business Case Package. The Grays Park area is identified as an area at potential risk from surface water flooding in Thurrock Council's Surface water Management Plan (SWMP). The Initial Assessment stage has been completed and has identified there is limited justification to progress the study further at this time. Whilst a positive benefit to cost ratio was identified, further work is required to more accurately determine the viability of the scheme, which proposed to develop a flood storage area within Grays Park. Recommendations from the study have identified the need to collect and verify flood records going forward to further strengthen the case for change and to progress a project. Thurrock Council will take these recommendations forward as well as to work closely with partner authorities to build upon the existing information.	Complete
Milehams Yard Scheme	Milehams Yard is a small site allocated to industrial use in Purfleet, Thurrock, located on Tank Hill Road, with Access from New Tank Hill Road, and is bounded by the C2C Purfleet Branch line and HS1. Following earth works to develop the then Channel Tunnel Rail Link (CTRL) now referred to as High Speed 1 (HS1), remedial measures were incorrectly implemented, resulting in surface water unable to drain away sufficiently. Milehams Yard sits at the lowest point, and is therefore susceptible to surface water flooding, as water is unable to drain away into the River Mardyke. Thurrock Council has investigated additional works to help drain water away and is in the process of determining if the proposed drainage route is viable. Works will also include a twin culvert under A1306 Arterial Road in Purfleet, ditch clearance, and re-profiling of a ditch. To enable drainage into the Mardyke. Cost profiles are in the region of £30k. AECOM has completed preliminary works. Thurrock Council has investigated the financial viability of making improvements to the Milehams Yard site. Results presented by AECOM has resulted in the scheme no longer becoming viable for the Council to deliver without external assistance. Thurrock Council are reviewing alternative solutions. Cost profiles are currently in the region of £120k.	Ongoing
Property Level Resilience Pilot	Thurrock Council has been in liaison with Essex County Council to expand on their scheme delivering Property Level Resilience to individual homes which have experienced surface water flooding within the dwelling. As this is a pilot study, only a handful of properties have been invited to participate (eight). Homes will be contacted by Essex County Council on Thurrock Council's behalf, inviting them to participate. A grant of up to £5,000 can be awarded to individual homes to install devices which prevent water from entering the property, such as one-way valves and air bricks, as well as the installation of flood doors. The home will be visited by an auditor to determine what is required, and if the resident agrees, these recommendations will be installed. Where a property is determined to be in a high flood risk area, or the property has been identified by AW as having had surface water flooding in the past, these schemes may be funded by these organisations.	Complete

5.2 Safeguard land for flood risk management

Thames Estuary 2100 Plan

5.2.1 The Thames Estuary 2100 Plan (TE2100) sets out the aims and objectives for managing the estuary throughout the 21st century, and how these will be realised. The Plan includes 3 high-level aims, 9 strategic objectives and 2 strategic enablers, and 13 outcomes, as summarised in Table 5-3.

Table 5-3 TE2100 Aims and Objectives

	AIM A Take an adaptive approach to manage tidal flooding and create climate resilient communities.	**AIM B Protect and enhance the value of the Thames, its tidal tributaries and floodplain. Deliver social, cultural and commercial benefits for communities and support resilient growth.**	**AIM C Tackle the climate and nature crises by putting sustainability at the heart of this Plan. Restore ecosystems, reduce carbon emissions, and deliver environmental and biodiversity net gain.**
Strategic Objectives			
1. Maintain flood defences in line with the flood risk management policies.	Outcome 1: Maintaining tidal flood defences. Outcome 4: Maintaining the Thames Barrier until 2070		
2. Adapt and improve all existing defences by the current deadlines set out in this Plan.	Outcome 2: Improving fixed flood defences		
3. Accelerate preparations to decide on an end-of-century option by 2040. The preferred option and timeline may change as this Plan adapts to future changes.	Outcome 5: Deciding on the future of the Thames Barrier		
4. Track indicators of change and review every 5 years. Update this Plan at least every 10 years using an adaptive FCERM economic approach based on monitoring evidence.	Outcome 11: Adapting our approach using the latest science and data		
5. Work together to develop community-led visions for future riversides. These will drive defence upgrades and identify where to deliver wider benefits.		Outcome 3: Creating a better riverside for local communities Outcome 8: Ensuring development is resilient to climate change	
6. Embed carbon reduction pathways within this Plan, striving to achieve carbon net zero status.			Outcome 10: Working towards net zero
7. Replace habitat lost to sea level rise over the course of this Plan. Support nature recovery and deliver environmental net gain.			Outcome 9: Improving biodiversity
8. Improve understanding of the link between sea level rise and other sources of flood risk. Use spatial and emergency planning to create resilient communities.	Outcome 6: Managing flood risk from all sources. Outcome 7: Increasing resilience to flood risk		
9. Share experience, innovation and learning of delivering and reviewing the Thames Estuary 2100 Plan with others planning to mitigate future climate risks.			
10. (Strategic enabler): develop and put in place a strategy to secure land to deliver this Plan - this will ensure future options remain viable and maximise opportunities for wider benefits	*Outcome 12: Securing land for Thames Estuary 2100*		
11. (Strategic enabler): develop and put in place a long-term investment strategy for this Plan - this will enable us to realise the financial benefits of an adaptation pathways approach	*Outcome 13: Funding multiple benefits through investment*		

5.2.2 Within the TE2100 Plan, Thurrock is covered by four specific Policy Units as follows:

Thames Estuary 2100 Plan

Policy Unit - Rainham Marshes (Policy Approach P4)

- The areas at risk of flooding include: Rainham Marshes Nature Reserve, a large landfill area and major transport links, including the A13 and the HS1 railway.
- The types of flooding that could affect this policy unit include: tidal flooding – when the tide overtops flood defences; fluvial flooding from the Thames and its tributaries including the Mardyke, when heavy rainfall causes rivers to overflow their banks or defences; fluvial flooding from local watercourses including the marsh drainage systems on Aveley marshes; a combination of these.
- To manage flood risks, flood defences include the tidal defences downriver of the Thames Barrier, fluvial flood defences on the Mardyke.

- The flood risk management policy is P4: take further action to keep up with climate and land use change so that flood risk does not increase.

- By 2040, tidal defence owners in this policy unit should: work with the council, developers and local infrastructure providers to adapt defences and achieve multiple benefits through proposed development; and work with the Environment Agency to raise defences where required.
- By 2030, councils should work with communities to plan how their riverside will look in the future and develop a riverside strategy.
- Network Rail will work with councils and the Environment Agency to ensure transport infrastructure in Essex is resilient to increasing flood risk. This will support growth in the outer estuary.
- The Thames Estuary Partnership will work with communities, councils, the Environment Agency and other partners to update the Thames Strategy East. This landscape vision for the river corridor will include a riverside strategy approach to tidal flood defence upgrades.

Policy Unit – Purfleet, Grays & Tilbury (Policy Approach P4)

- The area is mostly industrial and commercial and includes: port facilities, such as the Port of Tilbury; active riverside jetties and wharves; the Dartford Tunnel; HS1 railway northern tunnel portals.
- Most of the marsh areas are low lying, less than 1 metre above mean sea level, and some of the developed areas are very vulnerable to flooding.
- The types of flooding that could affect this policy unit include: tidal flooding – when the tide overtops flood defences; fluvial flooding from local watercourses – when heavy rainfall causes rivers to overflow; surface water flooding – when heavy rainfall is unable to drain away; a combination of these.
- There are tidal flood defences along the Thames Estuary frontage and other local flood defences in Tilbury Town.
- The Tilbury Dual Function Lock Gate (which replaced the Tilbury Barrier) can be closed to prevent flooding.
- There are drainage system outfalls in the area, including at West Thurrock and West Tilbury marshes.

- The flood risk management policy is P4: take further action to keep up with climate and land use change so that flood risk does not increase.

- By 2040, tidal defence owners in this policy unit should: work with the council, developers and local infrastructure providers to adapt defences and achieve multiple benefits through proposed development; and work with the Environment Agency to raise defences where required.
- By 2030, councils should work with communities to plan how their riverside will look in the future and develop a riverside strategy.
- Network Rail will work with councils and the Environment Agency to ensure transport infrastructure in Essex is resilient to increasing flood risk. This will support growth in the outer estuary.
- The Thames Estuary Partnership will work with communities, councils, the Environment Agency and other partners to update the Thames Strategy East upstream of Tilbury; and scope the need and potential extension of a Strategy downstream of Tilbury. Any agreed landscape visions for the river corridor will include a riverside strategy approach to tidal flood defence upgrades.

Policy Unit – East Tilbury & Mucking Marshes (Policy Approach P3)

- The East Tilbury and Mucking Marshes Policy Unit is an area of marshes that extends south from the western side of Stanford-le-Hope towards Coalhouse Fort. There are many local watercourses including Mucking Creek and the marsh drainage systems on East Tilbury Marshes. The main residential area is East Tilbury. The proposed Lower Thames Crossing emerges within this area.
- The areas at risk of flooding include: the Shoeburyness to London Fenchurch Street railway line; some residential areas; the former battery of the nearby Coalhouse Fort; buried archaeological remains; an important area of designated intertidal habitat. Much of the freshwater marsh is used for landfill.
- The types of flooding that could affect this policy unit include: tidal flooding – when the tide overtops flood defences; fluvial flooding from local watercourses including Mucking Creek and the marsh drainage systems on East Tilbury Marshes – when heavy rainfall causes rivers to overflow their banks or defences; surface water flooding in Stanford-le-Hope – when heavy rainfall is unable to drain away; a combination of these.
- Tidal flood defences on the Thames Estuary manage the risk of tidal flooding in this area. There are also fluvial drainage system outfalls at East Tilbury Marshes.
- Fluvial flood risk is likely to rise as the sea level rises and fluvial flows increase. Potential measures to reduce the flood risk include: outfall improvement; flood storage; local flood defences.

- The flood risk management policy is P3: Flood defences will be maintained at their current level, accepting that the likelihood and/or consequences of a flood will increase because of climate change.

- Flood defence owners and infrastructure providers will plan to realign flood defences and improve resilience.
- By 2030, councils should work with communities to plan how their riverside will look in future and prepare riverside strategies.

- The Environment Agency will work with Thurrock council and the local community to implement resilience measures to manage the increased flood risk.
- Network Rail will work with councils and the Environment Agency to ensure transport infrastructure in Essex is resilient to increasing flood risk. This will support growth in the outer estuary.
- The Thames Estuary Partnership will work with communities, councils, the Environment Agency and other partners to scope the need and potential extension of the Thames Strategy East or creation of an alternative Joint Thames Strategy to cover this policy unit. Any agreed landscape vision for the river corridor will reflect how increasing tidal flood risk will affect the environment.

Policy Unit – Shell Haven & Fobbing Marshes (Policy Approach P3)

- The areas at risk of flooding in this policy unit include: the marshes, London Gateway Port, residential areas of Stanford-le-Hope, Fobbing Marsh Nature Reserve.
- The types of flooding that could affect this policy unit include: tidal flooding from the Thames, Holehaven Creek and Vange Creek – when the tide overtops flood defences; fluvial flooding – when heavy rainfall causes the marsh drainage systems on Fobbing and Vange Marshes to overflow their banks or defences; surface water flooding in Stanford-le-Hope – when heavy rainfall is unable to drain away; a combination of these.
- To manage these risks there are: tidal defences on the Thames and Holehaven Creek; the Fobbing Horse Barrier and defences on Vange Creek; drainage system outfalls at Mucking Creek, Shell Haven, Fobbing Marshes and Vange Marshes.

- The flood risk management policy is P3. Flood defences will be maintained at their current level accepting that the likelihood and/or consequences of a flood will increase because of climate change. This policy will be supplemented with improved defences to protect key sites such as Coryton.

- Flood defence owners and infrastructure providers will plan to realign flood defences and improve resilience.
- There is currently no riverside strategy for this area. By 2030, councils should work with communities to plan how their riverside will look in future.
- The Environment Agency will work with Basildon and Thurrock councils and local communities to implement resilience measures where a P3 policy applies.
- Network Rail will work with councils and the Environment Agency to ensure transport infrastructure in Essex is resilient to increasing flood risk. This will support growth in the outer estuary.
- The Thames Estuary Partnership will work with communities, councils, the Environment Agency and other partners to scope the need and potential extension of the Thames Strategy East or creation of an alternative Joint Thames Strategy to cover this Policy Unit. Any agreed landscape vision for the river corridor will reflect how increasing tidal flood risk will affect the environment.

Riverside Strategies

5.2.3 The Thames Estuary 2100 Plan introduces the riverside strategy approach which integrates upgrades to flood defences with riverside improvements and wider benefits. Riverside strategies need to be in place by 2030.

5.2.4 Throughout much of the estuary, flood walls and embankments will need to be a metre or more higher by 2100. Without careful design, higher defences could restrict access to and views of the river. But with early planning, there are opportunities to upgrade defences and create good public spaces. These spaces can be green, accessible, vibrant and attractive, while providing flood protection.

5.2.5 Councils or other organisations can create riverside strategies. Riverside strategies should be an integral part of statutory local planning. They can be standalone documents or form part of a Local Plan. They should include community ambitions for the riverside.

Recommendation 5-2 *Thurrock Council must work with communities to plan how the riverside will look in future and prepare a riverside strategy.*

Future TE2100 defence improvements in Thurrock

5.2.6 Outcome 2 of the TE2100 Plan is ‘Improving fixed flood defences’: Flood walls and embankments protect against future sea level rise. They are adapted, raised, realigned or replaced in line with the flood risk management policies and riverside strategy visions.

5.2.7 By 2025, the Environment Agency will improve understanding of how defence heights could be raised across the estuary. This will include setting out the legal responsibilities of defence owners and how raising can be achieved.

5.2.8 By 2030, the Environment Agency, councils and defence owners will produce a plan for raising defences.

5.2.9 By 2040, defence owners downstream (east) of the Thames Barrier have adapted, raised, realigned or replaced defences in line with the flood risk management policies.

5.2.10 Any financial investment in Thurrock's flood defences will be subject to Defra's Flood and coastal resilience partnership funding policy statement whereby financial contributions will be required from partners (including Thurrock Council, Environment Agency, landowners and other key stakeholders) to attract the maximum amount of FCERM funding.

5.2.11 Ensuring protection from coastal flooding into the future will mean land must be safeguarded both for access and maintenance to current defences and to allow for expansion of defence footprints as a greater degree of protection is required. While most hard defences could be raised within existing footprints, embankments such as those in the Rainham Policy Unit, parts of East Tilbury and Shellhaven and Fobbing Marshes Policy Unit north of the Fobbing Horse Barrier would require widening to accommodate increased height.

5.2.12 Whilst hard defences could potentially be raised within existing footprints, the structures would be tall, unattractive and restrict public access. Additional space will be needed for construction works and vehicle access during defence-raising. Furthermore, land would be required for maintaining, replacing and improving flood defences along the Thames. Corridors of land along existing defence lines need to be safeguarded. Land requirements will vary by site and should be discussed and agreed with the Environment Agency.

5.2.13 Areas have also been identified within Thurrock where managed realignment of defences could achieve landscape, development, public amenity and environmental enhancements. Significant improvements can be made as part of integrated riverside design. Where defences require replacement, consideration should be given to flood defence adaptation rather than like-for-like replacement, utilising a combination of flood storage, river defences and floodplain attenuation. Any such designs must accommodate existing flood defence crest levels and allow for them to be raised in the future.

5.2.14 For further information, reference should be made to the TE2100 Plan: https://www.gov.uk/government/publications/thames-estuary-2100-te2100.

Recommendation 5-3 *The Local Plan and associated allocations should facilitate the recommendations of the TE2100 plan and South Essex CFMP in maintaining, enhancing and replacing flood defences, and safeguarding riverside land.*

Recommendation 5-4 *Where new development is proposed adjacent to the TTD, consideration should be given to the specific recommendations of the TE2100 plan, in requiring reduction of current and future flood risk through the following measures:*

- *Secure land likely to be needed for all long term estuary wide options for flood risk management in the Thames Estuary, specifically within Long Reach and Gravesend Reach;*
- *Raising existing flood defences to the required levels in preparation for future climate change impacts or otherwise demonstrate how tidal flood defences can be raised in the future, through submission of plans and cross-sections of the proposed raising;*
- *Demonstrating the provision of improved access to existing flood defences and safeguarding land for future flood defence raising and landscape, amenity and habitat improvements;*
- *Maintaining, enhancing or replacing flood defences to provide adequate protection for the lifetime of the development;*
- *Where opportunities exist, re-aligning or setting back flood defence walls and improving the river frontage to provide amenity space, habitat, access and environmental enhancements; and*
- *Securing financial contributions towards the anticipated costs of flood risk management infrastructure required to protect the proposed development over its lifetime.*

Options for Future Thames Barrier

5.2.15 A network of tidal flood defences currently provides a very high standard of protection in the Thames Estuary (from Twickenham in the west to Southend-on-Sea and Sheerness in the east). Part of this network includes the Thames Barrier, just downstream of the Isle of Dogs in east London. The Environment Agency are currently considering the future of the Thames Barrier. The TE2100 Plan takes an adaptive pathways approach, and therefore doesn't yet define a final option for replacing or upgrading the current Thames Barrier. Outcome 5 of the TE2100 Plan is 'Deciding on the future of the Thames Barrier'.

5.2.16 There are 7 end-of-century options for the future of the flood defence system which are listed briefly below[31]. A decision will be made by 2040, to enable implementation by 2070.

- Upgrade the Thames Barrier
- Flood storage and upgrade the Thames Barrier
- New barrier with a single set of gates in Gravesend Reach
- New barrier with a single set of gates in Long Reach
- New barrier with second set of gates and locks in Gravesend Reach
- New barrier with second set of gates and locks in Long Reach
- Convert existing Thames Barrier by adding second set of gates and locks

5.2.17 The option for a future flood barrier in Long Reach is within Thurrock Council's boundary. Thurrock Council and the Environment Agency are considering possible options to safeguard land for future construction of the barrier and permanent 'on-shore' facilities associated with it.

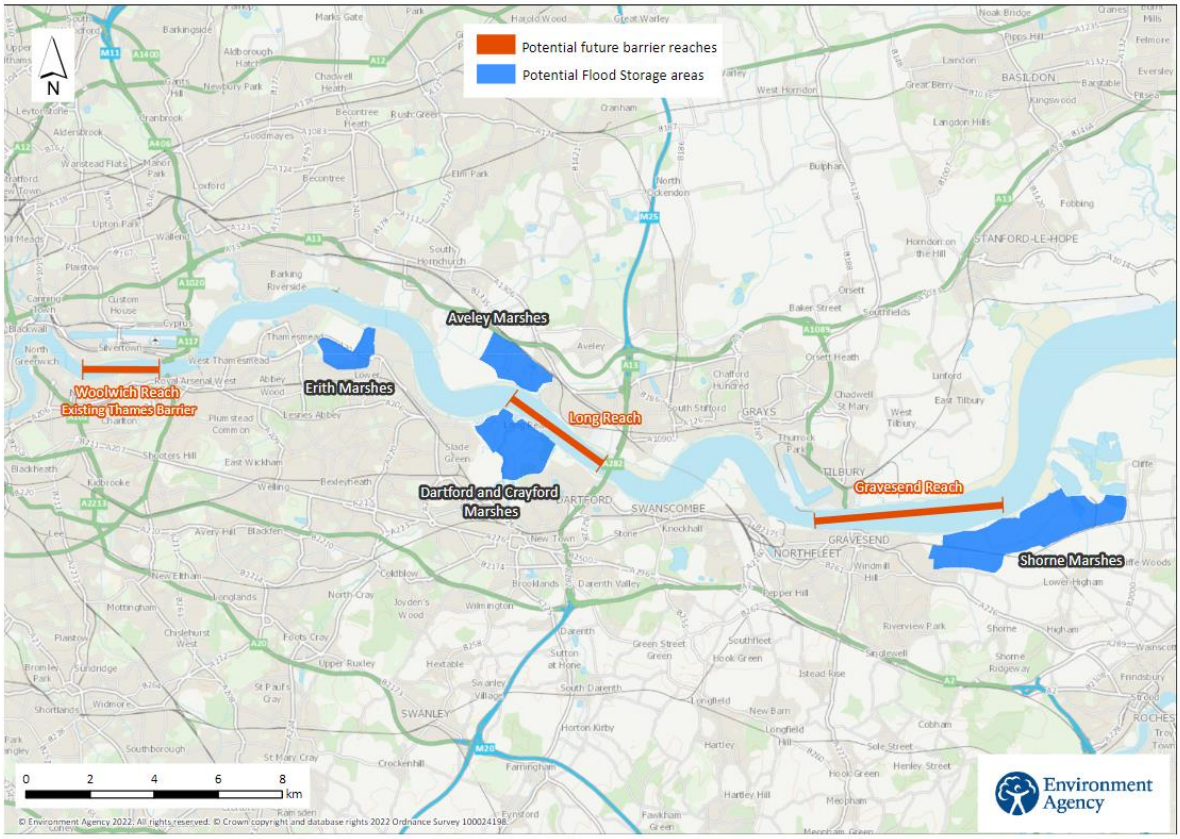


Figure 5-3 Potential locations for a future barrier and flood storage

Source: https://www.gov.uk/guidance/managing-future-flood-risk-and-thames-barrier-thames-estuary-2100#

Riverside Development

Recommendation 5-5 *Safeguard land either side of the River Mardyke, Thames, Stanford Brook and their tributaries and promote the setting back of development to enable sustainable and cost effective flood risk management including upgrading of river walls and embankments. As a minimum, 8m and 16m should be maintained along fluvial and tidal watercourses respectively.*

5.2.18 The Environment Agency is a statutory consultee for planning applications within 20m of main rivers. Permission from the Environment Agency is required for specific regulated flood risk activities[32] including

[31] Defra, Environment Agency, April 2023, Managing future flood risk and Thames Barrier: Thames Estuary 2100 https://www.gov.uk/guidance/managing-future-flood-risk-and-thames-barrier-thames-estuary-2100#
[32] Flood risk activities: environmental permits, September 2022 https://www.gov.uk/guidance/flood-risk-activities-environmental-permits

activity within 8 metres of the bank of a main river, (or 16 metres if it is a tidal main river), and activity within 8 metres of any flood defence structure or culvert on a main river, (or 16 metres on a tidal river). These 'corridors' of land should be protected from development for maintenance purposes and where possible opportunities should be sought for river restoration. Opportunities should be taken to de-culvert watercourses. Any projects such as landscape, development, public amenity and environmental enhancements of land around flood defences must accommodate existing flood defence crest levels and allow for them to be raised in the future.

5.2.19 As the LLFA, Thurrock Council adopt a similar protection along the edges of ordinary watercourses.

5.2.20 Consent will be refused if the works would result in an increase in flood risk, a prevention of operational access to the watercourse and/ or an unacceptable risk to nature conservation.

5.2.21 A pragmatic approach should be adopted for existing development in these areas and opportunities pursued for small scale set back of development from river walls to enable these structures to be modified, raised and maintained as needed.

5.2.22 Developers are encouraged to seek pre-application engagement with the Environment Agency before finalising development layout designs close to watercourses and flood defence structures.

5.2.23 Refer to Section 5.2 and Recommendation 5-4 in relation to riverside strategies for the River Thames.

Green Infrastructure

Recommendation 5-6 *Safeguard land likely to be needed for green infrastructure.*

5.2.24 Green Infrastructure (GI) is a strategically planned and managed network of natural and semi-natural green (land) and blue (water) spaces that intersperse and connect urban centres, suburbs and rural fringe, consisting of:

- Open spaces e.g. parks, woodland, nature reserves and lakes,
- Linkages e.g. river corridors, canals, pathways, cycle routes and greenways,
- Networks of 'urban green' e.g. private gardens, street trees, verges and green roofs.

5.2.25 The identification and planning of GI are critical to sustainable growth and flood risk management. GI can provide a wide range of ecosystem services, including climate mitigation and adaptation, and is central to climate change action. GI also provides additional green spaces for storm flows, freeing up water storage capacity in existing infrastructure and reducing the risk of damage to urban property, particularly in city centres and vulnerable urban regeneration areas. Additionally, GI can improve accessibility to waterways and water quality, supporting regeneration and improving opportunity for leisure, economic activity and biodiversity.

Flood storage

Recommendation 5-7 *Safeguard land for new flood storage areas, (e.g. upstream of Stanford le Hope, Bull Meadow in Grays).*

5.2.26 Flood Storage Areas (FSAs) are natural or man-made areas that temporarily fill with water during periods of high river level, retaining a volume of water which is released back into the watercourse after the peak river flows have passed. There are two main reasons for providing temporary detention of floodwater:

- To compensate for the effects of catchment urbanisation, and
- To reduce flows passed downriver and mitigate downstream flooding.

5.2.27 Providing flood storage within a development area or further upstream of a development can manage and control the risk of flooding. In some cases it can provide sufficient flood protection on its own; in other cases it may be chosen in conjunction with other measures. The advantage of flood storage is that the flood alleviation benefit generally extends further downstream, whereas other methods tend to benefit only the local area and may increase the flood risk downstream.

5.2.28 Further guidance on Flood Storage is provided within Chapter 10 of the Environment Agency's Fluvial Design Guide[33].

Bull Meadow Integrated Water Management Scheme

5.2.29 As identified in Table 5-2, Thurrock Council has identified an area of land off Dock Road and Rockery Lane (NGR TQ 63009 78070) which could provide environmental benefit as well as flood risk benefits. The area upstream is highly urbanised and has suffered from repeated surface water flooding over the years. This project is envisaged to improve the flood risk faced by the community. Thurrock Council will be working in partnership with the local community , Thames 21, the Environment Agency and Anglian Water.

Natural Flood Management

Recommendation 5-8 *Safeguard land for natural flood management (e.g. through the Mardyke and Stanford catchments)*

5.2.30 Natural flood management involves techniques that aim to work with natural hydrological and morphological processes, features, and characteristics to manage the sources and pathways of flood waters. Techniques include the restoration, enhancement and alteration of natural features and characteristics, but exclude traditional flood defence engineering that works against or disrupts these natural processes.

5.2.31 The contribution natural flood management techniques can make to reduce the causes and impacts of flooding will vary greatly from case to case. In some cases, they may be capable of comprehensively addressing flood risk to a site on their own, but in many cases, they will need to be used in a complementary way alongside more conventional flood risk management techniques such as engineered defences. Natural flood management techniques can also contribute to the delivery of biodiversity and environmental net gains and support the implementation of river basin management plans and the public body duty to have regard to them.

5.2.32 There are a number of opportunities available to reduce the causes and impacts of flooding through Working with Natural Processes (WWNP)[34]. This involves implementing measures that help to protect, restore, and emulate the natural functions of catchments, floodplains, rivers, and the coast. WWNP takes many forms and can be applied in urban and rural areas, and on rivers, estuaries, and coasts.

5.2.33 As part of a research project undertaken by the Environment Agency and Flood and Coastal risk Management Research and Development Programme, a series of spatial datasets have been generated for these natural processes[35], identifying their best estimate of locations in the country where the methods can be applied.

5.2.34 Defra have produced a Woodland Constraints dataset which refines potential locations for WWNP, taking into account roads, rail, urban areas, existing woodland, peat, and water bodies.

5.2.35 The WWNP data does not provide information on design, which may need to consider issues such as drain-down between flood events. It is important to note that land ownership and change to flood risk have not been considered. Locations identified may have more recent building or land use than available data indicates.

[33] Environment Agency, Fluvial Design Guidance Chapter 10
https://assets.publishing.service.gov.uk/media/60549b7a8fa8f545cf209a29/FDG_chapter_10_-_Flood_storage_works.pdf
[34] Environment Agency and Flood and Coastal Risk Management R&D Programme. (2021) Working with Natural Processes to Reduce Flood Risk. Available from: https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/working-with-natural-processes-to-reduce-flood-risk?web=1&wdLOR=c56AD7DAC-BB7B-471B-94B4-B5C5B91DEEE4
[35] Working with Natural Processes datasets
https://environment.data.gov.uk/searchresults;query=wwnp;searchtype=All;page=1;pagesize=20;orderby=Relevancy

Table 5-4 Description of WWNP datasets

Natural Process	Benefits	Most Effective Conditions	Notes
Floodplain Woodland Planting Potential	Slows floodwaters and increases water depth on the floodplain. Reduces flood peaks, delays flood peak timing and desynchronises flood peaks. Enhances sediment deposition on the floodplain.	Middle and lower river reaches of middle to large catchments.	Based upon Flood Zone 2. Information is largely based on modelled data and open constraints data and is indicative rather than specific.
Riparian Woodland Planting Potential (woodlands on land immediately adjoining a watercourse)	Slows flood flows. Reduces sediment delivery to the watercourse. Reduces bankside erosion. Creates below ground storage.	At the reach scale in middle and upper catchments.	Based upon a 50m buffer of available OS Open Data river networks. Information is largely based on open data and is indicative rather than specific.
Wider Catchment Woodland	Intercepts, slows, stores and filters water. Reduces flood peaks, flood flows and frequency.	Small events on small catchments – extent of reduction decreases as flood magnitude increases.	Based upon the 1:50k BGS geology survey and relies upon identifying drift and bedrock geologies that are characteristic of slowly permeable soils. Information is largely based on the 100m gridded version of BGS data and open constraints data and is indicative rather than specific.
Floodplain Reconnection Potential (reconnecting watercourses and floodplains)	Encourages more regular floodplain inundation and flood water storage Decreases the magnitude of flood peaks and reduces downstream flood depths.	High frequency, low return period floods.	Designed to support signposting of areas where there is currently poor connectivity such that flood waters are constrained to the channel and flood waves may therefore propagate downstream rapidly Based upon the Risk of Flooding from Rivers and Seas probability maps and identifies areas of low and very low probability that are close to a watercourse, but do not contain residential property or key services (may contain non-residential property – important to consider).
Runoff Attenuation Features (3.3% and 1% AEP) (includes swales, ponds and sediments traps)	Delays and flattens the hydrograph and reduces peak flow locally for small flood events.	A cluster of features working as a network throughout the landscape.	Based upon the Risk of Flooding from Surface Water datasets and identifies areas of high flow accumulations for the 1% (1 in 100 year) and 3.3% (1 in 30 year) AEP surface water maps. The areas of ponding or accumulation are between 100 and 5000 metres squared and have been tagged where they fall on an area of slope steeper than 6% as gully blocking opportunities

5.2.36 **Appendix A Map 15** provides information from the Environment Agency's 'Working with Natural Processes – Evidence Directory' about where these measures could be applied. This map shows that although there are a lot of existing woodland constraints within Thurrock, there are also a wide range of opportunities to implement natural processes to alleviate flooding. There are potential opportunities for floodplain reconnection along the Mardyke and Stanford Brook and opportunities for riparian woodland planting throughout the network of watercourses. Opportunities for floodplain woodland planting are identified throughout the floodplain of the upper Mardyke around Bulphan and West Horndon. Riparian and floodplain woodland planting also holds the potential to confer environmental benefits such as improved water quality, Biodiversity Net Gain, wildlife corridors, and carbon sequestration, in unison with natural flood management.

Catchment to Coast Project, Stanford-le-Hope

5.2.37 As identified in Table 5-2, as part of the Catchment to Coast project[36] there are proposals for the installation of nature-based water management and land management solutions in the upper catchment

[36] Environment Agency Flood and Coastal Resilience Innovation Programme, Catchment to Coast Project https://engageenvironmentagency.uk.engagementhq.com/sou019-catchment-to-coast

above Stanford-le-Hope. The project is being delivered by an established partnership between Southend-on-Sea and Thurrock Borough Councils.

5.3 Water Environment

Recommendation 5-9 *Through measures to manage and mitigate flood risk, Thurrock Council should also seek opportunities to achieve wider environmental benefits.*

5.3.1 A key objective of the WFD is the requirement to prevent deterioration in the current status of water bodies, whilst Heavily Modified Water Bodies (HMWBs) must achieve good ecological potential within a set deadline. If an activity has the potential to impact on the ecology or morphology of a water body, the risk of causing deterioration in the status must be assessed.

5.3.2 Thurrock is covered by the Thames River Basin Management Plan (RBMP), which identifies the current quality of water bodies in the Borough and sets objectives for making further improvements to the ecological and chemical quality.

5.3.3 Within Thurrock Council, the Mardyke is generally not designated as a Heavily Modified Water Body (HMWB) and has an overall status of moderate under the WFD. However, the Mardyke (West Tributary) and Mardyke (East Tributary) have a poor overall status and poor ecological status, although it is not designated as a HMWB. The Mardyke and Fobbing water body is designated as a HMWB and has moderate ecological potential under the WFD.

5.3.4 The section of Thames south of Thurrock extending east to Stanford-le-Hope is classed as the 'Thames Middle' water body, and is designated as a HMWB, with a current overall potential of moderate. The Thames Lower water body runs east from Stanford-le-Hope and is also designated as a HWMB, with an ecological and overall status of moderate.

5.3.5 Actions identified in the LFRMS have the potential to balance social, economic and environmental aims and objectives to achieve wider environment benefits. The implementation of sustainable flood risk management options and measures provides a good opportunity to improve the environment across Thurrock. The LFRMS will contribute to the achievement of wider environmental objectives through the following actions:

a. As flood risk management projects, schemes and initiatives identified within the Programme and Strategic Investment Plan are developed, Thurrock Council will ensure compliance with wider environmental objectives and targets (e.g. those set out by WFD and the RBMP) by ensuring water bodies and protected areas are suitably protected and that the implementation of any scheme does not cause any deterioration of waterbodies.

b. Enhancement of biodiversity and habitat creation within any future capital schemes.

c. Improvement of water quality through use of source control measures such as SuDS.

d. Working with key partners to ensure sustainable land use planning and safeguarding green open spaces to help reduce flood risk.

5.3.6 It is anticipated that growing population numbers and changing climate patterns will place increased pressure on water resources across the Thames Basin. New development can assist in alleviating this water scarcity by incorporating water efficiency measures such as grey water recycling, rainwater harvesting and water use minimisation technologies. This will also have a substantial benefit on the sewer system which will receive less wastewater from properties, potentially freeing up capacity during flood events.

5.4 Consultation with Water Companies

Recommendation 5-10 *Consult Anglian Water to determine constraints on drainage capacity and identify infrastructure requirements to support future growth.*

5.4.1 Large parts of Thurrock are at significant risk of flooding from surface water and inadequate local drainage infrastructure. For future development in the Borough to be sustainable, it must be delivered in parallel with improvements to the current infrastructure provision and strategic management of surface

water, to ensure that development can be safe for its lifetime and where possible will reduce flood risk overall.

5.4.2 New development provides an opportunity to reduce the causes and impacts of flooding associated with surface water and sewer surcharge. As part of the Infrastructure Deliver Plan and to inform the sites allocation process, Thurrock Council should work with Anglian Water to determine key areas for maintenance and locations that would benefit from infrastructure upgrades and/or flood alleviation schemes.

5.5 Sustainable Drainage Systems

Recommendation 5-11 *All major developments and other development should not result in an increase in surface water runoff, and where possible, should demonstrate betterment in terms of rate and volumes of surface water runoff. Sustainable Drainage Systems (SuDS) should be used to reduce and manage surface water run-off to and from proposed developments as near to source as possible in accordance with the requirements of the Technical Standards and supporting guidance.*

5.5.1 SuDS are designed to control surface water run off close to where it falls, combining a mixture of built and nature-based techniques to mimic natural drainage as closely as possible, and accounting for the predicted impacts of climate change. Where possible SuDS solutions for a site should seek to provide benefits for :

- Water quantity (reduce flood risk to the site and neighbouring areas),
- Water quality (reduce pollution),
- Biodiversity (wildlife), and,
- Amenity (landscape).

5.5.2 SuDS are typically softer engineering solutions inspired by natural drainage processes such as ponds and swales which manage water as close to its source as possible. Wherever possible, a SuDS technique should seek to contribute to each of the four goals identified below.

5.5.3 The layout and function of drainage systems needs to be considered at the start of the design process for new development, as integration with road networks and other infrastructure can maximise the availability of developable land. This should ideally be achieved by incorporating (SuDS).

5.5.4 Generally the aim should be to discharge surface water run-off as high up the following hierarchy of drainage options as reasonably practicable in accordance with the Building Regulations 2010 Drainage and Waste Disposal Approved Document[37].

- Into the ground (infiltration)
- To a surface water body
- To a surface water sewer, highway drain, or another drainage system
- To a combined sewer

5.5.5 SuDS techniques can be used to reduce the rate and volume and improve the water quality of surface water discharges from sites to the receiving environment (i.e. natural watercourse or public sewer etc.). The SuDS Manual[38] identified several processes that can be used to manage and control runoff from developed areas. Each option can provide opportunities for storm water control, flood risk management, water conservation and groundwater recharge.

- **Infiltration:** the soaking of water into the ground. This is the most desirable solution as it mimics the natural hydrological process. The rate of infiltration will vary with soil type and condition, the antecedent conditions and with time. The process can be used to recharge groundwater sources and feed baseflows of local watercourses, but where groundwater sources are vulnerable or there is risk of contamination, infiltration techniques are not suitable.

[37] Drainage and waste disposal: Approved document H. Building Regulations in England for foul water drainage and disposal. Available from: Drainage and waste disposal: Approved Document H - GOV.UK (www.gov.uk)
[38] CIRIA C697 SuDS Manual. Available from: http://www.ciria.org/Resources/Free_publications/the_suds_manual.aspx

- **Detention/Attenuation:** the slowing down of surface flows before their transfer downstream, usually achieved by creating a storage volume and a constrained outlet. In general, though the storage will enable a reduction in the peak rate of runoff, the total volume will remain the same, just occurring over a longer duration.
- **Conveyance:** the transfer of surface runoff from one place to another, e.g. through open channels, pipes and trenches.
- **Water Harvesting:** the direct capture and use of runoff on site, e.g. for domestic use (flushing toilets) or irrigation of urban landscapes. The ability of these systems to perform a flood risk management function will be dependent on their scale, and whether there will be a suitable amount of storage always available in the event of a flood.

5.5.6 As part of any SuDS scheme, consideration should be given to the long-term maintenance of the SuDS to ensure that it remains functional for the lifetime of the development. Table 5-5 has been reproduced from the SuDS Manual, CIRIA C697 and outlines typical SuDS techniques.

5.5.7 Adoption arrangements for SuDS scheme should be considered for the lifetime of the development. The LPA will need to consider whether the proposed standard of construction would facilitate adoption and maintenance by an appropriate body such as the water and sewerage company under the Ofwat-approved Sewerage Sector Guidance.

5.5.8 The application of SuDS is not limited to a single technique per site. Often a successful SuDS solution will utilise a combination of techniques, providing flood risk, pollution and landscape/wildlife benefits. In addition, SuDS can be employed on a strategic scale, for example with a number of sites contributing to large scale jointly funded and managed SuDS. It should be noted, each development site must offset its own increase in runoff and attenuation cannot be “traded” between developments.

Suitability for Infiltration SuDS

5.5.9 The use of infiltration techniques is highly dependent on the underlying ground conditions. As part of this SFRA, the detailed BGS Infiltration SuDS Map has been used to provide an indication of the suitability of using infiltration SuDS techniques across the Borough using the following categories:

- Highly compatible: The subsurface is likely to be suitable for free-draining infiltration SuDS.
- Probably compatible for infiltration SuDS: The subsurface is probably suitable for infiltration SuDS, although design may be influenced by the ground conditions.
- Opportunities for bespoke infiltration SuDS: The subsurface is potentially suitable for infiltration SuDS although the design will be influenced by the ground conditions.
- Very significant constraints are indicated: There is a very significant potential for one or more geohazards associated with infiltration.

5.5.10 **Appendix A Map 11** shows that throughout the majority of the study area there are significant constraints indicated for infiltration SuDS due to the underlying soils and geology. The presence of groundwater is also likely to render infiltration SuDS unsuitable.

Table 5-5 Typical SuDS Components

Technique	Description	Conveyance	Detention	Infiltration	Harvesting
Pervious Surfaces	Pervious surfaces allow rainwater to infiltrate through the surface into an underlying storage layer, where water is stored before infiltration to the ground, reuse, or release to surface water.		Y	Y	*
Filter Drains	Linear drains/trenches filled with a permeable material, often with perforated pipe in the base of the trench. Surface water from the edge of paved areas flows into the trenches, is filtered and conveyed to other parts of the site.	Y	Y		
Filter Strips	Vegetated strips of gently sloping ground designed to drain water evenly from impermeable areas and filter out silt and particulates.	*	*	*	
Swales	Shallow vegetated channels that conduct and/or retain water and can permit infiltration when unlined.	Y	Y	*	
Ponds	Depressions used for storing and treating water.		Y	*	Y
Wetlands	As ponds, but the runoff flows slowly but continuously through aquatic vegetation that attenuates and filters the flow. Shallower than ponds. Based on geology these measures can also incorporate some degree of infiltration.	*	Y	*	Y
Detention Basin	Dry depressions designed to store water for a specified retention time.		Y		
Soakaways	Sub-surface structures that store and dispose of water via infiltration.			Y	
Infiltration Trenches	As filter drains but allowing infiltration through trench base and sides.	*	Y	Y	
Infiltration Basins	Depressions that store and dispose of water via infiltration.		Y	Y	
Green Roofs	Green roofs are systems which cover a building's roof with vegetation. They are laid over a drainage layer, with other layers providing protection, waterproofing and insulation. It is noted that the use of brown/green roofs should be for betterment purposes and not to be counted towards the provision of on-site storage for surface water. This is because the hydraulic performance during extreme events is similar to a standard roof (CIRIA C697).		Y		
Rainwater Harvesting	Storage and use of rainwater for non-potable uses within a building, e.g. toilet flushing. It is noted that storage in these types of systems is not usually considered to count towards the provision of on-site storage for surface water balancing because, given the sporadic nature of the use of harvested water, it cannot be guaranteed that the tanks are available to provide sufficient attenuation for the storm event.	*	*	*	Y

*Y: primary process, * some opportunities subject to design*

Catchment to Coast Project

5.5.11 As identified in Table 5-2, the Catchment to Coast project[36] identifies potential opportunities in Stanford-le-Hope to install rainwater harvesting in individual homes near pinch points in the sewer system and stormwater harvesting for greywater purposes in the community (e.g. allotments).

Technical standards and supporting guidance

5.5.12 Developers, designers and consultants looking for information on how to design SuDS within Thurrock should refer to the Essex SuDS Design Guide[39] for guidance on surface water drainage schemes.

5.5.13 The following documents will also provide advice on how best to design sustainable drainage schemes in Thurrock:

- Non-statutory technical standards for sustainable drainage systems
- The CIRIA SuDS Manual (C753)

[39] http://www.essex.gov.uk/Environment%20Planning/Environment/local-environment/flooding/View-It/Documents/suds_design_guide.pdf

- BS8582 Code of practice for surface water management for development sites.

5.5.14 The Technical Standards that are of chief concern in relation to the consideration of flood risk to and from development relating to peak flow control and volume control are presented below:

Peak flow control

5.5.15 **S2** For greenfield developments, the peak runoff rate from the development to any highway drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100 year (1% AEP) rainfall event should never exceed the peak greenfield runoff rate for the same event.

5.5.16 **S3** For developments which were previously developed, the peak runoff rate from the development to any drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100 year (1% AEP) rainfall event must be as close as reasonably practicable to the greenfield runoff rate from the development for the same rainfall event but should never exceed the rate of discharge from the development prior to redevelopment for that event.

Volume control

5.5.17 **S4** Where reasonably practicable, for greenfield development, the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100 year (1% AEP), 6 hour rainfall event should never exceed the greenfield runoff volume for the same event.

5.5.18 **S5** Where reasonably practicable, for developments which have been previously developed, the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100 year (1% AEP), 6 hour rainfall event must be constrained to a value as close as is reasonably practicable to the greenfield runoff volume for the same event but should never exceed the runoff volume from the development site prior to redevelopment for that event.

5.5.19 **S6** Where it is not reasonably practicable to constrain the volume of runoff to any drain, sewer or surface water body in accordance with S4 or S5 above, the runoff volume must be discharged at a rate that does not adversely affect flood risk.

Flood risk within the development

5.5.20 **S7** The drainage system must be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur on any part of the site for a 1 in 30 year (3.3% AEP) rainfall event.

5.5.21 **S8** The drainage system must be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur during a 1 in 100 year (1% AEP) rainfall event in any part of: a building (including a basement); or in any utility plant susceptible to water (e.g. pumping station or electricity substation) within the development.

5.5.22 **S9** The design of the site must ensure that, so far as is reasonably practicable, flows resulting from rainfall in excess of a 1 in 100 year (1% AEP) rainfall event are managed in exceedance routes that minimise the risks to people and property.

5.5.23 All major development[40] should include provision for SuDS and, as the LLFA, Thurrock Council is a statutory consultee on surface water management drainage issues for all such major developments.

5.5.24 For smaller schemes located within Flood Zones 2 and 3, SuDS will need to be addressed as part of an FRA and will be assessed by Thurrock Council.

5.6 Floodplain compensation storage

Recommendation 5-12 *Where proposed development results in a change in building footprint, land raising or other structures such as bunds, the developer must ensure that it does not impact upon the*

[40] NPPF Annex 2 Glossary, Major development is defined as: “For housing, development where 10 or more homes will be provided, or the site has an area of 0.5 hectares or more. For non-residential development it means additional floorspace of 1,000m^2 or more, or a site of 1 hectare or more, or as otherwise provided in the Town and Country Planning (Development Management Procedure) (England) Order 2015”.

ability of the floodplain to store water and should seek opportunities to provide betterment with respect to floodplain storage.

5.6.1 Similarly, where ground levels are elevated to raise the development out of the floodplain, compensatory floodplain storage within areas that currently lie outside the floodplain must be provided to ensure that the total volume of the floodplain storage is not reduced.

5.6.2 Floodplain compensation must be provided on a level for level, volume for volume basis on land which does not already flood and is within the site boundary. Where land is not within the site boundary, it must be in the immediate vicinity, in the applicant's ownership and linked to the site. Floodplain compensation must be considered in the context of the 1% AEP flood level including an appropriate allowance for climate change. When designing a scheme flood water must be able to flow in and out and must not pond. An FRA must demonstrate that there is no loss of flood storage capacity and include details of an appropriate maintenance regime to ensure mitigation continues to function for the life of the development. Guidance on how to address floodplain compensation is provided in Appendix A3 of the CIRIA Publication C624[41].

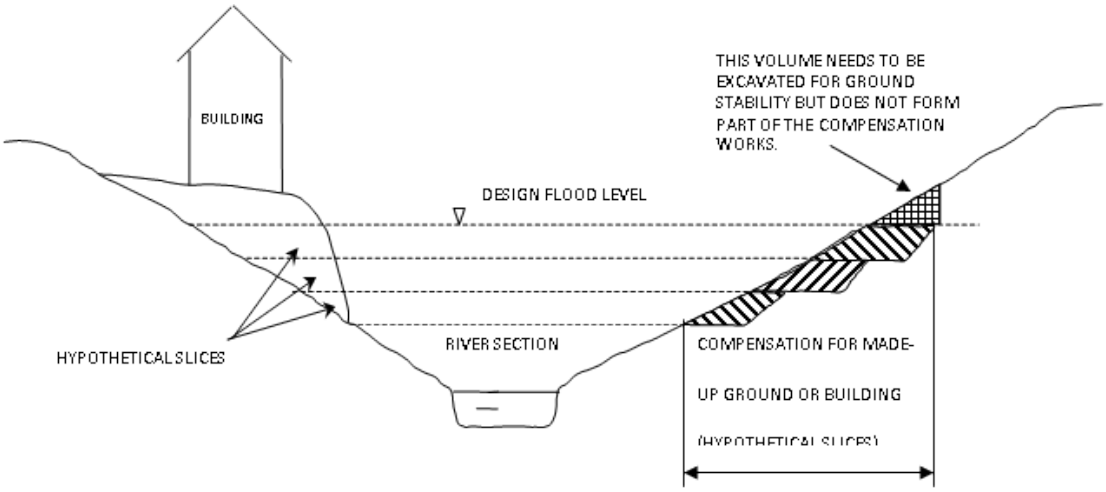


Figure 5-4 Example of Floodplain Compensation Storage (Environment Agency 2009)

5.6.3 The requirement for no loss of floodplain storage means that it is not possible to modify ground levels on sites which lie completely within the floodplain (when viewed in isolation), as there is no land available for lowering to bring it into the floodplain. It is possible to provide off-site compensation within the local area e.g. on a neighbouring or adjacent site, or indirect compensation, by lowering land already within the floodplain, however, this would be subject to detailed investigations and agreement with the Environment Agency to demonstrate (using an appropriate flood model where necessary) that the proposals would improve and not worsen the existing flooding situation or could be used in combination with other measures to limit the impact on floodplain storage.

5.6.4 In defended areas, the need for compensation should be based on the results of a sensitivity test. The test can be assessed in three parts:

- What increase in flood levels may result from development in the defended area if the defences were breached or overtopped
- What is the effect of this change, how much better or worse will flooding be to properties in particular
- Are the affects acceptable, and in reality, what mitigation measures can the developer implement to offset the impacts
- Compensation will be an appropriate solution if the principle of development in the area is in accordance with the NPPF.

5.6.5 This evidence will need to be provided by the developer for review and the Flood Risk Assessment for the development proposal must identify the resulting change.

[41] CIRIA (2004) CIRIA Report 624: Development and Flood Risk - Guidance for the Construction Industry

5.6.6 Rather than stating what the impact on flood levels will be, it must also include what the impacts are as a result of the change (i.e. how many more properties will be at risk of flooding). If the increase in flood level means that water exceeds a building threshold then it is likely the proposals will be unacceptable.

5.6.7 If, however, the increase in flood level is very small, such that no additional properties will be at risk, then the proposals may be considered acceptable.

5.6.8 In principle, flood risk must be reduced up to the design flood (as defined in NPPF and PPG) including allowances for climate change and people must remain 'safe' from flooding during an extreme event.

5.7 Risk of groundwater flooding

Recommendation 5-13 *Future development should assess the potential to impact on the risk of groundwater flooding as a result of subsurface development or additional infiltration. Where required a Hydrogeological Risk Assessment should be undertaken to determine the potential for impact of groundwater flooding and appropriate mitigation measures.*

5.7.1 The geology underlying creates pathways for groundwater to flow through the subsurface and the potential for groundwater flooding to occur, which is exacerbated when water levels in the watercourses are elevated. Additional subsurface development or additional infiltration has the potential to modify groundwater flows, leading to potential flooding elsewhere and/or impacting on groundwater abstractions downstream.

5.7.2 A preliminary Hydrogeological Risk Assessment (HRA) should be undertaken for all proposed developments. The preliminary HRA should identify:

i. the depth and geometry of the penetration of works into the sub-surface from the construction of the proposed development (for example piled foundations, basements, excavation for services). These features can disrupt groundwater flow, alter groundwater levels and therefore increase the risk of groundwater flooding at or around the site.

ii. any changes in drainage, for example impermeable surfaces or infiltration/SuDS systems which could alter groundwater flow patterns and the elevation of the water table.

5.7.3 If the preliminary HRA identifies works below ground and/or changes in drainage a HRA (sometimes called a Basement Impact Assessment) will be required. The scope and detail required for the HRA will vary depending on the scale of sub-surface construction proposed and the local geological and hydrogeological conditions.

5.7.4 The HRA should therefore be used to determine the geological and hydrogeological setting and whether sub-surface development will reach the water table. The water table will move up and down depending on rainfall; the assessment should consider the highest level. If the development does extend down to the water table it may disrupt groundwater flow in the aquifer by creating a barrier and increase the risk of flooding. The HRA should identify the impact and any required mitigation measures.

5.7.5 In some settings there may be an aquifer at depth and, depending on the proposed depth of the development, this may also have to be assessed. A site specific ground investigation (GI) with trial pits and boreholes should be recommend if there is uncertainty over the geological or hydrogeological conditions at any proposed development site.

5.7.6 The HRA should also identify changes in drainage as these may create additional inflows to ground which can also exacerbate groundwater flood risk.

5.8 Property Flood Resilience

Recommendation 5-14 *Where development or redevelopment is proposed in areas at risk of flooding, flood resilience measures must be implemented to mitigate the risk of flooding.*

5.8.1 'Property Flood Resilience' is an approach to building design which aims to reduce flood damage and speed recovery and reoccupation following a flood. It uses a combination of flood resistance and recovery measures and is described in the industry-developed CIRIA Property Flood Resilience Code of

Practice[42], which provides advice for both new-build and retrofit. It includes specific guidance for local authority planners.

5.8.2 Resistance and recovery measures are unlikely to be suitable as the only mitigation measure to manage flood risk, but they may be suitable in some circumstances, such as:

- Water Compatible and Less Vulnerable uses where temporary disruption is acceptable and the development remains safe.
- Where the use of an existing building is to be changed and it can be demonstrated that the avoidance measures are not practicable, and the development remains safe.
- As a measure to manage residual flood risk from flood risk management infrastructure when avoidance measures have been exhausted.

5.8.3 Flood resistance and recovery measures cannot be used to justify development in inappropriate locations.

5.8.4 Where historic buildings are involved, early consultation with Historic England should be undertaken and their guide[43] on flood resilience for historic properties provides additional information.

Flood Resistance 'Water Exclusion Strategy'

5.8.5 Flood resistant construction can prevent entry of water or minimise the amount that may enter a building where there is short duration flooding with water depth up to approximately 0.6 metres, depending on the building's characteristics. Where measures to exclude water in this way are proposed above this level, advice should be sought from a suitably qualified building surveyor, architect or structural engineer.

5.8.6 There is a range of flood resistance and resilience construction techniques that can be implemented in new developments to mitigate potential flood damage. Flood resistance measures, or dry-proofing, stops water entering a building up to a safe structural limit. Resistance measures can be passive, such as flood doors which are normally closed; or active, such as air brick covers or removable flood barriers. Passive measures are to be prioritized over active measures.

5.8.7 This form of construction needs to be used with caution and accompanied by measures that will speed-up flood recovery, as effective flood resistance can be difficult to achieve. Hydrostatic pressures exerted by floodwater can cause long-term structural damage, undermine the foundations of a building or cause leakage through the walls, floor or sub-floor, unless the building is specifically designed to withstand such stresses. In addition, temporary and demountable defences are not appropriate for new-build developments.

5.8.8 There are a range of property flood protection devices available on the market, designed specifically to resist the passage of floodwater. These include removable flood barriers and gates designed to fit openings, vent covers and stoppers designed to fit WCs. These measures can be appropriate for preventing water entry associated with fluvial flooding as well as surface water and sewer flooding. The efficacy of such devices relies on their being deployed before a flood event occurs. It should also be borne in mind that devices such as air vent covers, if left in place by occupants as a precautionary measure, may compromise safe ventilation of the building in accordance with Building Regulations.

Flood Recovery 'Water Entry Strategy'

5.8.9 Flood recoverability measures (or wet-proofing), accept that water will enter the building, but through careful design and changes to the construction will minimise damage and allow faster cleaning, drying, repairing and re-occupancy of the building after a flood. Measures are preferably passive, such as the use of resilient building materials, or active such as moving sensitive equipment or belongings to upper floors when flooding is expected.

5.8.10 Materials should be used which allow the passage of water whilst retaining their structural integrity and they should also have good drying and cleaning properties. Alternatively sacrificial materials can be included for internal and external finishes; for example the use of gypsum plasterboard which can be removed and replaced following a flood event. Flood resilient fittings should be used to at least 0.1m

[42] Kelly, D, Barker, M, Lamond, J, McKeown, S, Blundell, E and Suttie, E (2020) Guidance on the code of practice for property flood resilience, C790B, CIRIA, London (ISBN: 978-0-86017-895-8) https://www.ciria.org/CIRIA/Resources/Free_publications/CoP_for_PFR_resource.aspx
[43] Historic England, April 2015, Flooding and Historic Buildings. https://historicengland.org.uk/images-books/publications/flooding-and-historic-buildings-2ednrev/

above the design flood level. Recovery measures are either an integral part of the building fabric or are features inside a building that will limit the damage caused by floodwaters.

5.8.11 A variety of flood recovery tools can be implemented, such as:

- Using materials with either, good drying and cleaning properties, or, sacrificial materials that can easily be replaced post-flood.
- Design for water to drain away after flooding.
- Design access to all spaces to permit drying and cleaning.
- Raise the level of electrical wiring, appliances and utility metres.

5.8.12 Structures such as (bus, bike) shelters, park benches and refuse bins (and associated storage areas) located in areas with a high flood risk should be flood resilient and be firmly attached to the ground and designed in such a way as to prevent entrainment of debris which in turn could increase flood risk and/or breakaway posing a danger to life during high flows.

5.9 Finished Floor Levels

Recommendation 5-15 *Where developing in Flood Zone 2 and 3 is unavoidable, the recommended method of mitigating flood risk to people is to ensure internal floor levels are raised a freeboard level above the* ***design*** *flood level i.e. the known or modelled 1% AEP (1 in 100 year) flood level for rivers or the 0.5% AEP (1 in 200 year) flood level for tidal Thames, including an allowance for climate change.*

5.9.1 In areas at risk of **river flooding**, the climate change allowance required depends on the vulnerability of the development, as set out in the climate change guidance[20]. For More Vulnerable development the central allowance should be used.

5.9.2 In areas at risk of **tidal flooding**, finished floor levels for More Vulnerable development should be a freeboard above the 0.5% AEP (1 in 200 year) plus upper end climate change allowance. Finished floor levels for Less Vulnerable development should be a freeboard above the 0.5% AEP (1 in 200 year) plus higher central climate change allowance.

5.9.3 These requirements are summarised in Table 5-6.

Table 5-6 Requirements for finished floor levels in Thurrock

Development Vulnerability	Finished floor level requirements in areas at risk of tidal flooding	Finished floor level requirements in areas at risk of fluvial flooding
More Vulnerable	Finished floor levels should be raised a freeboard above the flood level for the 0.5% AEP (1 in 200 year) plus upper end climate change allowance. *Refer to Overtopping maps in Appendix C to determine if a site is at risk during this 'design event'.*	Finished floor levels should be raised a freeboard above the flood level for the 1% AEP (1 in 100 year) plus central climate change allowance.
Less Vulnerable	Finished floor levels should be set a freeboard above the flood level for the 0.5% AEP (1 in 200 year) plus higher central climate change allowance. *Refer to Overtopping maps in Appendix C to determine if a site is at risk during this 'design event'.*	Finished floor levels should be set a freeboard above the flood level for the 1% AEP (1 in 100 year) plus central climate change allowance.

5.9.4 For more vulnerable single-storey uses, ground floor levels should be provided 300mm above the 0.1% AEP (1 in 1000 year) flood level, inclusive of climate change.

5.9.5 For self-contained ground floor flats with access to refuge at a higher level for more extreme events, ground floor levels can be 300mm above the 1% AEP (1 in 100 year) fluvial level inclusive of climate change, or 300mm above the 0.5% AEP (1 in 200 year) tidal flood level, inclusive of climate change. If access to refuge from within the building is not available then the floor levels for ground floor self-contained flats should be the same as that for single storey developments.

5.9.6 In certain situations (e.g. for proposed extensions to buildings with a lower floor level or conversion of existing historical structures with limited existing ceiling levels), it could prove impractical to raise the internal ground floor levels to sufficiently meet the general requirements. In these cases, the Environment Agency and/or Thurrock Council should be approached to discuss options for a reduction in the minimum internal ground floor levels provided flood resistance measures are implemented up to an agreed level.

5.10 Basements

Recommendation 5-16 *Basement dwellings should not be permitted in areas at risk of flooding.*

5.10.1 Annex 3 of the NPPF (Flood Risk Vulnerability Classification), classifies basement dwellings as Highly Vulnerable. Table 2 of the Flood Risk and Coastal Change PPG concludes that Highly Vulnerable uses should not be permitted in Flood Zones 3a and 3b. Basement dwellings are therefore incompatible in Flood zone 3 and should not form part of developments planned in these areas.

5.10.2 Where basement dwellings are considered in Flood Zone 2, the Exception Test needs to be applied and a safe means to escape via internal access to higher floors is required (above the 0.1% annual probability (1 in 1000 year) flood level including an allowance for climate change, in line with the requirements for places of safety, described further in Section 6.6).

6. Assessing and managing residual risk

6.1 Assessing residual risk

6.1.1 Section 3 identifies that a large part of the Thurrock frontage is identified as Flood Zone 3, high probability of flooding from the Thames. Section 5 has identified that there are also flood defences along this frontage, providing a significant level of protection.

6.1.2 Whilst these defences provide a significant standard of protection, there remains a residual risk of flooding if defences breach due to operational or structural failure. The likelihood of such residual risk is very small; however, the scale of consequences from rapid inundation and deep water in heavily urbanised areas mean that these residual risks must be considered. Equally defences may be overtopped if flood events exceed the design level of the defence.

6.1.3 In order to better understand the residual risk of flooding from the tidal Thames, the scope of this SFRA includes updated tidal modelling, to simulate overtopping of the defences, as well as breaches in the flood defences at 21 locations along the frontage.

6.1.4 As described in **Appendix B Modelling Methodology,** the modelling was undertaken in accordance with the latest Breach Modelling Guidance[19] and in consultation with the Environment Agency's Partnership and Strategic Overview team and Asset Management team.

6.1.5 The results of the modelling are presented in Appendix C and D for the following events:

- Appendix C **Overtopping Results**
  - Map 1: Overtopping 0.5% AEP (1 in 200 year) (2125) – Maximum Depth (m)
  - Map 2: Overtopping 0.5% AEP (1 in 200 year) (2125) – Maximum Hazard Rating
  - Map 3: Overtopping 0.1% AEP (1 in 1000 year) (2125) – Maximum Depth (m)
  - Map 4: Overtopping 0.1% AEP (1 in 1000 year) (2125) – Maximum Hazard Rating
- Appendix D **Combined Breach Modelling Results**
  - Map 1: Breach Assessment 0.5% AEP (1 in 200 year) (2125) – Maximum Depth (m)
  - Map 2: Breach Assessment 0.5% AEP (1 in 200 year) (2125) – Maximum Hazard Rating
  - Map 3: Breach Assessment 0.1% AEP (1 in 1000 year) (2125) – Maximum Depth (m)
  - Map 4: Breach Assessment 0.1% AEP (1 in 1000 year) (2125) – Maximum Hazard Rating

6.1.6 Flood hazard is a function of the flood depth and flow velocity at a particular point in the floodplain along with a suitable debris factor to account for the hazard posed by any material entrained by the floodwater. The derivation of flood hazard is based on the methodology in Flood Risks to People FD2320[44].

Table 6-1 Hazard to People Rating (HR=d x (v +0.5)+DF) (Table 13.1 FD2320/TR2)

Flood Hazard (HR)	Description
Less than 0.75	Very low hazard – Caution
0.75 to 1.25	Dangerous for some – includes children, the elderly and the infirm
1.25 to 2.0	Dangerous for most – includes the general public
More than 2.0	Dangerous for all – includes the emergency services

[44] Environment Agency (2008) Supplementary note on Flood hazard ratings and thresholds for development planning and control purpose. Clarification of Table 13.1 FD2320/TR2 and Figure 3.2 FD2321/TR1. Available from: http://evidence.environment-agency.gov.uk/FCERM/Libraries/FCERM_Project_Documents/FD2321_7400_PR_pdf.sflb.ashx

6.2 Development safety

6.2.1 When assessing whether a development can be made safe, the following should be considered[45]:

- Characteristics of a possible flood event including residual risks from flood risk management infrastructure e.g. type and source of flooding, frequency, depth, speed of onset, likelihood of warning.
- Ability of residents and users to safely access and exit a building during a design flood[46] and to evacuate before an extreme flood (0.1% AEP (1 in 1000 year) including climate change).
- Structural safety of buildings.
- Provision of an accessible place of safety in the event that a failure of flood risk management infrastructure would result in speeds of onset flooding that would not make escape from the development feasible.
- Impact of a flood on the essential services provided to or from a development.

6.2.2 Areas behind flood defences are at particular risk from rapid onset of fast-flowing and deep-water flooding, with little or no warning if defences are breached. Measures need to be designed to[47]:

- avoid internal flooding from residual risk from flood risk management infrastructure wherever possible; and
- ensure people are not exposed to hazardous flooding, irrespective of the development's vulnerability classification.

6.2.3 In order to inform an assessment of development safety, the following sections describe the requirements for flood warning, emergency plans, access and escape, and places of safety.

6.3 Flood Warning Areas

6.3.1 The Environment Agency operates a free Flood Warning Service[48] for many areas at risk of flooding from rivers and the sea. In some parts of England the Environment Agency may also be able to tell when flooding from groundwater is possible.

6.3.2 There are 5 Flood Warning Areas in Thurrock as shown in **Appendix A Map 12.** The Environment Agency issues flood warnings to residents and businesses that have registered for the service in these specific areas when flooding is expected:

- Tidal Thames from The Mardyke to Barking Creek
- The Mardyke from North Stifford to Purfleet
- The Thames estuary from Grays to Purfleet, including West Thurrock
- The Thames estuary from Shellhaven, to and including Tilbury
- The Essex coast at Coalhouse Fort and surrounding marshland

Catchment to Coast Project

6.3.3 As part of the Catchment to Coast project[49] there are opportunities to explore the installation of local monitoring and early warning systems in the Stanford-le-Hope catchment. This would provide an opportunity pilot and evaluate a visual early warning system for high-risk surface water locations through improvements to local telemetry.

[45] PPG Flood Risk and Coastal Change paragraph 005.
[46] i.e. 0.5% AEP tidal event including appropriate allowance for climate change, or 1% AEP fluvial flood event or surface water event including an appropriate climate change allowance.
[47] PPG Flood Risk and Coastal Change paragraph 042.
[48] Environment Agency Flood Warning Service https://check-for-flooding.service.gov.uk/
[49] Environment Agency Flood and Coastal Resilience Innovation Programme, Catchment to Coast Project https://engageenvironmentagency.uk.engagementhq.com/sou019-catchment-to-coast

6.4 Emergency plan

6.4.1 **Evacuation** is where flood alerts and warnings provided by the Environment Agency enable timely actions by residents or occupants to allow evacuation to take place unaided, i.e. without the deployment of trained personnel to help people from their homes, businesses and other premises.

6.4.2 **Rescue** by the emergency services is likely to be required where flooding has occurred, and prior evacuation has not been possible. An emergency plan will be needed wherever emergency flood response is an important component of making a development safe.

6.4.3 Emergency Plans will be essential for developments where a failure of flood risk management infrastructure would result in speeds of onset flooding that would not make escape from the development feasible and the use of escape to a place of refuge at a higher level within a building needs to be relied upon to help the users of the development to remain safe in such circumstances (see advice in Section 6.6)

6.4.4 Emergency Plans will be essential for sites at risk of flooding used for holiday or short-let caravans and camping and for any site with transient occupancy (e.g. hostels and hotels).

Recommendation 6-1 *For all developments (excluding minor developments and change of use) proposed in Flood Zone 2 or 3, an Emergency Plan should be prepared to demonstrate what actions site users will take before, during and after a flood event to ensure their safety, and to demonstrate their development will not impact on the ability of the local authority and the emergency services to safeguard the current population.*

6.4.5 For sites in Flood Zone 1 that are located on 'dry islands', it may also be necessary to prepare an Emergency Plan to determine potential egress routes away from the site through areas that may be at risk of flooding during the 1% annual probability (1 in 100 year) flood event including an allowance for climate change.

6.4.6 The Environment Agency has a tool on their website to create a Personal Flood Plan[50]. The Plan comprises a checklist of things to do before, during and after a flood and a place to record important contact details. Where proposed development comprises non-residential extension <250m^2 and householder development (minor development), it is recommended that the use of this tool to create a Personal Flood Plan will be appropriate. Reference should be made to the ADEPT and Environment Agency guidance 'Flood Risk Emergency Plans for New Development[51].

6.4.7 Emergency Plans should include:

- How flood warning is to be provided, such as:
  - Availability of existing flood warning systems,
  - Where available, rate of onset of flooding and available flood warning time, and,
  - How flood warning is given.
- What will be done to protect the development and contents, such as:
  - How easily damaged items (including parked cars) or valuable items (important documents) will be relocated,
  - How services can be switched off (gas, electricity, water supplies),
  - The use of flood protection products (e.g. flood boards, airbrick covers),
  - The availability of staff/occupants/users to respond to a flood warning, including preparing for evacuation, deploying flood barriers across doors etc., and,
  - The time taken to respond to a flood warning.
- Ensuring safe occupancy and access to and from the development, such as:

[50] Environment Agency Tool 'Make a Flood Plan'. Available from: https://www.gov.uk/government/publications/personal-flood-plan
[51] ADEPT, Environment Agency Flood Risk Emergency Plans for New Development. https://adeptnet.org.uk/floodriskemergencyplan

- Occupant awareness of the likely frequency and duration of flood events, and the potential need to evacuate,
- Safe access route to and from the development,
- Where flooding has arisen without prior warning, the Plan should provide advice for accessing places of safety/refuge within a building (refer to Section 6.6).
- If necessary, the ability to maintain key services during an event,
- Vulnerability of occupants, and whether rescue by emergency services will be necessary and feasible, and,
- Expected time taken to re-establish normal use following a flood event (clean-up times, time to re-establish services etc.)

6.4.8 There is no statutory requirement for the Environment Agency or the emergency services to approve evacuation plans. Thurrock BC is accountable via planning condition or agreement to ensure that plans are suitable. This should be done in consultation with emergency planning staff.

Recommendation 6-2 *Where development is proposed or expected in flood risk areas with implications for emergency planning, local planning authorities should work with their emergency planning officers to produce local guidelines setting out requirements for flood warning, evacuation and places of safety, against which individual planning applications can then be judged. These should avoid additional burdens on emergency services, explore opportunities for development proposals to address any shortfall in emergency service and infrastructure capacity, and minimise the need for further consultation at planning application stage.*

6.5 Access and Escape

Recommendation 6-3 *Where development may be proposed in areas at risk of flooding, safe access and escape are required to enable the evacuation of people from the development, provide the emergency services with access to the development during times of flood and enable flood defence authorities to carry out any necessary duties during periods of flood.*

6.5.1 A safe access/escape route should allow occupants to safely enter and exit the buildings and be able to reach land outside the flooded area (e.g. within Flood Zone 1) using public rights of way without the intervention of emergency services or others during design flood conditions, including climate change allowances (i.e. 0.5% AEP (1 in 200 year) tidal event including appropriate allowance for climate change, or 1% AEP (1 in 100 year) fluvial flood event or surface water event including an appropriate climate change allowance).

6.5.2 Where access and escape are important to the overall safety of development in areas of flood risk, the local planning authority should consult with emergency planning staff and, where appropriate with the emergency services, unless local standards or guidelines have been put in place in lieu of consultation.

6.5.3 For developments located in areas at risk of fluvial and tidal flooding safe access / escape must be provided for new development as follows in order of preference:

- Safe dry route for people and vehicles.
- Safe dry route for people.
- If a dry route for people is not possible, a route for people where the flood hazard (in terms of depth and velocity of flooding) is low and should not cause risk to people.
- If a dry route for vehicles is not possible, a route for vehicles where the flood hazard (in terms of depth and velocity of flooding) is low to permit access for emergency vehicles. However, the public should not drive vehicles in floodwater.

‘Dry Islands’

6.5.4 During times of flood, it is possible that all the land surrounding areas in higher elevation becomes flooded, resulting in this higher area becoming a ‘dry island’. During prolonged periods of flooding, it may prove difficult to provide resources and emergency services to those living in these areas. In order to reduce the flood risk, these ‘dry islands’ should be treated the same as for the level of flood risk in the

area surrounding them, regardless of their size. When contemplating development, it is important to study the wider area of the flood map to ensure that there is a dry route to a point outside the floodplain.

6.5.5 In exceptional circumstances, safe access above the design flood level including an allowance for climate change may not be achievable. In these circumstances the Environment Agency and Thurrock Council should be consulted to determine whether the safety of the site occupants can be satisfactorily managed. This will be informed by the type of development, the number of occupants and their vulnerability and the flood hazard along the proposed egress route. For example, this may entail the designation of a safe place of refuge on an upper floor of a building, from which the occupants can be rescued by emergency services. It should be noted that sole reliance on a safe place of refuge is a last resort, and all other possible means to evacuate the site should be considered first. Provision of a safe place of refuge will not guarantee that an application will be granted.

6.6 Places of safety

Recommendation 6-4 *Where a failure of flood risk management infrastructure would result in flooding with a speed-of-onset that would not allow sufficient time for safe access and escape, an internally accessible place of safety, capable of accommodating the likely number of occupants or users of the proposed development should also be provided.*

6.6.1 Places of safety should be located above the extreme flood level (0.1% AEP (1 in 1000 year) including an appropriate allowance for climate change. Along the Thurrock frontage, consideration should also be made to the flood levels from the tidal breach modelling and safe refuge should be provided above the modelled breach flood level during the 0.1% AEP (1 in 1000 year) event including climate change.

6.6.2 Local planning authorities should consider whether the development can be considered safe given the predicted duration of flooding and the vulnerability of occupants/users. In doing so, local planning authorities should account for the likely impacts of flooding on essential services such as electricity, gas, telecommunications, water supply and sewerage. Any place of safety needs to be designed to facilitate rescue in case emergency care is needed or if it is unlikely to be safe for occupants/users to wait until flood waters have receded sufficiently for safe access/escape to be possible.

6.6.3 Reference should be made to the ADEPT/EA guidance[51] section entitled ‘How should residual risks be considered?’ as well as Section 7 of its Emergency Plan checklist which provides guidance on how the Emergency Plan for a development should include information on temporary facilities/areas.

6.7 Emergency planning

6.7.1 Thurrock Council Emergency Planning Team prepares contingency plans for incidents and risks across Thurrock to ensure adequate preparation and response during flood events. There are also several groups which support emergency planning across Essex. Where a new development or change of land use is proposed, flood evacuation plans should be developed through liaison with the emergency planners and the emergency services51.

Recommendation 6-5 *Emergency planning strategies should be reviewed in the light of this updated SFRA to determine the suitability of refuge centres and evacuation routes based on the updated flood risk mapping produced.*

6.7.2 Emergency Planning can be broadly split into three phases, all of which should be considered in managing flood risk across the Borough:

2. Before a flood – raising flood awareness, ensuring no inappropriate use of the floodplain/flow paths, preparing suitable flood emergency plans and communicating them to the wider community;
3. During a flood – Flood alerts and communication, rescuing occupants, providing safe refuge and alternative accommodation;
4. After the flood – providing support to help people recover and return to their homes and businesses.

6.7.3 Consideration of emergency planning is even more critical when it relates to vulnerable sites and essential infrastructure, as further described below.

Vulnerable Sites

6.7.4 Emergency service authorities responsible for hospitals, ambulance, fire and police stations as well as prisons should ensure that emergency plans, in particular for facilities in flood risk areas, are in place and regularly reviewed so that they can cope in the event of a major flood. These plans should put in place cover arrangements through other suitable facilities, if deemed needed.

6.7.5 The NPPF classifies police stations, ambulance stations, fire stations and command centres as Highly Vulnerable buildings. It is essential that all establishments related to these services are located in the lowest flood risk zones to ensure that in the event of an emergency those services vital to the rescue operation are not impacted by flood water. Furthermore, development management policies should seek to locate more vulnerable uses such as schools and care homes in areas at the lowest risk of flooding to minimise the impact of a flood on their vulnerable users.

6.7.6 Allied to this, nominated rest and reception centres should also be identified within the study area and compared with the outputs of this SFRA to ensure that these centres are not at risk of flooding, so that evacuees will be safe during a flood event. Developments that would be suitable for such uses would include leisure centres, churches, schools and community centres.

6.7.7 On occasions where development of vulnerable sites within flood risk areas is unavoidable, necessary measures should be implemented to ensure the site is as safe as possible.

Critical Infrastructure

6.7.8 In the event of a flood incident, it is essential that the evacuation and rescue routes to and from any proposed development remain safe. Floodplain management and emergency response activities must have a focus on key infrastructure and any properties that are below sea level. Essential infrastructure located in Flood Zone 3a or 3b must be operational during a flood event to assist in the emergency evacuation process.

6.7.9 Relevant transport authorities and operators should examine and regularly review their infrastructure including their networks, stations, and depots, for potential flooding locations and to identify the need for any flood risk reduction measures. For large stations and depots, solutions should be sought to store or disperse rainwater from heavy storms in a sustainable manner.

Emergency Planning Teams

6.7.10 Thurrock Council Emergency Planning Team prepares contingency plans for incidents and risks across Thurrock. There are also several groups which support emergency planning across Essex, these are listed below:

1. Essex Resilience Forum
2. Community Risk Register

7. Preparing a site specific FRA

7.1 When is a Flood Risk Assessment required?

7.1.1 A site-specific Flood Risk Assessment (FRA) is a report suitable for submission with a planning application which provides an assessment of flood risk to and from a proposed development and demonstrates how the proposed development will be made safe, will not increase flood risk elsewhere and where possible will reduce flood risk overall in accordance the NPPF/PPG and Thurrock's Core Strategy adopted in 2015[52]. The assessment should demonstrate to the decision-maker how flood risk will be managed now and over the development's lifetime, taking climate change into account, and with regard to the vulnerability of its users. A FRA must be prepared by a suitably qualified and experienced person and must contain all the information needed to allow Thurrock Council to satisfy itself that policy requirements have been met.

7.1.2 The NPPF states that a site-specific FRA is required in the following circumstances:

- Proposals for new development (including minor development and change of use) in Flood Zones 2 and 3.
- Proposals in Flood Zone 1 with a site area of 1 hectare or more.
- Proposals for new development (including minor development and change of use) in an area within Flood Zone 1 which has critical drainage problems (as notified to the LPA by the Environment Agency).
- Proposals in an area within flood zone 1, which was identified in a SFRA as being at increased flood risk in future.
- Where proposed development or a change of use increases the vulnerability classification and where the SFRA shows it is at risk from other sources of flooding.

7.2 What needs to be addressed in a Flood Risk Assessment?

7.2.1 The PPG states that the objectives of a site-specific flood risk assessment are to establish:

- Whether a proposed development is likely to be affected by current or future flooding from any source,
- Whether it will increase flood risk elsewhere,
- Whether the measures proposed to deal with these effects and risks are appropriate,
- The evidence for the local planning authority to apply (if necessary) the Sequential Test, and,
- Whether the development will be safe and pass the Exception Test, if applicable.

7.2.2 The PPG states that site-specific FRAs need to be credible, fit for purpose, and proportionate to the anticipated degree of flood risk and the nature and scale of the development. Site-specific FRAs need to make optimum use of information already available, including information on the Flood Map for Planning and surface water flood risk information, although in some cases additional modelling or detailed calculations will need to be undertaken. Flood risk assessments need to include the information set out in the flood risk assessment checklist in the PPG[53].

7.2.3 As a result, the scope of each site-specific FRA will vary considerably. Table 7-1 presents the different levels of site-specific FRA as defined in the CIRIA publication C624[54] and identifies typical sources of information that can be used. Sufficient information must be included to enable the Council and where appropriate, consultees, to determine that the proposal will be safe for its lifetime, not increase flood risk

[52]Thurrock Council (2015) Core Strategy and Policies for Management of Development
[53] Site specific FRA Checklist https://www.gov.uk/guidance/flood-risk-and-coastal-change#para80
[54] CIRIA, 2004, Development and flood risk – guidance for the construction industry C624.

elsewhere and where possible, reduce flood risk overall. Failure to provide sufficient information will result in applications being refused.

Table 7-1 Levels of Site-Specific Flood Risk Assessment

Description
Level 1 Screening study to identify whether there are any flooding or surface water management issues related to a development site that may warrant further consideration. This should be based on readily available existing information. The screening study will ascertain whether a FRA Level 2 or 3 is required. Typical **sources of information** include: • Thurrock Council SFRA • Flood Map for Planning (Rivers and Sea) • Environment Agency Standing Advice • NPPF Tables 1, 2 and 3
Level 2 Scoping study to be undertaken if the Level 1 FRA indicates that the site may lie within an area that is at risk of flooding, or the site may increase flood risk due to increased run-off. This study should confirm the sources of flooding which may affect the site. The study should include: • An appraisal of the availability and adequacy of existing information, • A qualitative appraisal of the flood risk posed to the site, and potential impact of the development on flood risk elsewhere, and • An appraisal of the scope of possible measures to reduce flood risk to acceptable levels. The scoping study may identify that sufficient quantitative information is already available to complete a FRA appropriate to the scale and nature of the development. Typical **sources of information** include those listed above, plus: • Local policy statements or guidance. • Thames Catchment Flood Management Plan. • Data request from the Environment Agency to obtain result of existing hydraulic modelling studies relevant to the site and outputs such as maximum flood level, depth and velocity. • Consultation with EA/Thurrock/sewerage undertakers and other flood risk consultees to gain information and to identify in broad terms, what issues related to flood risk need to be considered including other sources of flooding. • Historic maps. • Walkover survey to assess potential sources of flooding, likely routes for floodwaters, the key features on the site including flood defences, their condition. • Site survey to determine general ground levels across the site, levels of any formal or informal flood defences
Level 3 Detailed study to be undertaken if a Level 2 FRA concludes that further quantitative analysis is required to assess flood risk issues related to the development site. The study should include: • Quantitative appraisal of the potential flood risk to the development, • Quantitative appraisal of the potential impact of the development site on flood risk elsewhere, and • Quantitative demonstration of the effectiveness of any proposed mitigations measures. Typical **sources of information** include those listed above, plus: • Detailed topographical survey. • Detailed hydrographic survey. • Site-specific hydrological and hydraulic modelling studies which should include the effects of the proposed development. • Monitoring to assist with model calibration/verification. • Continued consultation with the LPA, Environment Agency and other flood risk consultees.

7.3 Pre-application Advice

Recommendation 7-1 *At all stages, Thurrock Council, and where necessary the Environment Agency and/or the Statutory Water Undertaker may need to be consulted to ensure the FRA provides the necessary information to fulfil the requirements for planning applications.*

7.3.1 The Environment Agency and Thurrock Council each offer pre-application advice services which should be used to discuss particular requirements for specific applications.

- Thurrock Council: https://www.thurrock.gov.uk/pre-application-advice/apply-for-pre-application-advice
- Environment Agency: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/297018/LIT_9015_c2822b.pdf

7.3.2 The following government guidance sets out when LPAs should consult with the Environment Agency on planning applications https://www.gov.uk/flood-risk-assessment-local-planning-authorities.

8. Next steps

8.1 Next steps

8.1.1 Thurrock Council should use this SFRA, the associated mapping and resulting recommendations to:

- Develop their Local Plan and associated strategic policies,
- Safeguard land for flood risk management and green infrastructure,
- Carry out the sequential test for potential allocation sites,
- Carry out the sequential test for individual planning applications,
- Make decisions about individual planning applications,
- Decide whether a development can be made safe without increasing flood risk elsewhere,
- Identify the need for local design guidance or codes,
- Aid discussions with emergency planning teams.

8.1.2 Where development must be allocated in areas at risk of flooding further assessment of the risk of flooding may be required, for example through the preparation of a Level 2 SFRA.

8.2 Future monitoring and update

8.2.1 SFRAs are living documents that should be reviewed after a significant flood event or when there are changes to:

- The predicted impacts of climate change on flood risk,
- Detailed flood modelling - such as from the Environment Agency or Lead Local Flood Authority,
- Local Plans, spatial development strategies or relevant local development documents,
- Local flood management schemes,
- Flood Risk Management Plans,
- Shoreline Management Plans,
- Local Flood Risk Management Strategies, and,
- National planning policy or guidance.

Appendix A Mapping

Map	Title
Map 1	River Network
Map 2	LiDAR Topography
Map 3	Superficial Geology
Map 4	Bedrock Geology
Map 5	Historic Flood Map
Map 6	Records of sewer flooding
Map 7	Risk of Flooding from rivers and sea
Map 8	Risk of Flooding from surface water
Map 9	BGS Susceptibility to groundwater flooding
Map 10	Risk of flooding from reservoirs
Map 11	Infiltration SuDS Suitability
Map 12	Flood Warning Areas
Map 13	Opportunities to reduce the causes and impacts of flooding
Map 14	Flood risk management policies
Map 15	Land to be safeguarded for flood management

Appendix B Tidal Modelling Methodology

Appendix C Mapping – Tidal Overtopping

Present Day (2025)

Figure 1: Overtopping 0.5% AEP (1 in 200 year) (2025) – Maximum Depth (m)

Figure 2: Overtopping 0.5% AEP (1 in 200 year) (2025) – Maximum Hazard Rating

Figure 3: Overtopping 0.1% AEP (1 in 1000 year) (2025) – Maximum Depth (m)

Figure 4: Overtopping 0.1% AEP (1 in 1000 year) (2025) – Maximum Hazard Rating

Future including Climate Change (2125)

Figure 5: Overtopping 0.5% AEP (1 in 200 year) (2125) – Maximum Depth (m)

Figure 6: Overtopping 0.5% AEP (1 in 200 year) (2125) – Maximum Hazard Rating

Figure 7: Overtopping 0.1% AEP (1 in 1000 year) (2125) – Maximum Depth (m)

Figure 8: Overtopping 0.1% AEP (1 in 1000 year) (2125) – Maximum Hazard Rating

Appendix D Mapping – Tidal Breach

Combined Breach Results - including Climate Change (2125)

Appendix E Mardyke Sensitivity Analysis

Appendix F West Horndon Integrated Modelling

Appendix G Tilbury Integrated Modelling

Appendix H Recommendations

The following recommendations are made throughout the SFRA report.