Caterham-on-the-Hill Flood Alleviation Scheme

Strategic Outline Case

Version No: 3

***Date*: 08/03/2018**

BUSINESS CASE APPROVAL SHEET

1 Review & Technical Approval

Project title	Caterham-on-the-Hill flood alleviation scheme		
Authority project reference		EA reference	
Lead authority	Surrey County Council	Date of submission	
Consultant	Atkins	Document stage (SOC/OBC/FBC)	SOC
Previous document	N/A	Previous doc ref	N/A

Job title	**Name**	**Signature**	**Date**
'I confirm that this project meets our quality assurance requirements, environmental obligations and Defra investment appraisal conditions and that all internal approvals, including member approval, have been completed and recommend we apply to the Environment Agency for capital grant and local levy in the sum of £			
Authority Project Executive			
'I have reviewed this document and confirm that it meets the current business case guidelines for local authority and Internal Drainage Board applications.'			
Business case reviewer			
'I confirm that the project is ready for assurance and that I have consulted with the Director of Business Finance'			
Area Flood & Coastal Risk Manager			

NPAS Assurance ☐ Projects £100k - £10m (Tick the appropriate box)	Large project review group ☐ Projects >£10m (LPRG)

Recommended for approval			Date
NPAS or LPRG Chair			
Project total as approved £		Version number	
Project total made up of :	Capital Grant (£k)		
	Levy (£k)		
	Other Contributions (£k)		

2 Project Financial approval

Financial scheme of approval	Project total	**Name**	**Signature**	**Date**
Director of Business Finance	All >£100k			
Director of Operations	£1m -£10m			
Executive Director of Operations	>£10m			
Chief Executive	>£20m			

3 Defra approval

Date sent to Defra (or N/A)		Version number (if different)	
Date approved by Defra (or N/A)			
Comments			

For FSoD Coordinator use only:

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Glossary

AADs	Average Annual Damages
AEP	Annual Exceedance Probability
AOD	Above Ordnance Datum
BCRs	Benefit Cost Ratios
BERT	Brockham Emergency Response Team
Defra	Department for Environment, Food & Rural Affairs
DTM	Digital Terrain Model
EAP	Environmental Action Plan
EIA	Environmental Impact Assessment
FAS	Flood Alleviation Scheme
FBC	Full Business Case
FCERM-AG	Flood and Coastal Erosion Risk Management – Appraisal Guidance
FDGiA	Flood Defence Grant in Aid
FCERM GiA	Flood and Coastal Erosion Risk Management Grant in Aid
FSA	Flood Storage Area
FSoD	Financial Scheme of Delegation
H&S	Health and Safety
ICM	Integrated Catchment Model
LBC	London Borough of Croydon
LFRMS	Local Flood Risk Management Strategy
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
MAGIC	Multi-agency Geographic Information for the Countryside
MCM	Multi-Coloured Manual
MFP	Main Flow Path
NPPF	National Planning Policy Framework
NRD	National Receptor Database
OB	Optimism Bias
OBC	Outline Business Case
PV	Present Value
PVb	PV benefit
PVd	Present Value damage
RMA	Risk Management Authorities
RoFSW	Risk of Flooding from Surface Water
SCC	Surrey County Council
SFRA	Strategic Flood Risk Assessment
SOC	Strategic Outline Case
SSSI	Site of Special Scientific Interest
SuDS	Sustainable Drainage Systems
SWMS	Surface Water Management Study
TDC	Tandridge District Council
TWUL	Thames Water Utilities Limited

1. Executive Summary

Approval amount being sought

This Strategic Outline Case (SOC) is to seek Financial Scheme of Delegation (FSoD) approval for £581k, to prepare an Outline Business Case (OBC) for the Caterham-on-the-Hill Flood Alleviation Scheme (FAS) and then progress to submit the Full Business Case (FBC) for approval. The approval is being sought by Surrey County Council (SCC).

Project summary

A detailed Initial Assessment has been undertaken by Atkins on behalf of SCC to identify the flood risk issues in Caterham-on-the-Hill and to identify potential options to reduce this flood risk. An economic assessment has also been undertaken to determine whether the proposed options would be economically viable.

Multiple historic flood events have affected Caterham-on-the-Hill, with the most significant recorded being in June 2016. The pattern of flooding follows the shape of the valley; a main flow path with three adjoining smaller flow paths has been identified. The source of flood risk in Caterham-on-the-Hill is a result of surface water flooding.

The Initial Assessment has determined that cost-beneficial options exist to alleviate flooding in Caterham-on-the-Hill.

At this stage, the leading option is found to be a combination of above-ground flood storage at Queens Park recreation ground and two locations on Coulsdon Common and underground storage at Hillcroft Primary School. However, this is subject to change and continued assessment to confirm the best option or combination of options will be undertaken as part of the next stage (OBC) before the preferred option is identified.

It is therefore recommended that the project is taken forward to OBC.

1.1. The business case development process

Strategic Outline Case (SOC)

A Strategic Outline Case (SOC) is a brief initial document identifying the case for change. The SOC should provide business justification to proceed a project to an Outline Business Case (OBC) and include the following information:

- The concept of the project and the reason for governmental intervention;
- Preliminary strategic aims, business needs and project objectives;
- High level consideration of potential options;
- Preliminary assessment of costs, benefits, risks, funding and affordability; and
- Management considerations.

Analysis completed at the SOC stage should be sufficiently broad and indicative to determine whether it is worth committing the resources to progress the project to OBC; a preferred solution should not be determined at this stage, although a leading option can be identified.

Outline Business Case (OBC)

An OBC is a more detailed analysis to identify a preferred option (or combination of options) and provide the procurement strategy which will progress a project to the Full Business Case (FBC). Completed before commencing formal procurement, the OBC should provide a more complete assessment of the strategic fit, option appraisal, achievability, assumptions about costs, benefits, risks and funding. The OBC should determine the preferred option in terms of level and form of service provision, and should recommend a specific procurement route.

Full Business Case (FBC)

The Full Business Case (FBC) should provide the investment decision; this is the information required to support a decision to award a contract and commit actual funding. The FBC should provide details of the necessary project management, monitoring, evaluation and benefits realisation for the preferred option. The FBC should include the following:

- Key changes and developments since the OBC was submitted;
- Full details of the procurement process;
- Appraisal of bids received from suppliers and a conventional procurement option;
- Final review of strategic fit, options, value for money, affordability and achievability;
- Securing of any planning permission, consents or permits;
- Plan and timetable for final negotiations and award of contract; and
- Final plans for monitoring, evaluation and benefits realisation.

1.2. The five-case model

The five-case model is recommended for the preparation of business cases by HM Treasury and the Welsh Government (HM Treasury, 2016). It is widely used across the UK public sector and provides a step-by-step approach which helps to ensure that each key aspect of an investment proposal is systematically addressed. Figure 1 demonstrates the detail required for each case at each stage; SOC, OBC and FBC (Environment Agency, 2015). An explanation of the five cases and their purposes are detailed below.

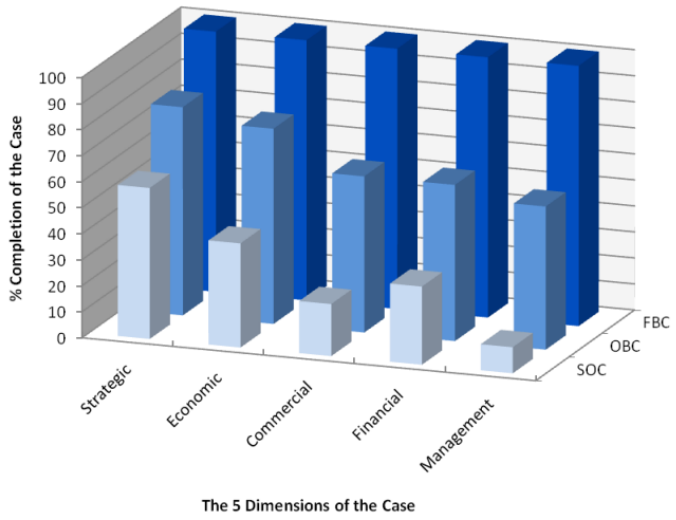


Figure 1 - Development of the content of the five-case model through the SOC, OBC and FBC (HM Treasury, 2016).

1. The strategic case

The overall aim of the strategic case is to set the context of the projects and demonstrate the reasons for pursuing the project. The strategic case is therefore a key part of the SOC. At OBC and FBC stages the strategic case can be summarised; the focus should be on any new matters or areas that have changed since the SOC was approved.

The strategic case should summarise the problem, the need for an intervention and the consequences of doing nothing. It should refer to how the project aligns with the business strategy for the organisation and any related national or functional strategies (HM Treasury, 2016). The case should describe the current organisational approach, activities, the associated revenue costs and any previous investments made in relation to the project. Furthermore, any relevant environmental issues, regulatory requirements, legal obligations or other dependencies around the project should be summarised. Investment objectives, main benefits and any strategic risks should also be stated. Constraints surrounding the planned approach to deliver the project objectives should be identified as well as whether the project objectives or delivery is reliant on other projects or on other things being in place.

2. The economic case

The aim of the economic case is to determine which option (or combination of options) provides the best value for money, while also being deliverable and meeting project objectives (HM Treasury, 2016).

At the SOC stage, the focus should be on identifying the long-list of options and selecting those for the short-list as well as outlining the approach to be followed in the later appraisal stage. Technical descriptions of each of the short-listed options should be provided as well as their associated environmental impact or benefit and risks. The economic case is a key element of the OBC, where the case should demonstrate a robust approach to the selection of the preferred option, including an assessment of the financial and non-financial benefits of each of

the shortlisted options. A summary of the economic case formulated at OBC should be provided at FBC.

The economic case should result in the selection of a leading option in the SOC and a preferred option in the OBC.

3. The commercial case

The aim of the commercial case is to outline the procurement strategy and the methodologies for commercial risk management to demonstrate that the preferred option will result in a viable procurement and well-structured deal (HM Treasury, 2016).

At the SOC and OBC stages, the focus of the commercial case should be to summarise the procurement strategy and highlight the key aspects of the approach being taken to manage commercial risk. At the FBC stage, the commercial case should briefly summarise the approach taken since OBC and highlight the key aspects of the tender process. This should draw on but not replace the Contract Award Report.

4. The financial case

The aim of the financial case is to summarise the planned costs for the scheme over the intended lifespan of the project (whole life costs) and determine the required amount for approval. Furthermore, the financial case should demonstrate that the preferred option will result in a fundable and affordable deal (HM Treasury, 2016).

A SOC should provide project costs in as much detail as possible from the initial high-level estimates made. These should include the costs incurred in preparing the SOC and estimates of the future development costs from SOC to OBC and from OBC to FBC, as well as the full project costs of construction and future operation / maintenance. At the OBC and FBC stages, these costs should be updated, with confirmed (tendered) prices at FBC.

The SOC should also include the first draft of a partnership funding calculation to identify the potential contributions required for the leading option. At subsequent stages, evidence of the future arrangements for funding should be provided, with funding sources agreed in principle at OBC and confirmed at FBC.

5. The management case

The management case should demonstrate that the preferred option is capable of being delivered successfully (HM Treasury, 2016). It should include:

- The proposed project management strategy and governance arrangements;
- A summary of the key project stages and timescales;
- Details of the approach to communicating project plans and progress with key customers and stakeholders;
- Details of the strategy, framework and plan for implementing the change and managing the delivery of benefits;
- Identification of key operational or project delivery risks, including who is responsible for each risk;
- The strategy, framework and plan for managing the contract (once this has been signed), setting out who is responsible for the project over the life of the contract;
- Timings for peer review, as well as any arrangements for planned or necessary post project appraisal to assess project outcomes; and
- Details of the arrangements in place to guarantee continued delivery of required outputs if this project or part of it fails or changes significantly.

In line with the graphic provided in Figure 1, very little detail is required as part of the management case in a SOC, as most of the information is not yet known. The level of detail in this case should then increase through preparation of the OBC and FBC.

2. The Strategic Case

2.1. Introduction

Caterham-on-the-Hill is in eastern Surrey. The Risk Management Authorities (RMAs) for Caterham-on-the-Hill are Surrey County Council (SCC), Tandridge District Council (TDC), London Borough of Croydon (LBC), the Environment Agency and Thames Water Utilities Limited (TWUL).

Please refer to Section 2.2 for further details on the responsibilities of each of the RMAs.

Location

Caterham-on-the-Hill is located with Croydon to the north and the M25 to the south. It is a predominantly residential area with some shops and businesses along the High Street and the Westway.

There are five main areas of open space, namely Queens Park recreation ground, Hillcroft Primary School playing field, Westway Common, Town End recreation ground and Coulsdon Common. The catchment area has been derived using a Light Detection and Ranging (LiDAR) Digital Terrain Model (DTM) (mapped in Figure 2 below) and has an area of 4.4 km^2.

The catchment is small and relatively steep sided; gradients are in the range of 1 in 50, sloping northwards towards Coulsdon Common. Within the catchment, ground levels range from a maximum of 205 m Above Ordnance Datum (AOD) to the south of Queen's Park and a minimum of 110 m AOD at the northern end of Caterham Drive.

Geology

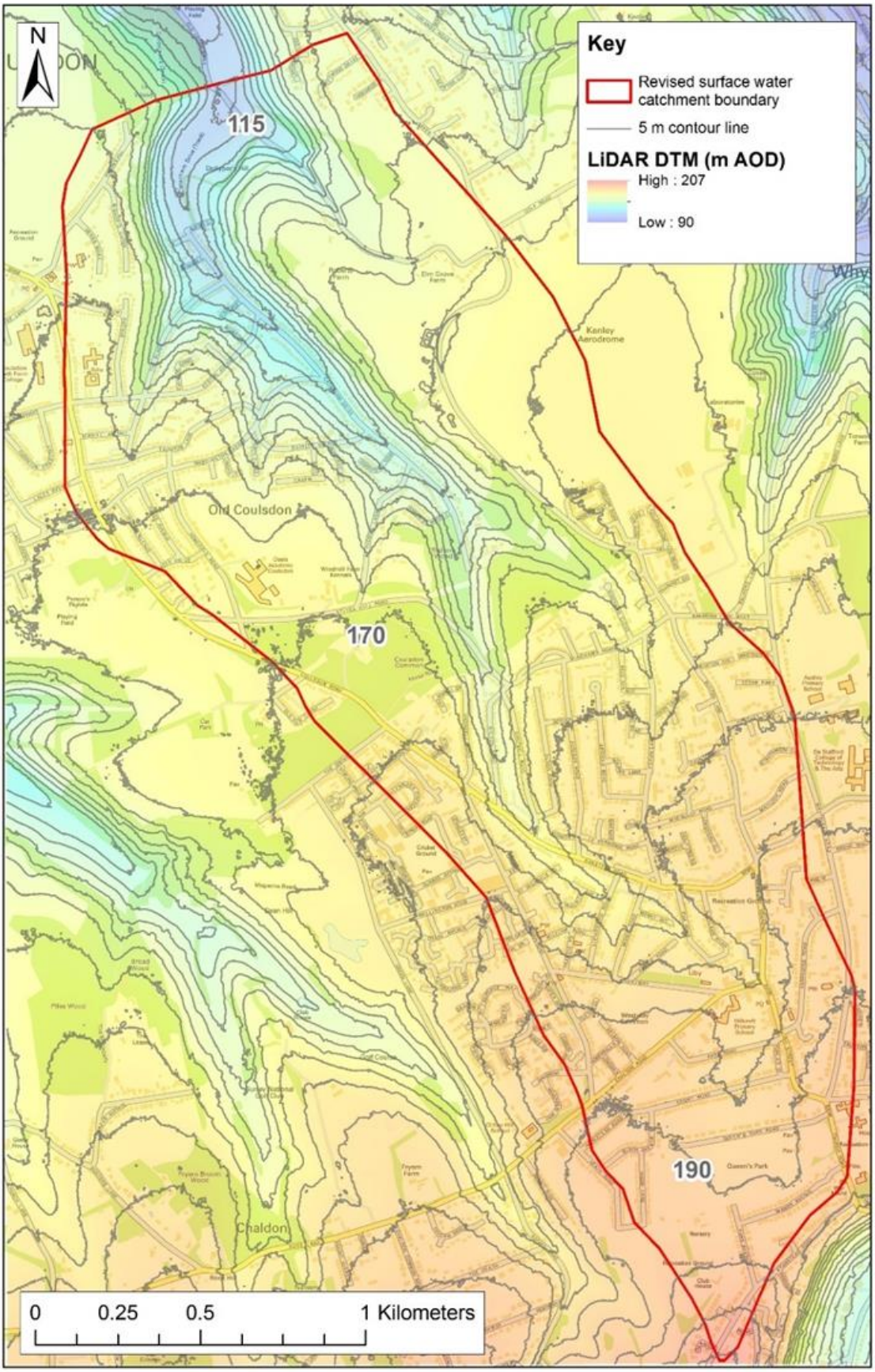
The underlying geology of the site is the Lewes Nodular Chalk Formation, overlain with superficial deposits of clay, silt, sand and gravel (British Geological Society, 2017). The chalk is a 'principal' aquifer, with a high permeability and capable of providing a high level of water storage. The whole of the study area is located within a Groundwater Source Protection Outer Zone (Environment Agency, 2015).

Surface water drainage

The hydraulic response of the catchment is dominated by surface water runoff, with one main surface water flow path and several minor flow paths. Figure 3 illustrates the Environment Agency Risk of Flooding from Surface Water mapping (RoFSW). The main surface water flow path (Figure 3) flows in a northerly direction from just upstream of the Queens Park recreation ground. The flow route then follows the path of the piped watercourse, along the bottom of the valley. This piped watercourse runs north from the northern boundary of Queens Park recreation ground, through the "Money Pit" adjacent to St. Michaels Road and ends in a soakaway on Coulsdon Common. This soakaway has no safe overflow mechanism. During past flood events, the soakaway capacity has been exceeded, the manhole cover has lifted and water has flooded onto Stites Hill Road.

A drainage ditch conveys surface water across Coulsdon Common from Stites Hill Road. It ends in a dug-out storage area with no apparent onward connection. There is a surface water drain conveying water north under Caterham Drive (Figure 3).

New integrated catchment modelling has been undertaken as part of this SOC (Atkins, 2017). The results of this modelling are more detailed than the current Environment Agency RoFSW mapping as the Integrated Catchment Model (ICM) directly includes the drainage (both surface water and foul sewer) network.



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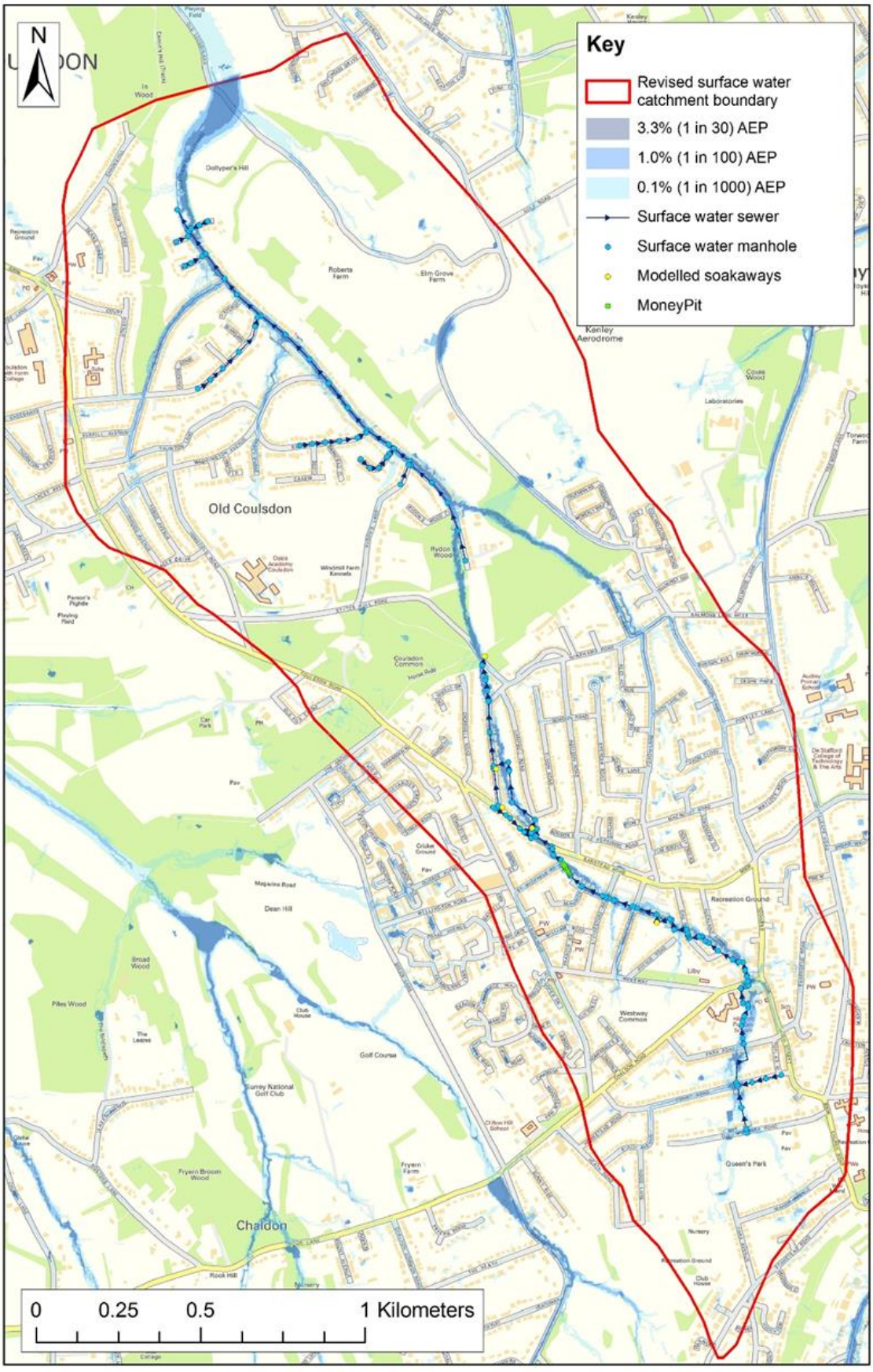
Please note that the values of the contour lines are displayed in metres above ordnance datum (m AOD)

Figure 2 - LiDAR Map.



Contains Ordnance Survey data. © Crown copyright and database right (2017).
Please note that the flood risk show is the Annual Exceedance Probability (AEP) of the risk of flooding from surface water.

Figure 3 – Main surface water flow path according to the Environment Agency's Risk of Flooding from Surface Water (RoFSW).

Surface water flood risk occurs mainly due to the topography and urban nature of the catchment. The capacity of the surface water network is insufficient to cope with large and intense rainfall events.

The model assumes that the main drain is free-flowing without silt or blockage. We have not included road gullies in the model because information regarding connectivity is not available and this level of detail was beyond the modelling scope for an SOC-stage project. From our work it does appear that regardless of the condition of the surface water drainage system, flooding would be likely because of the catchment topography and urban nature of the area.

Current Risk Management

The south westerly extent of Coulsdon Common forms the district boundary between TDC (within SCC) and LBC. This SOC has been prepared as a partnership project with representatives from the councils and also TWUL and the Environment Agency forming the project board.

The existing approach to flood risk management includes maintenance of the road gullies by SCC and by LBC. In the past, SCC have also undertaken maintenance work on the Money Pit, and the Stites Hill Road soakaway.

June 2016 flood event

Between 12:30 and 15:00 on the 7th June 2016, an intense rainstorm occurred in the Caterham-on-the-Hill catchment and led to widespread flooding of properties and roads (Surrey County Council, November 2016). The recorded 72.6 mm of rainfall over a 2.5-hour storm duration (Surrey County Council, November 2016) is greater than the entire monthly June average rainfall in this area. The Caterham Drive Section 19 report (London Borough of Croydon, January 2017) details the rainfall records in Caterham Drive, Caterham-on-the-Hill and the surrounding area (Table 1). The much lower rainfall depth recorded at Purely Oaks demonstrates the localised and intense nature of the flood event.

Table 1 – Rainfall records for 7th June 2016 (London Borough of Croydon, January 2017).

Weather station	Location relative to Caterham Drive	Rainfall recorded	Data source
Kenley	1.4 km north.	40 mm in 1 hour.	Rain gauge data collected by the Met Office.
Caterham drive	-	40.9 mm in 1 hour.	Local weather station.
Caterham-on-the-Hill	1.8 km south.	72.6 mm in 2 hours.	Local weather station.
Purely Oaks	4.0 km north.	11 mm daily rainfall.	Environment Agency rain gauge.

Radar rainfall data was recorded for Caterham-on-the-Hill throughout this event (Hyrad Display Client, 2016). This is displayed in Figure 4.

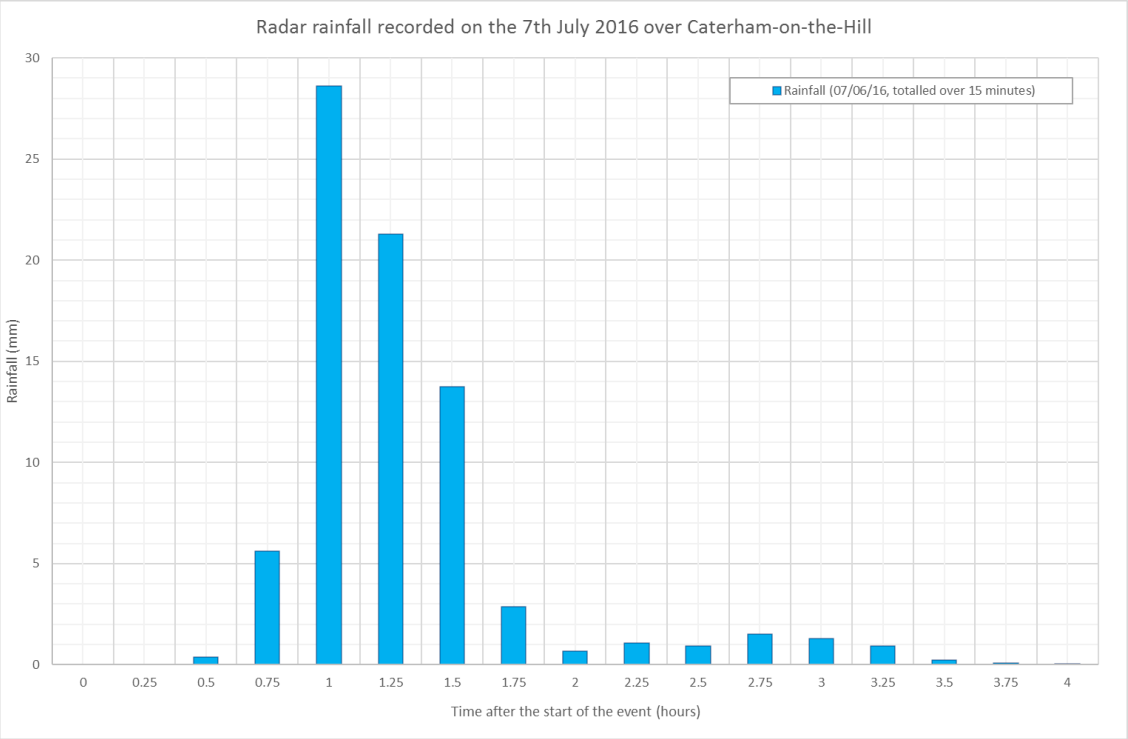


Figure 4 - Radar rainfall recorded on 07/07/2016 (Hyrad Display Client, 2016).

Approach to the SOC

Development of an Initial Assessment to inform preparation of a SOC was commissioned by SCC in 2017. The Initial Assessment involved building an ICM of the surface and foul water catchment, completion of additional survey work, option development, high level costing of the short-listed options and a detailed economic assessment. In addition to this, a Flood Forum meeting was held by the Caterham and Old Coulsdon Flood Action Groups, SCC and Atkins on the 10th May 2017 to gather information about the flood that occurred in Caterham-on-the-Hill on 7th June 2016. The long-listed options were discussed and a short list of options was agreed at a project board meeting, which involved the Environment Agency, SCC, TDC, LBC, TWUL and Atkins, on the 21st July 2017. Further engagement activities with both the project board and residents are planned for the future.

2.2. Business strategies

2.2.1. Project partners

The Caterham-on-the-Hill Flood Alleviation Scheme (FAS) is being managed as a partnership project between the agencies listed below.

Environment Agency

The Environment Agency is the RMA responsible for taking a strategic overview of the management of all sources of flooding in England and Wales. They provide advice to the Government and have prepared strategic plans which set out how to manage risk. Additionally, they provide support to other RMAs through the development of risk management skills and provide a framework to support local delivery of flood risk management. The Environment Agency are flood risk Category 1 responders (Civil Contingencies Act 2004).

Surrey County Council (SCC) and the London Borough of Croydon (LBC)

SCC is the Lead Local Flood Authority (LLFA) and the Highways Authority responsible for managing flooding from surface water, ordinary watercourses, groundwater and highway drainage in Surrey. LBC is the LLFA with the same responsibilities for the Croydon area. SCC and the LBC also have responsibilities as Emergency Responders (under the Civil Contingencies Act 2004).

The LLFA is responsible for the following flood risk management functions:

- The establishment of a Local Flood Risk Management Strategy (LFRMS);
- Maintaining a register of structures or features which impact flood risk;
- Consenting and enforcement works on Ordinary Watercourses;
- Undertaking mitigation works towards reducing surface water and groundwater flooding; and
- Undertaking Section 19 investigations.

The Highways Act (1980) states that the Highways Authority are to maintain highways that are maintainable at public expense, including any maintenance of existing highways drainage. SCC are the local Highways authority; therefore, they ensure that roadside gullies are subject to routine maintenance, the frequency of this is dependent on their risk categorisation.

Tandridge District Council (TDC)

TDC works with the LLFA carrying out the following practices:

- Management works on minor watercourses; and
- Control of development within their area to ensure the management of flood risk.

TDC is required to help as a Category 1 responder where they can, through the following actions:

- Supporting emergency services;
- Providing emergency accommodation; providing sandbags to residents and businesses at risk of flooding;
- Assisting in evacuation transport;
- Helping in a vulnerable people search; and
- Assisting in the coordination of recovery.

Thames Water Utilities Limited (TWUL)

TWUL is responsible for managing their drainage assets under the Water Resources Act (1991). Under the Civil Contingency Act, 2004, TWUL are Category 2 responders to national disasters or emergencies. Under the Flood and Water Management Act 2010, TWUL are required to manage any risk associated with their assets or processes that could cause or be affected by flooding. Furthermore, TWUL are required to share their data with the other RMAs under the Flood and Water Management Act 2010.

2.2.2. National or functional strategies

Department for Environment, Food & Rural Affairs policy

Many of Department for Environment, Food & Rural Affairs (DEFRA)'s high level policies are relevant to this scheme. These include reducing the threats of flooding and adapting to climate change. These are integral to the scheme's objectives.

Environment Agency Corporate Plan

The Environment Agency's 6-year flood and coastal erosion risk management investment programme sets out how £2.3 billion is being spent on more than 1,500 projects to reduce the risk of flooding to more than 300,000 households. Caterham-on-the-Hill Flood Alleviation Scheme (FAS) is included in the investment programme.

2.2.3. Supporting documentation

Tandridge District Council Strategic Flood Risk Assessment (Tandridge District Council, 2015)

Caterham-on-the-Hill falls within the study area of the TDC Strategic Flood Risk Assessment (SFRA) (Tandridge District Council, 2015). The SFRA seeks to meet the requirements of the National Planning Policy Framework (NPPF) in providing an up-to-date assessment of flood risk

in the district, to inform the production of the Local Development Framework and decision making on planning applications. Any option which is taken forward will need to meet the requirements of the NPPF, such as not making flooding worse elsewhere. Any flood risk management options taken forward as part of the Caterham-on-the-Hill FAS will need to be designed in line with the guidance in the SFRA and the requirements of the NPPF.

Tandridge District Council Local Plan (Tandridge District Council, 2017)

TDC's Local Plan is currently being developed. Once adopted it will set out the development strategy of the district up until 2033. The main aims of the local plan (Tandridge District Council, 2017) will be to:

- Deliver infrastructure;
- Provide affordable housing;
- Preserve the character of the area;
- Support local business and attract inward investment; and
- Ensure the district remains a place where people would like to live, work and visit.

The local plan will replace the existing TDC Core Strategy (Tandridge District Council, 2008) and potentially some of the detailed policies. The Core Strategy sets objectives under four main themes:

1. Social progress, recognising everyone's needs;
2. Effective protection of the environment;
3. Maintenance of high and stable levels of economic growth; and
4. Prudent use of resources.

The Caterham-on-the-Hill FAS will help TDC to meet the objectives set out under the themes of the existing TDC Core Strategy. This includes effective protection of the environment (through environmental impact assessments and incorporation of environmental improvements), and prudent use of resources (through a robust business case which justifies option selection on economic and financial criteria). The FAS will additionally help TDC towards achieving the main aims of the future TDC local plan by managing flood risk in a way which benefits communities, businesses and the environment.

London Borough of Croydon Level 1 SFRA (AECOM, 2015) and Level 2 SFRA (AECOM, 2016)

Caterham Drive is located within the study area of the LBC Level 1 and Level 2 SFRA reports. The LBC Level 1 SFRA is joint with the boroughs of Merton, Sutton and Wandsworth. It assesses the local flood risk and provides a summary of the information required to apply the sequential test in each borough. The Level 2 SFRA provides the required information to justify the development of sites satisfying the exception test in each borough. The Level 2 SFRA also provides information on the suitability of Sustainable Drainage Systems (SuDS).

Both SFRA documents seek to meet the requirements of the NPPF in providing an up-to-date assessment of flood risk in the boroughs, to inform the production of the Local Development Framework and decision making on planning applications. Any flood risk management options taken forward as part of the Caterham-on-the-Hill FAS will need to be designed in line with the guidance in the SFRAs and the requirements of the NPPF.

London Borough of Croydon Local Plan (London Borough of Croydon, 2016)

LBC's Local Plan is currently under partial review to reflect the revised London Plan (Greater London Authority, 2016). Providing guidance on housing, economy, community facilities, infrastructure, environment, and securing good design, the Local Plan directs the future development of Croydon. Consultation on the main modifications to the Croydon Local Plan are currently underway.

Once adopted it will set out the development strategy of the district up until 2036. The main strategic objectives of the local plan are in relation to Croydon being:

- A place of opportunity;
    - Establish Croydon as the premier business location;
    - Develop an environment where cultural and creative enterprises can prosper;

    - Provide a choice of housing for people at all stages of life; and
    - Reduce social, economic and environmental deprivation, through priority measures to reduce unemployment, improve skills and education and renew housing, community and environmental conditions.
- A place to belong; and
    - Ensure that high quality new development both integrates, respects and enhances the borough's natural environment and built heritage;
    - Provide and promote well designed emergency services, community, education, health and leisure facilities to meet the aspirations and needs of a diverse community; and
    - Conserve and create spaces and buildings that foster safe, healthy and cohesive communities.
- A place with a sustainable future.
    - Improve accessibility, connectivity, sustainability and ease of movement to, from and within the borough;
    - Ensure the responsible use of land and natural resources and management of waste to mitigate and adapt to climate change;
    - Improve the quality and accessibility of green space and nature, whilst protecting and enhancing biodiversity; and
    - Tackle flood risk by making space for water and utilising sustainable urban drainage systems.

The Caterham-on-the-Hill FAS project will evolve to ensure that it aligns with all national and local strategies; this will help LBC achieve the objectives set out in their local plan.

Caterham-on-the-Hill Surface Water Management Study (Atkins, April 2016)

In 2016 Atkins were commissioned by SCC to undertake a Surface Water Management Study (SWMS) in Caterham-on-the-Hill and to develop conceptual designs for options which would improve drainage asset performance and reduce flood risk (Atkins, April 2016). The surface water management strategy that was produced undertook:

- A review of existing drainage asset data and commissioning of survey for collection of further data where gaps in information were identified;
- A high-level review of modelled and historic flooding and a high-level economic appraisal of baseline flood damages; and
- Conceptual option development.

The assessment of flood risk concluded that there are around 100 properties located along the main flow path thought to be at risk of flooding from surface water up to an annual risk level of 1 in 30 (3.3%). The report estimated Present Value (PV) damages (over a 100-year period) to be in the order of £6 million. It is noted that the study area for this work was restricted to the SCC area and so did not include Caterham Drive and other properties to the north of Coulsdon Common.

A long list of conceptual options which would improve drainage asset performance and reduce flood risk was developed. The long list of options included:

- Further survey / investigation to address outstanding data gaps;
- Maintenance of existing assets, including litter management;
- Improved surface water management making use of green infrastructure and SuDS;
- Kerb raising in flood risk areas;
- Creation of a flood storage area in Queen's Park recreation ground;
- Replacement of the Money Pit underground asset with an above-ground detention basin; and
- Various options for Coulson Common including soakaway clearance, installation of a silt trap, soakaway re-build and measures to better manage exceedance (including

installation of an overflow pipe, construction of a flood bund and / or landscaping to create a storage area).

The SWMS recommended that further work was carried out on the proposed options to determine which are most suitable and/or achievable. This recommendation has been followed with the commissioning of this current work.

Surrey local flood risk management strategy (LFRMS) 2017-2032 (Surrey County Council, 2017)

The Surrey LFRMS has been written to outline the steps that SCC are taking to manage flood risk within the county. Multiple flood sources result in high flood risk in certain parts of Surrey, and while this risk cannot be entirely prevented, SCC and their partners are committed to reducing this risk. In Surrey, there are in excess of 30,000 properties at risk from fluvial and surface water sources, and several major flood incidents have been experienced in the last ten years. With the support of residents and businesses, SCC aim to increase the resilience of communities in a number of ways including influencing policy, empowering local people and investing in both natural and engineered flood alleviation schemes.

The strategy is outlined in the following eight objectives:

- Objective 1: (Information) "Our understanding of local and strategic flood risk will be improved through clear data management and sharing between risk management authorities to ensure partnership delivery of works to high risk areas";
- Objective 2: (Maintenance) "Risk Management Authorities will reduce flood risk by delivering an effective maintenance regime for their drainage assets and managing their estates across the County in an environmentally sustainable manner";
- Objective 3: (Risk Management Authority responsibility) "We will agree with partners who the Risk Management Authorities in Surrey are, jointly define their responsibilities and establish clear lines of communication with them to support the delivery of partnership-based flood alleviation projects";
- Objective 4: (Landowner responsibility) "Private owners will be made aware of their riparian responsibilities to maintain their drainage assets and watercourses. We will support, promote and enforce these responsibilities";
- Objective 5: (Resilience) "The residents and businesses of Surrey will be supported to improve community resilience. Local people will be empowered to reduce the risk of flooding on both an individual and community level";
- Objective 6: (Planning) "We will reduce the risk of flooding to and from development through local planning policy and processes";
- Objective 7: (Investment) "We will reduce flood risk from all sources via a programme of capital works, which will be integrated with the activities of other Risk Management Authorities"; and
- Objective 8: (Investigation) "We will investigate significant flooding incidents in order to make recommendations that help to reduce flood risk".

The Caterham-on-the-Hill FAS aligns with several of the objectives listed above. The FAS is a partnership project with representatives from the councils, the Environment Agency and TWUL on the project board. Working together with the other RMAs, this project will help SCC to achieve objectives 1, 2 and 3. Furthermore, if the scheme continues past the SOC stage, the FAS will contribute to objectives 4 and 7.

Section 19 flood investigation report – Caterham-on-the-Hill (Surrey County Council, November 2016)

On 7th June, 2016 a flash flood occurred in north Tandridge. Caterham-on-the-Hill, Caterham Valley and Whyteleafe were affected, as well as areas to the north in the London Borough of Croydon (LBC) including Coulsdon Common and Caterham Drive. To meet the requirements of Section 19 of the Flood and Water Management Act 2010, a Section 19 Report (Surrey County Council, November 2016) was produced focusing specifically on the Caterham-on-the-Hill catchment. The purpose of the report was to investigate which RMAs had flood risk management functions during the flooding that took place and whether the relevant RMAs exercised, or propose to exercise, their risk management functions (as per section 19(1) of the Flood and Water Management Act 2010).

The rainfall event occurred between 12:30 and 15:00 on the 7th June; it was localised and equivalent to one and a half times the total June average rainfall in the Caterham-on-the-Hill area, as calculated using records from both radar rainfall and a local weather station. The local road and drainage infrastructure did not have sufficient capacity to convey the resulting surface water runoff, and the rainfall led to 86 reports of internal property flooding and a further 63 reports of external property flooding. The internal property flooding included sewage in many locations. Additionally, 40 roads/road sections were affected by the flooding, some of which had to be closed.

The Section 19 report details the actions of SCC, TDC, TWUL and the emergency services during the event. SCC is the lead RMA for incidents of surface water and groundwater flooding. TWUL and TDC also performed other functions during the event, some of which were under different legislation including the Civil Contingencies Act (2004), the Water Industry Act (1991), and the Water Resources Act (1991). After the flooding, the National Flood Forum conducted follow up events to engage with residents. This National Flood Forum has also facilitated the setup of a Flood Action Group in Caterham-on-the-Hill to provide a mechanism for residents to improve communication with RMAs.

Several key recommendations of the Section 19 report are pertinent to this study, these have been listed below. Please see the full report for a full list of recommendations.

1. Drainage network investigation; and
    a. SCC, TDC and TWUL to investigate the ownership of the piped watercourse/surface water sewer network connections in-order to clarify maintenance responsibilities;
    b. Review and expand the recommendations of the Caterham on the Hill SWMS with an aim to continue the options appraisal to mitigate flooding – this has been undertaken as part of this current work;
    c. To investigate sewer connections to the surface water network and to review options to reduce internal sewer flooding; and
    d. To identify funding opportunities to contribute to future feasible schemes.
2. Resident engagement;
    a. For residents to work with the National Flood Forum to create a Flood Action Group in the Caterham on the Hill area to address areas of ongoing concern and develop resilience for those properties at risk of flooding. This group will be the conduit for the RMAs to communicate to the residents and for the residents to monitor progress on specific issues. This Flood Action Group has now been formed, has been used to gather data about historic flood risk and will be used when SCC communicate the findings of this current work with local residents.

The information gathered and reported in the Caterham-on-the-Hill Section 19 report (Surrey County Council, November 2016) has been used alongside further information provided by residents to better understand the 2016 flood event and to validate the results of the ICM.

<u>Section 19 flood investigation report – Caterham Drive (London Borough of Croydon, January 2017)</u>

LBC published a separate Section 19 flood investigation report covering the cross-administration border area of the Caterham-on-the-Hill catchment focused on Caterham Drive (London Borough of Croydon, January 2017). LBC is the local LLFA and is therefore required to meet the requirements of Section 19 of the Flood and Water Management Act 2010. The flood event on the 7th June 2016 met three of LBC developed flood investigation protocol criteria (London Borough of Croydon, January 2017) concluding that:

1. “Six properties were reported to have suffered internal flooding more than 0.1 m. Flooding reached up to 900 mm in some locations.”
2. “Some clarification is required on necessary actions to mitigate future flooding.”
3. “Residents of Caterham Drive have experienced flooding and property damage on a number of occasions over the last 15-20 years.”

The report aimed to assess:

- The historic flood risk of the area;
- The flooding mechanisms which resulted in the flood event;

- The responsibilities of the RMAs and the actions they carried out;
- Any successful response measures and lessons learned; and
- Recommendations for the future.

The Section 19 Report concludes that LBC, SCC and TWUL carried out all their legal responsibilities with regards to their legal obligations, however the report identifies a number of actions which should be implemented to better address the mitigation of the flood risk. Several key actions which are pertinent to this study, are listed below. Please see the full report for a full list of actions.

1. Liaison and recording:
    a. LBC with neighbouring authorities should engage with local landowners and residents;
    b. LBC should follow up with residents that reported flooding to acquire additional details of flooding which could then be used in future studies;
    c. The RMAs should work together to identify asset ownership in the catchment; and
    d. Collaborative working between LBC, TWUL and SCC should be further built upon through the newly created Multi-Agency Project Board.
2. Maintenance:
    a. LBC to review gully cleaning regimes and check functionality of gullies and soakaways in flooding hotspots.
3. Flood management:
    a. Consider the use of SuDS in urban areas and upstream open parkland;
    b. Land known as “Dollypers Hill” could be further enhanced to mitigate flooding. It is proposed that this is considered in conjunction with a Brow ditch or interceptor drain to capture runoff from the steep slopes; and
    c. Residents should ensure their properties are protected for example using property flood resistance measures.

The information gathered and reported in the Caterham Drive Section 19 Report (London Borough of Croydon, January 2017) has been used in the same way as that from the Caterham-on-the-Hill Section 19 Report (Surrey County Council, November 2016) described above.

2.3. Environmental and other considerations

As part of the Initial Assessment, a high-level desk study has been undertaken to review the environmental risks, issues and opportunities. This made use of the publicly available material from the MAGIC (Multi-agency Geographic Information for the Countryside) website (Natural England, 2017). The top environmental issues which may impact future schemes have been summarised in the table below.

Table 2 – Key environmental issues.

No.	Key environmental issues	Adopted mitigation measures
1	The deciduous woodland on Coulsdon Common has been identified on Natural England’s priority habitats inventory. The project must ensure that the quality of this landscape is not compromised.	Avoid impacts through option selection and design where possible. If not, mitigate impacts through measures such as tree planting. Opportunities to include habitat improvements as part of any scheme in this area, which could provide biodiversity and amenity benefits as well as additional funding opportunities.
2	Most of the catchment area is located within the Farthing Downs and Happy Valley Site of Special Scientific Interest (SSSI) Impact Risk Zone. The project must not adversely impact the SSSI.	The risk of adverse impacts on the SSSI is considered to be very low because the SSSI is located in a different catchment, to the west of Caterham-on-the-Hill.
3	Queen’s Park recreation ground and Coulsdon Common are important open spaces for the local community. The project needs to ensure	Avoid impacts through option selection and design where possible. If not, mitigate impacts through measures such as sensitive landscaping and planting. Opportunities to

No.	Key environmental issues	Adopted mitigation measures
	that the recreation and common land uses are not compromised.	include habitat and recreational improvements as part of any scheme in this area, which could provide biodiversity and amenity benefits as well as additional funding opportunities.
4	There are several listed buildings within the study area. The coal tax post on Stites Hill Road is a Grade II listed structure. These buildings / structures must not be negatively impacted.	No adverse impacts on listed buildings are anticipated and some may benefit from the reduction in flood risk. Any work along Stites Hill Road should be designed to avoid impacts on the coal tax post.
5	Caterham-on-the-Hill is a predominantly urban area with many impermeable surfaces. This must be considered in the development of any options.	Green infrastructure and SuDS options offer opportunities for environmental enhancements including habitat creation, water quality improvements and amenity benefits.

Environmental considerations for each flood risk management option will be further identified during the Outline Business Case (OBC) phase of the project. Options may have permanent changes to the landscape, and construction impacts such as noise will need to be mitigated through the implementation of either an Environmental Impact Assessment (EIA) and/or Environmental Action Plan (EAP).

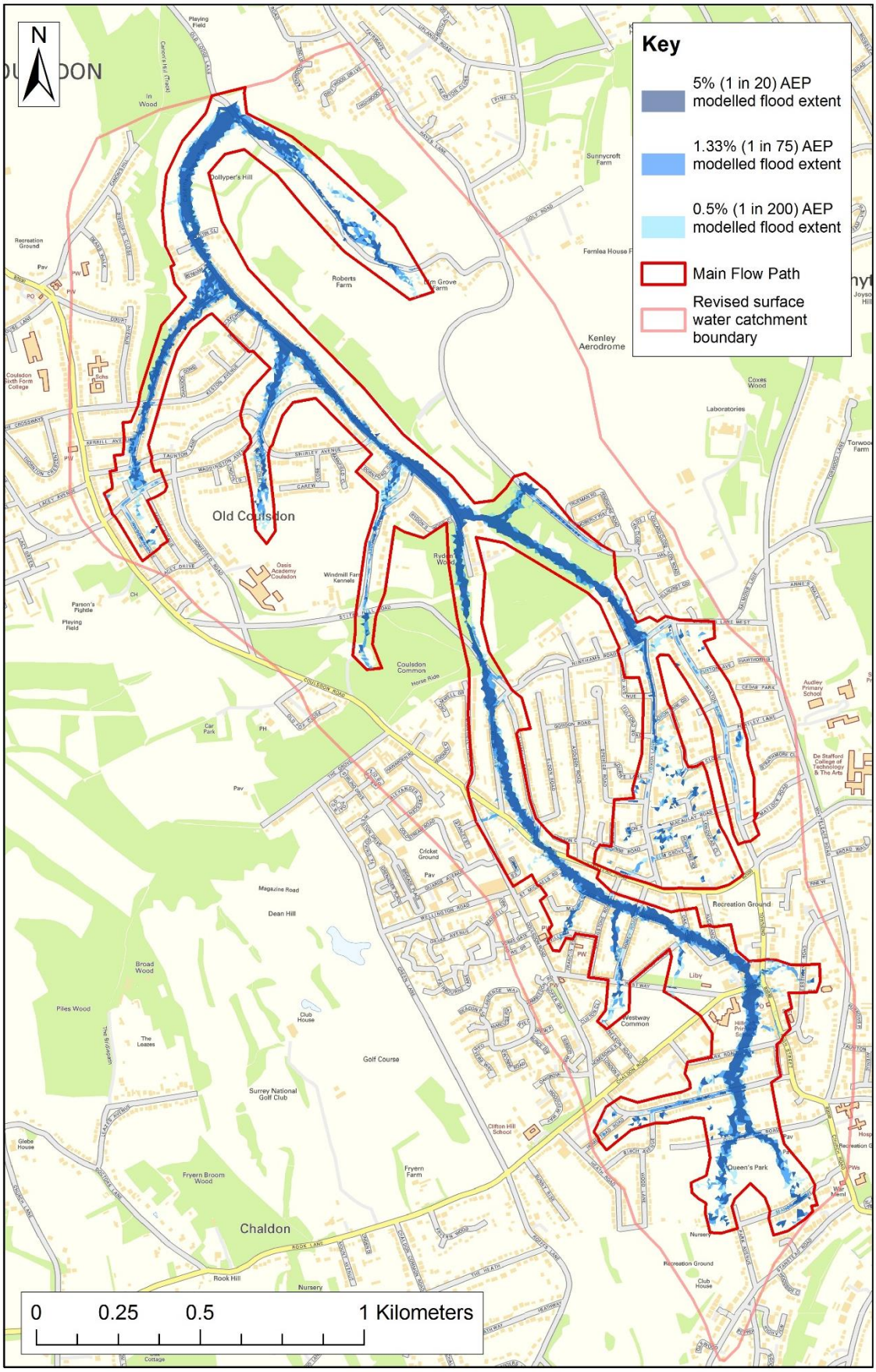
2.4. Investment objectives

The objectives for the Caterham-on-the-Hill FAS at the SOC stage are to:

1. Promote a jointly funded scheme to reduce surface water flood risk to people and property. Partners could include Thames Water, the Environment Agency and other beneficiaries of the scheme e.g. the local flood action group;
2. Promote a scheme which provides the best possible economic standard of protection that where possible, is resilient and adaptive to climate change;
3. Identify options which help create a better place and work with the community to maximise environmental outcomes for people and wildlife; and
4. Minimise and mitigate for both adverse impacts and any safety or environmental risks that may result from the scheme.

2.5. Current arrangements

The study area for this SOC has focussed on the surface water Main Flow Path (MFP) through the catchment (Figure 5). The study area has been derived to encompass all the properties which are modelled to be at risk of flooding from the main surface water flow paths. The definition of the MFP used the 0.5% Annual Exceedance Probability (AEP) flood event results from the Caterham-on-the-Hill ICM. Details about this model are provided in the model build report in Appendix A. The MFP outline was also defined with reference to properties recorded as flooded in the June 2016 flood event.



Please note that the flood risk show is the Annual Exceedance Probability (AEP) of the risk of flooding from surface water.

Figure 5 – Study area with reference to the modelled flood extents exported from the Caterham-on-the-Hill ICM.

2.6. Main benefits

The Initial Assessment has identified that subject to more detailed work, flood risk management options appear to be technically and economically viable. The options taken forward will reduce the risk of flooding in Caterham-on-the-Hill and Old Coulsdon. This will benefit mainly residential properties but also non-residential properties and roads. Investment could result in up to approximately 120 buildings in Caterham-on-the-Hill and Old Coulsdon having reduced flood risk. Mapping of the modelled short-listed options is provided in Appendix E. Furthermore, investment would ensure that flood risk management assets are maintained and are able to adapt to climate change over the next 100 years. A more accurate assessment of the benefits of the options will be provided in the OBC.

2.7. Main risks

At this stage, strategic project risks are considered at a high-level (Table 3) and are largely centred around three themes. Please refer to Section 6.2 for more detail on risk.

Table 3 - Strategic risks

Strategic risks	Mitigation
Inability to secure the required funding could lead to the implementation of an alternative option, which has less benefit than the leading option. This may also result in raising expectations which then cannot be met.	The development costs of the project are being funded through a mixture of FCRM Partnership Funding and stakeholder contributions. Key stakeholders are already aware of the scheme in its current form. The OBC stage will look into funding in greater detail. The FAS will not proceed without significant contributions being identified, secured and confirmed.
Development of the project to appraisal stage reduces the estimated benefit of the leading option and could require additional funding to be sought.	Modelling and economics in this study has been completed in more detail to that typically provided at a SOC stage. This provides an increased level of confidence in the economic and financial cases presented here. Further work on option costs, potentially with input from a contractor is recommended for completion at an early stage of the OBC to further improve confidence in the amount of funding required.
Reputational damage resulting from a failure to engage and/or meet the demands of any stakeholders. This could lead to bad publicity for the organisation promoting the scheme and its partners. It also could lead to a loss of public confidence.	Development of the project is shared with the Project Board at each stage. Furthermore, the residents are engaged with the project through the Flood Action Group meetings. Feedback from both the project board and the flood action group is considered in the project development.

2.8. Constraints

The key constraints to implementing the Caterham-on-the-Hill FAS are as follows:

- Securing funding – SCC will contribute towards the appraisal, design and construction for this project. Depending on the cost of construction, Flood Defence Grant in Aid (FDGiA) and funding from SCC may not be sufficient to cover the cost of a scheme and further partnership funding is likely to be required.
- Landowner issues – It may not be possible to obtain landowner permission for some of the options e.g. options within the recreation ground or school playing fields.
- Technical limitations – There may be limitations due to the topography of the area, tying in with existing drainage / structures and limitations of space available. The catchment is densely populated and the gradients within the catchment are steep. These factors could constrain the options available and the reduction in flood risk which can be achieved. From the option testing work that has been done at this early stage, available space for flood

storage has been identified as a particular constraint. Additionally, no utility information has been obtained at this stage; therefore utilities such as gas mains could further constrain option location and design.

- Environmental limitations – Some parts of the catchment are vegetated, in particular Coulsdon Common. Construction of new flood risk management assets in these locations may result in significant tree loss; likely to result in both opposition, require sufficient mitigation and provide a construction programme constraint. A phase 1 habitat survey undertaken as part of the OBC may identify other environmental constraints which affect option location, design and construction programme.

2.9. Dependencies

The key project dependencies are:

- Agreement of all partners on the Project Board – Agreement of The Environment Agency, SCC, TDC, LBC and TWUL is required for the project to progress.
- Funding viability – Partnership funding contributions will be required for the FAS to be progressed because the scheme cannot be fully funded by Grant in Aid (GiA).
- Technical viability – The options developed must be technically viable and reduce flood risk in Caterham-on-the-Hill and Old Coulsdon. Furthermore, options cannot worse flood risk to any neighbouring areas.
- Planning permission and consents – At this stage it is likely that many of the options will require planning permission from the Local Authority, which would require consultation from an early stage.
- Landowner / stakeholder agreements – Stakeholders and landowners will need to be engaged at an early stage. The main known landowners are TDC, Hillcroft Primary School and the City of London Corporation. Other interested stakeholders would include SCC, LBC, TWUL and users of the recreation ground. Further review would be required to identify other parties.

3. The Economic Case

3.1. Introduction

A wide range of options for reducing flood risk have been considered for Caterham-on-the-Hill.

The 'Maintain' scenario has been used as the baseline scenario in the economic case. The appraisal therefore looks at the benefit of doing more than just maintaining the system. This 'Maintain' scenario represents a clear and free-flowing pipe network where there are no blockages nor is there any sedimentation. Traditionally, flood economic appraisals use a 'Do Nothing' scenario as the economic baseline; this is a theoretical scenario in which the maintenance of all assets ceases, leading to asset condition deterioration, sedimentation and permanent blockage. In a catchment at risk of surface water flooding, defining a realistic 'Do Nothing' scenario can be difficult, because blockages in the pipe network in one location can reduce flooding in another location. It is also difficult to identify where asset blockages should be applied.

Flood damages in a 'Do Nothing' baseline are typically higher than in a 'Maintain' baseline. By using a 'Maintain' baseline, this appraisal could therefore be under-valuing the option benefits. To counter this effect, the current maintenance regime costs have been excluded, so leading to a more appropriate benefit cost ratio.

Please refer to Section 3.5 for the methodology used to calculate the economic damages.

3.2. Critical success factors

Project specific critical success factors have been developed, these are listed and their importance ranked in Table 4 below.

Table 4 - The critical success factors.

No	Critical Success Factor	Measurement Criteria for the scheme	Importance (1-5)
1	Strategic fit and business needs.	• Continues delivering benefits over the next 100 years, allowing for climate change where possible; • Compatible with future schemes used to adapt to climate change; and • Does not increase flood risk downstream.	1 2 1
2	Potential value for money.	• Achieves viable cost-benefit ratio; • Delivers efficiencies; and • Minimises future operational and maintenance requirements and consequently costs.	1 3 2
3	Potential achievability.	• Fits within the study area; • Does not negatively impact flood levels elsewhere in the catchment; • Generates and maintains political and stakeholder support; • The project has a clear and achievable timeline; and • The scheme is integrated with existing flood risk management in the area.	2 1 2 2 3
4	Supply-side capacity and capability.	• A clear delivery model is provided; and • Future operational and maintenance requirements are agreed and understood.	3 2
5	Potential affordability.	• The design will benefit future finding partners; • A joint funding strategy will be employed; and • Contributes towards Defra's target outcome measures.	2 1 2

3.3. Long list options

The long-list of options was developed, presented, discussed and evaluated at the Project Board Meeting (21st July 2017). The descriptions and assumptions of each of the long-listed options can be found in Appendix B.

3.4. Short list options

3.4.1. Overview

Some of the long-list options were eliminated as they were either technically not viable or unlikely to provide any significant benefit to property flooding. Table 5 provides the short list of options decided upon following the Project Board Meeting. An estimate of the benefits has been calculated for these options. Figure 6 provides a plan of the option locations.

Table 5 - Options short list.

Options	Description
Maintain	Continue with maintenance tasks e.g. clearing and repairing gullies and maintaining the money pit and key soakaways. This would additionally include the following: • Re-instate broken pipes and clear root masses and silt along the piped watercourse, as identified on the CCTV surveys; • Clean soakaways; • More regular gully cleaning, including more robust noticing and planning procedure for the cleaning; and • Review existing practice and implement a more proactive and regular maintenance regime of the storm water drainage assets.
Improvement options: modelled	
Option 1	Flood storage area at Queen's Park recreation ground.
Option 2	Flood storage area below the Hillcroft Primary School playing field.
Option 3	Flood storage areas on the western flow path on Coulsdon Common.
Option 4	Flood storage areas on the eastern flow path on Coulsdon Common.
Option 5	Removal of the Money Pit.
Option 6	Divert water out of the catchment from the piped watercourse (at the Money Pit) to Surrey National Golf Club. Storage would need to be provided to prevent any increase in flood risk downstream.
Option 7	Divert water from the piped watercourse in a new drain under Money Road and north along Foxton Lane, discharging onto Coulsdon Common. In order to accommodate the increased flow across Coulsdon Common without increasing downstream flood risk, this option would be combined with Option 4.
Improvement options: not modelled	
Option 8	Install overflow on Coulsdon Common soakaway.
Option 9	Installation of silt trap in manhole chambers upstream of the Money Pit and the Coulsdon Common soakaway.
Option 10	Litter campaign.
Option 11	Local measures to reduce the volume of surface water runoff in the piped network e.g. rainwater gardens and water-butts.

Contains Ordnance Survey data. © Crown copyright and database right (2017).
Please note that the locations of the proposed options are indicative

Figure 6 – Option locations.

3.4.2. Technical, environmental and social assessment

There are technical, environmental and social matters that relate to each of the proposed options that must be considered. These are detailed in Table 6.

Table 6 - The technical, environmental and social matters pertinent to each option.

Options	Description	Technical, environmental and social matters
Maintain.	Assumed current situation, Including maintenance of the piped watercourse, cleaning soakaways, regular gully cleaning and proactive and regular asset maintenance	Under the current situation, both properties and roads are at risk of flooding in low return period rainfall events. <u>Technical</u> • The piped watercourse would be kept in operational service, working at the designed capacity. Flood risk issues will still occur if the existing assets do not have sufficient capacity to convey water; • Broken pipes could be a source of silt and debris resulting in blockages downstream; • Cleaning soakaways may lead to improved discharge capacity of soakaways, with reduced risk of surcharging. It can however be difficult to adequately clear / clean deep soakaways and funding is not always available for maintenance work. Furthermore, soakaway potential may be limited by underlying geology and flood risk issues will still occur if the asset does not have a sufficient soakaway capacity; • Clear gullies are essential for road drainage and reduce the risk of flooding in low return period events. Highways drainage is not however generally designed to provide a high standard of protection (typically not in excess of a 20% AEP). It is also not possible to guarantee access to gullies, especially in roads where off-street parking is not available. Residents could ensure their vehicles are moved while gully clearing is taking place. This could be organised through the Flood Action Group; • Residents to inform the Drainage Authority if a drainage problem is seen; • Some drainage assets are the responsibility of riparian landowners; and • Sufficient funding not always available for maintenance work. <u>Environmental</u> • No significant adverse environmental impacts, but also no environmental opportunities associated with maintenance activities. <u>Social</u> • Likely closure of roads while the piped watercourse maintenance takes place, this could cause disruption to traffic and local residents; • Access to residential property drive-ways and gardens could be required for maintenance works; • Some soakaways might be owned by residents, these also need to be cleaned and maintained appropriately; • The H&S risk associated with surcharging soakaways will be reduced if the assets are well maintained; • Opportunity for community engagement, with reduced number of parked cars preventing access to gullies; and • Potential opportunity for the community to be involved with the maintenance of the drainage system. Not relevant to below-ground assets but can be used for above-ground ditches and storage areas as long as training and equipment is provided to ensure that the work can be done safely. Could be organised through the Flood Action Group. There are examples from other places in Surrey where this is successfully undertaken.
Improvement options: modelled		
Option 1	Queens Park Flood Storage Area (FSA).	<u>Technical</u> • The option stores runoff in the upstream of the catchment. While this will reduce the risk of property flooding in this area, it only accounts for 12% of the catchment to Stites Hill Road and a smaller proportion of the total catchment to the northern end of Caterham Drive. The potential for this option to reduce the risk of flooding to properties further downstream is therefore limited;

		• The proposed location is directly upstream of three roads known to have experienced flooding on multiple occasions; • The volume of water to be stored means that the asset would not fall under the Reservoirs Act (1975); • Additional work will be required to determine option feasibility. Existing gullies / pipe connections in the park may need to be excavated. A local source of earth would be preferable to minimise construction costs and traffic; and • The height of the bund would be dependent on the desired level of protection that the bund would provide. Initial modelling work suggests that a maximum bund height of 1.5 m would store flood waters during 0.5% (1 in 200) AEP flood events, while allowing some flood water to drain through a small pipe (150 mm diameter). The bund height can be reduced; however, this will lower the standard of protection provided. Bund height and design will be investigated further if taken forward to OBC. <u>Environmental</u> • Potential for loss of trees, hedges and / or shrubs to make space for the bund; and • Opportunities for landscaping enhancements as part of the scheme. <u>Social</u> • The bund may affect access to the recreation ground, particularly to wheelchair users and pushchairs / buggies; • The footprint of the bund may result in a small permanent loss of amenity space. During a flood event there would be a temporary larger loss of amenity space, although this area is naturally subject to waterlogging and ponding; • The bund would need to be designed to mitigate any potential negative visual impacts affecting both local residents and recreation ground users; and • Potential Health and Safety (H&S) implications for recreation ground users when the flood storage area is in use.
Option 2	Hillcroft Primary School FSA.	<u>Technical</u> • The option stores runoff in the middle of the catchment, this will reduce the risk of property flooding in this middle section of the catchment; • Storage of water below ground means that the asset would not fall under the Reservoirs Act (1975) • There would be ongoing maintenance costs particularly in relation to keeping the storage area free of silt to maintain the design capacity; and • Additional work will be required to determine option feasibility. The available space for the option within the school grounds (taking into account the Thames Water foul sewer which is located in the same area) and the location and size of connecting pipes will need to be optimised. <u>Environmental</u> • No significant adverse environmental impacts anticipated. Construction would require removal of existing earth (with potential traffic impacts) to make space for storage. The existing ground surface would be re-instated following completion of the excavation works. Few opportunities for environmental enhancements. <u>Social</u> • The storage area is under the Hillcroft School playing fields, therefore construction would need to be organised so that the impact on the students is minimised. Works would have to be undertaken around school operation. The playground would additionally have to be closed while the structure is maintained; and • There are opportunities to include TCD planning and SCC education if this option were to be taken forward.
Option 3	Western Coulsdon Common FSA.	<u>Technical</u> • The option stores runoff reducing the discharge downstream; this will reduce the risk of property flooding in the downstream section of the catchment;

		• The proposed location is directly upstream of Caterham Drive, properties on which have experienced flooding on multiple occasions; • The volume of water to be stored means that the asset would not fall under the Reservoirs Act (1975); and • Additional work required to determine option feasibility. The valleys are very steep-sided, therefore the area over which storage can be achieved is limited without the construction of very high bunds. A local source of earth would be preferable to minimise construction costs and traffic. The height of the bund(s) would also be dependent on the desired level of protection that the option would provide. Initial modelling work suggests that maximum bund heights of 1.2 m for the southern bund and 1.4 m for the northern bund would still be insufficient to store a 20% (1 in 5) AEP flood event. <u>Environmental</u> • High risk of adverse environmental impacts as a result of construction in a wooded area, for example loss of trees and woodland habitats. Note that the deciduous woodland on Coulsdon Common has been identified on Natural England's priority habitats inventory; and • Opportunities for landscaping enhancements and habitat creation as part of the scheme. <u>Social</u> • Potential impacts on Coulsdon Common users during the construction period; and • Potential H&S implications for Coulsdon Common users when the flood storage area is in use.
Option 4		The same technical, environmental and social matters as Option 3 apply to Option 4. Initial modelling work suggests that the height of the southern two bunds would be 2.4 m, while the northern-most bund would have a maximum height of 2.5 m. These bunds would store flood waters during 2% (1 in 50) AEP flood events, while allowing some flood water to drain through small pipes in the southern two bunds, each with a 150 mm diameter. To enable water to drain through the northern-most bund, a 225 mm diameter pipe has been modelled connecting into the existing local drainage network.
Option 5	Removal of the Money Pit.	<u>Technical</u> • The option reduces storage capacity in the middle of the catchment and so removal of this storage could worsen existing property flood risk; • Ownership and maintenance responsibility of the Money Pit is unknown; • Technical maintenance difficulties would be removed; and • Maintenance time and costs would be reduced. At present the Money Pit is a very costly and difficult asset to maintain. <u>Environmental</u> • No significant adverse environmental impacts; and • Replacement of the Money Pit with an above-ground pond would result in habitat creation and an opportunity to improve water quality through natural processes. <u>Social</u> • Opportunities to use the land more effectively; and • Implications on residents of increased flood risk and / or presence of above-ground storage.
Option 6	Divert water from Money Pit to the golf course.	<u>Technical</u> • Expensive option and technically-difficult to construct because the diversion pipe would either need to be very deep below existing ground level (in order to achieve drainage by gravity) or would need to be pumped. Additional work required to determine option feasibility. <u>Environmental</u>

		• Potential adverse environmental impacts on the golf course habitats as a result of re-directing surface water runoff into this neighbouring catchment; and • The Farthing Downs and Happy Valley SSSI is located downstream of the golf course. Potential for adverse environmental impacts to these areas as a result of the flow diversion. Social • Construction would result in disruption and likely closure of local roads; and • Consultation with the golf course required; option would need to include some form of storage facility to attenuate the diverted flow and prevent it from increasing flood risk downstream. This storage would result in golf course land-take; unlikely to be accepted by the golf course owners.
Option 7	Divert water along Foxton Lane.	Technical • Expensive option because the diversion pipe would either need to be very deep below existing ground level (in order to achieve drainage by gravity) or would need to be pumped; • Could increase flood risk elsewhere if this option is implemented in isolation. Initial modelling work suggests that flood risk to properties is not increased if option 7 is combined with option 4; and • Additional work required to determine option feasibility. Environmental • No significant adverse environmental impacts, but also no environmental opportunities. Social • Construction would result in disruption and likely closure of local roads.
Improvement options: not modelled		
Option 8	Coulsdon Common soakaway overflow.	Technical • Overflow would allow excess water to be safely conveyed downstream without lifting of the manhole cover; • Drainage ditch already exists, to which a formal connection could be constructed; and • Option in isolation (without addressing soakaway discharge capacity issues) could increase risk of flooding downstream. Environmental • No significant adverse environmental impacts. Potential visual environmental opportunities associated with improvements to landscaping. Social • The H&S risk associated with surcharging will be reduced as the result of installing a controlled overflow; and • Option could reduce the risk of flooding of Stites Hill Road.
Option 9	Silt trap upstream of the Money Pit and / or the Stites Hill Road soakaway.	Technical • Silt would be trapped before it reaches both the Money Pit and Stites Hill road soakaway; • Required maintenance frequency (and therefore maintenance costs) of the Money Pit and the soakaway would be reduced. Note however that the ownership and maintenance responsibility of the Money Pit is unknown; and • Regular maintenance of the silt traps would be required to ensure they functioned effectively. Environmental • No significant adverse environmental impacts, but also no environmental opportunities. Social • Cleaning the silt traps would result in lower H&S maintenance risks than cleaning the Money Pit and the soakaway.
Option 10	Litter campaign.	Technical

		• Difficult to determine effectiveness but if successful, could reduce the likelihood of blockages in the system and increase the likelihood of the system operating at design capacity. Environment • Benefits from reducing the amount of litter in the environment. Social • Reduce public health and H&S issues that are currently associated with surcharge of the drainage system; • Opportunity for community engagement; • An action for the Flood Action Group and parish to consider, advertise and progress; and • Benefits likely to be greatest if it was a borough-wide campaign.
Option 11	SuDS.	Technical • Provides storage of surface water and promotes infiltration, thereby reducing surface water runoff rates and volumes and associated flood risk; • SuDS can be implemented and have a positive impact at individual property level, however, SuDS measures are most effective when implemented on a larger scale. For example, in schools and on other community buildings, when applied across whole areas and when combined with other management options; and • May be the only technically-viable way of reducing surface water flood risk in parts of Caterham-on-the-Hill and Old Coulsdon which are urbanised and steep, making other engineered solutions difficult to design and construct. Environment • Opportunity for environmental, biodiversity and aesthetic benefits as these are often inherent in SuDS / green infrastructure assets. Social • It is recommended that a robust planning policy is implemented to include SuDS and surface water storage on all minor and major developments in Caterham-on-the-Hill and Croydon; • Long term strategy in retrofitting SuDS and reducing impermeable area through local planning policy on major and minor developments will provide a cumulative benefit over local flood risk management strategy and local plan periods; and • Opportunity for community engagement; as more of the community gets involved, the benefit of using SuDS will amplify.
Option 12	Property flood resistance	Technical • Cost-effective option as measures can be relatively inexpensive to install; • Measures can either prevent property internal inundation (resistance measures) or allow inundation but reduce damage and speed-up clean up time and reduce clean-up costs (resilience measures); and • Some measures are reliant on resident actions (for example demountable flood boards across doors) who require both a warning system and warning time in order to act. Other measures can provide permanent protection (for example waterproof doors and airbrick covers) and so are more suited to catchments such as Caterham-on-the-Hill where warning time is very limited. Environmental • No significant adverse environmental impacts, but also no environmental opportunities. Social • Opportunity for community engagement; and • Grants may be available for properties which have flooded before.

The modelled options were found to have localised benefits. To maximise the area benefiting from the Caterham-on-the-Hill FAS, two combinations of options were additionally tested:

- Combination 1
    - Option 1: Queens Park FSA;

    - Option 3: Western Coulsdon Common FSA; and
    - Option 4: Eastern Coulsdon Common FSA.
- Combination 2
    - Option 1: Queens Park FSA;
    - Option 2: Hillcroft Primary School underground FSA;
    - Option 3: Western Coulsdon Common FSA; and
    - Option 4: Eastern Coulsdon Common FSA.

Combination 1 and Combination 2 were both modelled in the Caterham-on-the-Hill ICM and included in the economic assessment.

3.5. Economic appraisal

The results from the ICM were used to undertake a depth damage economic assessment. The economic appraisal followed the principals of the Flood and Coastal Erosion Risk Management – Appraisal Guidance (FCERM-AG) (Environment Agency, 2010), as updated by supplementary guidance on the DEFRA website. Depth damage data was taken from the Multi-Coloured Manual (MCM) (Flood Hazard Research Centre, 2017).

The economic flood assessment included calculation of the following:

- Residential and non-residential property damages for the Caterham-on-the Hill study area (as previously mentioned, the economic assessment only includes properties located along the MFP). This:
    - Used the National Receptor Database (NRD) (version 3, 2011) and Mastermap building outlines to derive the property dataset;
    - Used maximum flood depth extracted at each property location from the hydraulic model results for a range of design flood events (20%, 5%, 2%, 1.33%, 1% and 0.5% AEP flood events);
    - Applied the MCM methodology and depth damage curves (as updated in 2017);
    - Assumed thresholds of 150 mm for residential properties and 50 mm for non-residential properties;
    - Capped residential property damages at their current market value, calculated using average house prices taken from www.house.co.uk; and
    - Capped non-residential property damages at an average rateable value multiplied by 100/yield (Department for Communities and Local Government, 2012).
- Evacuation costs for residential properties experiencing above floor level flooding using the MCM data;
- Vehicle damages were assessed by using the MCM methodology, which assumes that:
    - The average value of a UK motor vehicle is £3,100;
    - The average number of vehicles per (residential) household is 1.15; and
    - Vehicles are most likely to be damaged (and written off) when flood depths exceed 0.35 m.

  Vehicle damages were therefore calculated by: £3,100 x 1.15 x number of residential properties where external flood depth > 0.35 m;
- Cost of emergency services, estimated as 5.6% of the total property damages; and
- Risk to life, estimated as a 1% addition to the total calculated flood damages.

The benefits of a reduced risk of flooding on the human intangible effects of health and stress were also included. These are measured directly as a benefit and so are listed separately in the option comparison tables.

The impact of climate change was not included in this economic assessment as the purpose of this appraisal is to make a decision as to whether to proceed to detailed appraisal. Should the scheme proceed then climate change will have to be fully included in accordance with Environment Agency guidance (Environment Agency, 2016).

In accordance with Treasury guidance, Average Annual Damages (AADs) were discounted over a 100-year appraisal period using the Treasury variable discount rate to generate a Present Value damage (PVd) for each option. The PV benefit (PVb) of each improve option was then calculated as the difference between the improve option PVd against the baseline PVd.

Benefits

Table 7 to Table 10 provide counts of properties modelled to be at risk of internal flooding (above floor level) in the Maintain baseline and in each of the modelled options and combination of options. These have been sub-divided into those located within Tandridge District Council (TDC) i.e. Caterham-on-the-Hill and those located within the London Borough of Croydon (LBC) i.e. Old Coulsdon. Property counts are presented both as numbers flooding in the maintain baseline and numbers benefiting from the various options compared against the baseline.

Table 11 provides property counts for Outcome Measure (OM) 2; part of the partnership funding calculator.

Table 7 - Present day count of residential properties with above floor level damages within the study area

	5% (1 in 20) AEP flood event	1.3% (1 in 75) AEP flood event	1% (1 in 100) AEP flood event	0.5% (1 in 200) AEP flood event
Maintain (baseline)				
TDC	142	188	194	232
LBC	44	69	79	106
Total	**186**	**257**	**273**	**338**

Table 8 - Count of residential properties benefitting from each modelled options.

	5% (1 in 20) AEP flood event	1.3% (1 in 75) AEP flood event	1% (1 in 100) AEP flood event	0.5% (1 in 200) AEP flood event
Option 1				
TDC	12	8	8	8
LBC	0	0	0	0
Total	**12**	**8**	**8**	**8**
Option 2				
TDC	10	6	7	9
LBC	0	0	0	1
Total	**10**	**6**	**7**	**10**
Option 3				
TDC	0	0	0	0
LBC	6	2	9	5
Total	**6**	**2**	**9**	**5**
Option 4				
TDC	0	0	0	0
LBC	12	9	13	9
Total	**12**	**9**	**13**	**9**
Option 5				
TDC	0	0	0	0
LBC	-1	-2	0	-1
Total	**-1**	**-2**	**0**	**-1**
Option 6				
TDC	6	4	1	3
LBC	0	0	0	1
Total	**6**	**4**	**1**	**4**
Option 7				
TDC	2	2	1	1
LBC	12	9	15	9
Total	**14**	**11**	**16**	**10**
Combination 1				
TDC	12	8	8	8
LBC	15	8	15	11
Total	**27**	**16**	**23**	**19**
Combination 2				
TDC	35	29	29	34
LBC	15	8	15	11
Total	**50**	**37**	**44**	**45**

Table 9 - Present day count of non-residential properties with above floor level damages within the study area.

	5% (1 in 20) AEP flood event	1.3% (1 in 75) AEP flood event	1% (1 in 100) AEP flood event	0.5% (1 in 200) AEP flood event
Maintain (baseline)				
TDC	19	38	39	47
LBC	7	9	10	12
Total	**26**	**47**	**49**	**59**

Table 10 - Count of non-residential properties benefitting from each modelled option.

	5% (1 in 20) AEP flood event	1.3% (1 in 75) AEP flood event	1% (1 in 100) AEP flood event	0.5% (1 in 200) AEP flood event
Option 1				
TDC	1	2	2	1
LBC	0	0	0	0
Total	**1**	**2**	**2**	**1**
Option 2				
TDC	2	2	2	3
LBC	0	0	0	0
Total	**2**	**2**	**2**	**3**
Option 3				
TDC	0	0	0	0
LBC	2	0	0	0
Total	**2**	**0**	**0**	**0**
Option 4				
TDC	0	0	0	0
LBC	2	1	1	1
Total	**2**	**1**	**1**	**1**
Option 5				
TDC	0	0	0	0
LBC	0	0	0	0
Total	**0**	**0**	**0**	**0**
Option 6				
TDC	0	0	0	0
LBC	0	0	0	0
Total	**0**	**0**	**0**	**0**
Option 7				
TDC	0	0	0	0
LBC	2	1	1	1
Total	**2**	**1**	**1**	**1**
Combination 1				
TDC	1	2	2	1
LBC	2	1	1	1
Total	**3**	**3**	**3**	**2**
Combination 2				
TDC	4	9	6	7
LBC	2	1	1	1
Total	**6**	**10**	**7**	**8**

Table 11 – Quantifying benefits under Outcome Measure (OM) 2 : Households better protected against flood risk.

Scenario	60% least deprived areas		
	Moderate risk	Significant risk	Very significant risk
Maintain	81	71	186
Option 1	81	75	174
Option 2	77	75	176
Option 3	78	75	180
Option 4	81	74	174
Option 5	80	72	187
Option 6	81	73	180
Option 7	82	74	172
Combination 1	78	82	159
Combination 2	73	84	136

Note that these property counts are not cumulative. In the Maintain scenario, 186 residential properties are modelled to be at risk of flooding in events with an AEP of 5% (1 in 20) and greater. A further 71 residential properties are modelled to be at risk of flooding in events with an AEP of less than 5% (1 in 20) but greater than or equal to 1.3% (1 in 75). A further 81 residential properties are modelled to be at risk of flooding in events with an AEP of less than 1.3% (1 in 75) but greater or equal to 0.5% (1 in 200).

Table 7, Table 8, Table 9 and Table 10 demonstrate that in comparison to the baseline modelling, each proposed option, excluding Option 5, benefits properties with above floor level flooding. The tables above show that Option 5 (Removal of the Money Pit) worsens flooding at properties with above floor level flooding. From this it is concluded that the flood storage provided by the Money Pit benefits properties, and therefore it is recommended that the structure is not removed.

Costs

The option costs for each of the short-listed modelled options were estimated using rates collected from the following sources:

- Environment Agency's Unit Cost Database – 2011 Dataset Page 19 of 26;
- SPONS Civil Engineering and Highway Works 2010;
- SPONS External Works and Landscape Price Book 2010; and
- Forestry.gov.uk guidance for civil works.

All rates have been adjusted for inflation to 2017 prices. Updated sources of both the SPONS Civil Engineering and Highway Works and the SPONS External Works and Landscape Price Book are available. The costs will be reviewed and further refined if necessary in the OBC. An optimism bias of 60% has been applied to the costs, this should insure any variation in the cost of each option is accounted for.

A brief analysis of the locations for each storage area option was undertaken using the LiDAR DTM to determine the likely bund location, length and crest level which would maximise the flood storage volume achieved while ensuring realistic bund heights. Drainage pipe sizes to drain the flood storage areas were assumed, with small pipes used to minimise the pass-forward flow, thus maximising the downstream flood benefit. The sizing of the other options was undertaken through both an assessment of available space and the surrounding drainage network. The options were conceptually designed to provide evidence of their feasibility in terms of the cost benefit ratio. Further work is required to refine the options and to obtain greater certainty on the cost estimates.

The following timescale for the works has been assumed and accounted for within the economic assessment:

- Preparation of the OBC (including outline design) in 2018/19;

- Preparation of the Full Business Case (FBC), planning permission (if required) and detailed design in 2019/2020; and
- Construction in 2020/2021.

From the year after construction (2022) maintenance costs have been included as follows:

- Options 1, 3, 4, 6 and 7;
    - £2k per year for maintenance and inspections; and
    - £20k every 10 years for reactive repairs.
- Option 2; and
    - £5k per year for maintenance and inspections; and
    - £50k every 20 years for reactive repairs.
- Option 5.
    - £0.5k per year for maintenance and inspections; and
    - £20k every 10 years for reactive repairs.

All costs have been discounted to PV using the Treasury variable discount rate.

Optimism Bias (OB) has been included in all costs as 60%, as recommended in the HM Treasury Green Book and by the Environment Agency as appropriate for SOC stage.

Options 6 and 7 were identified as being prohibitively costly because of high construction costs. The Benefit Cost Ratios (BCRs) were estimated to be below one (unity), making the options not economically viable. For this reason, a detailed cost estimate was not undertaken for these two options. To ensure the options were considered in full and a BCR could be derived, an indicative construction cash cost of £2 million was estimated for each of the options. A more detailed understanding of the underlying geology and early involvement with the contractor (with the relevant construction expertise) would be required if these options were to progress to the next stage of appraisal.

The two combination options have been costed by combining the capital costs of each of the individual options but assuming a 20% efficiency saving in both design and construction. Maintenance costs for each individual option have been summed to calculate the maintenance cost of each combined option.

Appendix C provides the PV cost tables for each of the options.

Present Values

Table 12 below is a simplified version from the business case template. Full appraisal would be carried out if the project is taken forward to OBC stage and the full table then completed.

Table 12 - Detailed present value costs.

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Combination 1	Combination 2
Existing staff costs	Not separately costed at this stage.								
Further staff costs									
Consultants' fees (appraisal & design) (£k)	£118	£222	£118	£128	£132	£222	£292	£209	£341
Contractors' fees	Not separately costed at this stage; incorporated into either the consultant's design fees above or the construction costs below.								
Cost consultants' fees									
Site investigation and survey									
Construction (£k)	£87	£1,628	£87	£124	£160	£1,804	£1,928	£239	£1,541
Environmental mitigation	Not separately costed at this stage; incorporated into either the design or construction costs above.								
Environmental enhancement									
Site supervision									
Land & compensation									
Optimism bias (£k)	£154	£1,137	£150	£178	£177	£1,242	£1,385	£353	£1,240
Risk contingency (50%ile)	Not separately costed at this stage; incorporated into the construction costs above.								
Other									
Subtotal (£k)	**£358**	**£2,988**	**£355**	**£430**	**£469**	**£3,268**	**£3,605**	**£801**	**£3,122**
Future costs (construction and maintenance) (£k)	£244	£175	£96	£372	£372	£96	£193	£296	£472
Optimism bias (£k)	£31	£78	£31	£31	£8	£31	£62	£94	£172
Project total (PV) costs (£k)	**£493**	**£3,241**	**£482**	**£557**	**£494**	**£3,396**	**£3,860**	**£1,191**	**£3,766**

Option ranking & Economic appraisal conclusion

The BCR of each of the short-listed modelled options are displayed below in Table 13.

Table 13 – Benefit cost ratios for short listed options.

Options	Present value costs (£k)	Present value damages (£k)	Present value benefits (£k)	Average benefit : cost ratio (BCR)	Incremental benefit : cost ratio (IBCR)	Option for incremental calculation
Maintain	Not calculated	£30,321	Not calculated; Maintain used as economic baseline		Not relevant	
Improvement options: modelled						
Option 1	£493	£27,956	£2,412	4.9	Options have been designed to protect different areas and do not provide differing standards of protection to the same area. Calculation of an IBCR is not appropriate.	
Option 2	£3,241	£25,326	£5,012	1.5		
Option 3	£482	£29,651	£734	1.5		
Option 4	£557	£28,190	£2,222	4.0		
Option 5	£494	£31,177	-£856	-1.7		
Option 6	£3,396	£28,324	£2,033	0.6		
Option 7	£2,309	£27,121	£3,294	0.9		
Combination 1	£1,191	£25,450	£5,035	4.2	3.8	1
Combination 2	£3,766	£20,333	£10,317	2.7	2.1	8

Note: Options that have not been modelled have not been costed.

3.6. Non-financial benefits appraisal

This project has the potential to achieve benefits beyond the direct flood risk reductions achieved by the options. Through promoting partnership working, RMAs and residents can benefit the local community. This could be through improving flood risk management plans, or through bettering the reputation and the awareness the community has of various organisations and Flood Action Groups. Where this is applicable, the benefits will be assessed at the OBC stage.

Within the high-level appraisal, a few of the options have some potential for delivering environmental enhancement or habitat creation. These benefits will require further investigation at OBC stage, with potential quantification as part of the partnership funding calculator OM4.

Where possible, benefits will be defined and monetised in line with latest relevant guidance for inclusion in economic appraisal. Where this is not possible, a qualitative (non-financial) assessment will be undertaken.

3.7. Leading option

Table 13 shows that there are cost-beneficial options to alleviate flooding within Caterham-on-the-Hill. The option with the highest BCR is Option 1 (Queens Park FSA). Option 1 however, only reduces flood risk in the upstream section of the catchment. Combination 1 and Combination 2 are a combination of Options 1, 2, 3 and 4, they benefit a much wider area across the whole catchment. As demonstrated in Table 13, the IBCR is sufficient (greater than 1) to justify stepping up from Option 1 to Combination 1 and from Combination 1 to Combination 2. Therefore, Combination 2 is the current leading option. Combination 2 is more expensive than Combination 1, therefore implementation of this option will be dependent on funding available.

It is recommended that further investigation and analysis are carried out to make a more informed decision on choosing a preferred option and that the project should therefore be taken forward to OBC phase.

Due to the nature of the catchment and potential solutions, the proposed options only benefit some of the properties at risk, and thus residual flood damage remains high. For example, modelling results suggest that Hillcroft Court sheltered housing is at risk from flood events more

frequent than 5% (1 in 20) AEP and while Options 1 and 2 both reduce the flood depths at this property, there is no change to the predicted probability of flooding.

It is therefore recommended that SuDS solutions would be the best way of managing surface water runoff rates and volumes in the catchment (especially in low return period events) in addition to the construction options described above. SuDS solutions can also provide wider benefits such as water quality improvements and opportunities for community engagement and education. It is also recommended that property flood resistance measures are considered along the MFP. This should be further investigated at OBC stage.

Consideration should also be given to the other options which were not modelled or costed at this stage including property flood resistance, silt traps and enhanced maintenance activities. Brockham have an active local community group; Brockham Emergency Response Team (BERT) (Brockham Parish Council, 2017); a volunteer community resilience group helping the community during floods or other threats. Funded by public donations BERT has recruited and trained over 50 active volunteers (including 12 young volunteers under 18). The public funding additionally supplies the group with the necessary equipment to help keep drains and ditches free flowing. BERT also provides an additional link between the residents, local council and the Flood Forum. There is the potential to introduce a group like this in Caterham-on-the-Hill.

3.8. Sensitivity analysis

At this SOC stage, the sensitivity analysis has focused on whether the project should be taken forward to the next stage. The results of the sensitivity analyses are presented in Table 14.

Table 14 – Sensitivity tests.

Test	Result for leading Option 9	Comments
50% increase in construction cost of leading option.	The BCR reduces to 1.5 and IBCR reduces to 1.0. Combination 2 remains the leading option, but any further increase in cost would change this decision.	The leading option is sensitive to cost, following outline design, there will be more certainty in the option costs.
50% reduction in benefits of leading option.	The BCR reduces to 1.4 and IBCR reduces to 1.0. Combination 2 remains the leading option, but any further reduction in benefit would change this decision.	The benefits will be reviewed at OBC stage; however they are unlikely to change significantly.
Exclusion of damages calculated from below-floor property flooding.	Benefits have been reduced by £172k. No Change in BCR and minor change in IBCR. Combination 2 remains the leading option.	The baseline Maintain damages are reduced by £3.5 million. There is a similar reduction in the residual damage of all of the options.
Assumption that the existing drainage system provides a 20% (1 in 5) AEP standard of protection and hence no property flooding occurs in this event.	The BCR reduces to 1.9 and IBCR reduces to 1.5. Combination 2 remains the leading option.	The baseline Maintain damages are reduced by £8.2 million. There is a similar reduction in the residual damage of all of the options.

A full sensitivity analysis will be undertaken and reported at the OBC stage. The analysis will demonstrate the effect of both decreased economic benefit and increased costs on the choice of preferred option and the financial viability of the scheme.

4. The Commercial case

4.1. Procurement Strategy

Procurement of further appraisal will be through SCC's Professional Services Contract (PSC) Framework. Procurement of detailed design and build work would be through either: the PSC framework, SCC's own contractors or through a tendering process.

4.2. Key contractual terms & risk allocation

Key contractual terms and risk for OBC will be managed through the procurement and the Terms and Conditions of the PSC framework. Terms and risk allocation for FBC, design and build will be considered and reported as part of the OBC.

4.3. Efficiencies and commercial issues

Project efficiencies and commercial arrangements would be identified and assessed during the OBC phase.

5. The Financial case

This business case seeks assurance to prepare an OBC for the Caterham-on-the-Hill FAS and then progress to submit the FBC for £581k. Total project spend is estimated at this stage to be £3,930k, including whole life costs. Optimism bias has been included at 60% for capital expenditure.

The purpose of this section is to set out the indicative financial implications of the preferred way forward. Detailed analysis of the financial case including affordability takes place at OBC stage.

For the purposes of this SOC (as detailed in the economic case, Section 3), the costings from the leading option, Combination 2, have been used as at this stage it seems the best option considering benefit and technical feasibility. However, it is recommended that further investigation and analysis are carried out to make a more informed decision on choosing a preferred option; the options identified within this SOC should be taken forward into detailed project appraisal before developing a preferred option at OBC stage.

Reference material, including the Environment Agency's Unit Cost Database, was used to develop a conceptual cost for the shortlisted options presented in this SOC. Using an optimism bias of 60%, the cash cost of preparing the OBC and FBC based on 'Combination 2' will cost £581k. The option costing is included as Appendix C for reference.

Table 15 below shows the current project summary and is based on the following assumptions:

- Costs do not include any SCC staff costs;
- Capital cost includes all costs required to build the options; and
- Maintenance costs account for any future maintenance that would be required in relation to the new assets constructed as part of the chosen option.

Table 15 - Annual cash expenditure based on the leading option.

Project Summary, inc optimism bias at 60%	Yr 0 (2017)	Yr 1 (2018)	Yr 2 (2019)	Yr 3 (2020)	Future costs	Total
Capital cost (£k)	32	96	485	2,734	1,232	4,579
Maintenance cost (£k)	0	0	0	0	1,690	1,690
Project Total	32	96	485	2,734	2,922	6,269

5.1. Funding sources

The scheme is requesting Flood and Coastal Erosion Risk Management Grant in Aid (FCERM GiA) within the 6-year Area programme.

Table 16 details the results of the FCRM Partnership Funding (PF) Calculator for Flood and Coastal Erosion Risk Management Grant in Aid (FCERM GiA) which has been completed for all the economically viable options. Further details on the PF calculator are provided in Appendix D. A 100-year duration of benefits has been used as none of the options have significant additional capital expenditure in the future.

As demonstrated in Table 16, none of the options can be fully funded by GiA and therefore partnership contributions will need to be secured. These could be sourced from local government (SCC, LBC and TDC), Thames Water and the local community. Furthermore, FCERM GiA will only contribute to design and construction costs. The Local Authorities need to commit to paying all post-construction maintenance costs.

Table 16 – Funding.

Option	Total PV cost (£k)	Raw funding partnership score (%)	FRCM GiA contribution to design & construction costs (£k)	Partnership funding required (£k)	Post-construction maintenance costs (£k)
Option 1	£493	39%	£128	£198	£166
Option 3	£482	14%	£45	£283	£154

Option	Total PV cost (£k)	Raw funding partnership score (%)	FRCM GiA contribution to design & construction costs (£k)	Partnership funding required (£k)	Post-construction maintenance costs (£k)
Option 4	£557	33%	£134	£269	£154
Combination 1	£1,191	26%	£187	£529	£474
Combination 2	£3,766	22%	£668	£2,343	£755

In the high-level appraisal, a raw partnership funding score of 22**%** has been calculated for the leading option using the Partnership Funding Calculator for FCERM GiA. Based on this the estimated FCERM GiA contribution is £668k**.**

For the remaining £2,343k contribution, the project team will seek funding from Local Levy. The project team will seek further external contributions from the Project Board to reduce dependences on GIA and Levy contributions.

The partnership funding calculation presented in this initial assessment will be reviewed as part of the OBC. The team will work with partners to gain suitable partnership funding as required. External contributions will be sought regardless of any funding shortfall. Legal agreements for these contributions will be drawn up prior to the completion of the FBC.

A detailed funding strategy will be developed through the next stage of the project. This will identify and confirm all potential beneficiaries to the scheme and levels of support they may be able to provide. Discussions should be held during the OBC stage to determine where the remaining funding could be obtained. During the OBC phase, the appraisal process would be able to confirm with greater accuracy the impacts of flooding and the benefits that would be provided by the options. This improved evidence-base would be instrumental during discussions with potential funding contributors.

5.2. Impact on revenue and balance sheet

The leading option will require long term maintenance; the cost of this will be covered by the owner and operators of the new assets; likely to be SCC and the LBC. The preferred option will be confirmed as part of the OBC and the planned maintenance budgets will need to be adjusted to accommodate.

Opportunities for external contributions towards maintenance will be explored during the appraisal.

It is anticipated that the current leading option, if appraised and deemed satisfactory, would create new tangible flood risk assets, which will need to be added to the register as required by Section 21 of the Flood and water Management Act (Department for Environment, 2018).

5.3. Overall affordability

Table 15 shows the initial forecast with regards to the costof the project over its expected lifespan. Costs are subject to change in line with an increasinglyrefined delivery model which it is anticipated help the project team to meet efficiency targets.The OBC would be completed after Year 1, the FBC after Year 2, while the construction of theoption would be in Year 3.

Beneficiaries will be identified and approached for contributions if appropriate. These may include developers, landowners, businesses, infrastructure owners, insurers and individual property owners.

6. The Management case

6.1. Project management

The OBC will be managed by SCC, taking the lead on the project partnership board. SCC would therefore have responsibility for project management of any preferred option taken forward for detailed design and construction. Limited information is available on roles and responsibilities, stakeholder engagement, project tasks and milestones, and programme at this SOC stage. These are items which will be developed as part of the OBC.

6.2. Project structure and governance

The project governance structure and key roles and responsibilities are shown in Figure 7.

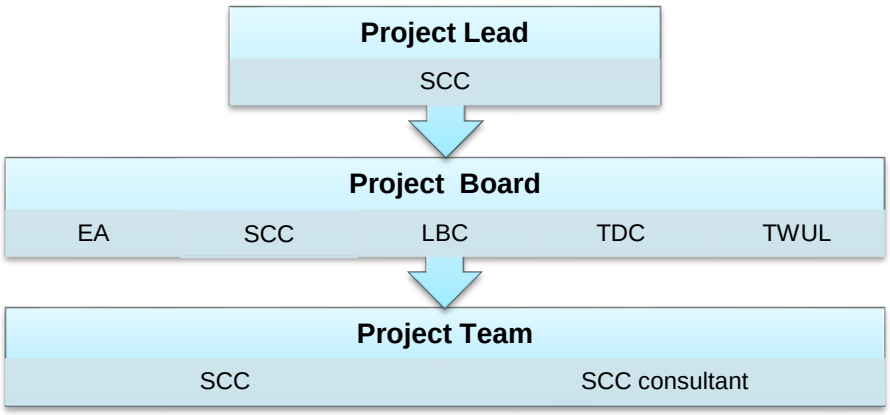


Figure 7 – Project structure.

6.3. Project roles and responsibilities

Table 17 outlines the main roles and responsibilities for the project.

Table 17 - Project roles and responsibilities.

Role	Name	Role description and main responsibility
Project Sponsor.	SCC.	Ultimately accountable for the success of the project and benefits realisation: • Strategic decisions and leadership; and • Delegation of delivery of business case to Project Executive, within defined approvals.
Project Board.	EA, SCC, LBC, TDC, TWUL.	Accountable to Sponsor and Programme Board for delivery of outcomes: • Delivery within tolerances set by Sponsor/Programme Board; • Manage project issues and risk; • Escalation route for project issues; and • Responsible for project and external communications.
Project Team.	SCC and SCC consultant.	• The Project team work with project staff to deliver the work.

6.4. Project plan

An initial project plan with milestones is provided in Table 18. This will be updated as the project progresses to OBC and FBC.

Table 18 - Initial project plan.

Milestone description	Estimated start date	Estimated end date	Asset to be created?
SOC submission and approval	February 2018	April 2018	Y (Integrated model)
Appoint appraisal suppliers	May 2018	May 2018	N
Complete appraisal to OBC	May 2018	May 2019	N
OBC Review	June 2019	August 2019	N
Complete appraisal to FBC	September 2019	March 2020	N
FBC Approval	April 2020	June 2020	N
Construction	June 2020	March 2021	Y
Defect period	March 2021	March 2022	N

6.5. Communication and stakeholder engagement

Internal communications will focus on the following areas:

- Monthly progress reports to be produced by the consultant and provided to SCC; and
- Project Board to meet at least quarterly and more regularly or by exception as required.

External communications with the Flood Action Group and the residents will be guided by a stakeholder engagement plan. This will be prepared and maintained as part of the OBC and will detail the project stakeholders and the approach to consultation with each group of stakeholders. The stakeholder engagement plan will be produced early in the appraisal and will identify and prioritise key stakeholders and their interests.

At this stage in the project the following key stakeholders have been identified:

- Environment Agency;
- SCC and LBC – as Lead Local Flood Authorities;
- TDC;
- Thames Water;
- Local Flood Action Group;
- Hillcroft Primary school (landowners); and
- City of London Corporation (Coulsdon Common landowners).

6.6. Change management

The Project Board is ultimately accountable for project delivery. Any deviation from agreed tolerances will need to be raised and agreed by the Project Board. Similarly, the Project Board will set tolerances which the project team will need to work within.

6.7. Benefits realisation

The key benefit to realise is the reduction in flood risk to residential properties, infrastructure and key assets along the main flow paths in Caterham-on-the-Hill and Old Coulsdon, providing an improved SoP which balances technical and environmental feasibility with value for money and likely future climate change. At this SOC stage, the potential whole life benefits have been calculated as being in the order of £10 million.

Other benefits are environmental and social, for example through habitat and biodiversity improvements and through wider amenity benefits and empowering local communities.

A benefits realisation plan covering what benefits are to be measured will be developed in the next stage of the project and appended to the OBC. This will state who is accountable for the expected benefits, how and when they will be achieved and what resources are needed to carry out the work. Consideration will also be given to whether disadvantages should be measured and reviewed.

It is anticipated that benefits will be split into two categories:

- Financial – non-cashable (cost avoidance); and
- Non-financial.

The Project Manager will work closely with the Project Board to profile anticipated benefits.

6.8. Risk management

Project risks would be assessed and considered in the OBC stage once the preferred option is selected. Table 19 provides an initial assessment of the key risks associated with all options.

Table 19 - Key risks.

	Key risks	H/M/L	Owner	Mitigation
1	Appraisal – Flood alleviation options may impact on the public / parks / recreation areas and affect the reputation of SCC.	M	SCC	Engage stakeholders as early as possible to discuss options and minimise disruption. This is already occurring through the newly-formed Flood Action Group.
2	Appraisal – Design of options and economic benefits are based on results of the ICM. There are uncertainties associated with missing asset data, ground infiltration rates / losses and design rainfall events. While the model was validated using the June 2016 flood event, no observed data (flow or level) is available for model calibration.	M	SCC	Awareness of limitations and uncertainties inherent in hydraulic modelling with use of sensitivity testing. Consideration of use of data from a short-term-flow-survey to calibrate the model. Consideration of inclusion of greater level of detail e.g. road gullies and property boundary fences.
3	Appraisal – Whole life costs of options during OBC increases making the scheme unviable.	M	SCC	Undertake regular cost review of options. Mitigate key risks early by undertaking detailed SI / GI during appraisal phase.
4	Environmental – Construction work on Coulsdon Common could be deemed unacceptable for environmental reasons.	M	SCC	Early engagement with the City of London Corporation who own and maintain Coulsdon Common. Inclusion of an environmental specialist on the OBC project team to further identify the option environmental risks and mitigation measures. A phase 1 habitat assessment is likely to be required for OBC which may identify additional environmental works.
5	Funding – funding is required to progress scheme to detailed design and construction	M	SCC	Action plan will be developed in the next phase of works to develop partnerships and secure contributions.
6	Planning Approval – Proposed option may not gain planning approval.	H	SCC	Planning authorities (TDC and LBC) already represented on the project board. Develop public engagement plans to show a consistent message of the benefits of the scheme.
7	Buildability – Options investigated may have buildability issues which make them unviable.	L	SCC	Undertake site desk studies and investigation works prior to detailed design. Early contractor involvement to increase confidence in buildability, construction methods and costs.
8	Buildability – Risk of flood event occurring prior to or during scheme	M	SCC	Identify opportunities to mitigate delays to programme.

	Key risks	H/M/L	Owner	Mitigation
	construction resulting in increased technical difficulties and costs.			

6.9. Contract management

Contract management will be the responsibility of the SCC Project Manager. They will liaise with the procurement and commercial teams on a regular basis to manage SCC consultants and / or contractors on the PSC Framework over the life of the contract. At this SOC stage it is not known the preferred procurement route for the design and construction work.

6.10. Assurance, approval and post project evaluation

Project board meetings would occur at intervals throughout the development of the OBC. Once the OBC is approved by SCC it is understood that it will go to the Environment Agency for approval.

6.11. Post-project evaluation

Post project appraisal and evaluation will be carried out in accordance with Environment Agency, SCC and LBC best practice.

6.12. Contingency plans

There are no formal contingency plans in place at the time of writing. However, in the event of flooding the various RMAs that make up the Project Board would work closely together alongside the emergency services and other partners.

7. Recommendations

Subject to the potential funding required for implementation being viable, it is recommended that the project is taken forward to OBC. Although at this stage the leading option is the combination of above and below ground storage (options 1, 2, 3 and 4), both these and other options should be assessed in more detail before a preferred option is identified. Consideration should also be given to the options which were not modelled or costed at this stage including SuDS, property flood resistance, silt traps and enhanced maintenance activities. Given the constraints in this urban, steep catchment, it is likely that both SuDS and property flood resistance will form part of any future preferred option. It is further recommended that Option 5 is not taken forward; it is recommended that the Money Pitt is not removed from the catchment as it provides flood risk benefits to the catchment.

Financial Scheme of Delegation (FSoD) approval is sought for £581k. This would include the preparation of an OBC for the Caterham-on-the-Hill FAS (£96k) and then the progression to submit the FBC (including further design and option costing work and applications for planning permission where required) for approval (£485k). This is based on the leading option of Combination 2 and includes a 60% optimism bias allowance.

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Appendix A: Model build report

Caterham-on-the-Hill Model Build Report

Project:	Caterham-on-the-Hill Flood Alleviation Scheme
Subject:	Model build report
Date:	September 2016

Version	Purpose	Originator	Checked	Reviewed	Authorised	Date
1	Appended to SOC	BW	WR	IS	CH	12/09/2017

Introduction

Atkins have been commissioned by Surrey County Council (SCC) to complete Phase Two of the Caterham-on-the-Hill Surface Water Management Study. As part of this study an Integrated Catchment Model (ICM) was built to assess the surface water flow routes through Caterham-on-the-Hill and to inform the development of flood risk management options. This technical note details the data used and the model build and option testing methodologies, including the key assumptions made. The intention is that this model build report is appended to the Strategic Outline Case (SOC).

Model purpose

Properties and land across the Caterham-on-the-Hill surface water catchment flood on a regular basis. The aim of the Caterham-on-the-Hill ICM is to successfully replicate the surface water drainage routes and flooding mechanisms within the catchment. The Caterham-on-the-Hill ICM has been used to develop and assess flood risk management options, and facilitated the determination of whether the identified options are technically and economically viable. The level of detail is appropriate for the stage of the project; specifically, preparation of the SOC.

Model build

The Caterham-on-the-Hill ICM was built using Infoworks ICM software, version 7.0 and then updated to run in version 7.5. The model contains both one dimensional (1D) and two dimensional (2D) components.

The 1D component of the model is comprised of 2.6 km of main surface water drain, 2.3 km of surface water sewer and 12.7 km of foul water sewers. Five soakaways are represented in the 1D domain as well as the Money Pit, more detail of their inclusion in the model is provided below. A 2D triangular grid mesh represents 4.4 km² of surface topography, this area covers the whole Caterham-on-the-Hill surface water catchment north of the most northerly extent of Caterham Drive (531650, 158650). Table 1 summarises the data used in the model build.

Data

A review of all incoming data sets was conducted to ensure that they were sufficient and suitable for use in the Caterham-on-the-Hill ICM.

Table 1 - Model build data.

Data	Data type	Data source	Description
Catchment data			
Ordnance Survey Mapping (OSM).	Geographical Information Systems (GIS) (Raster file).	Ordnance Survey.	Raster GIS mapping data.
Ordnance Survey MasterMap (OSMM).	GIS (Shapefile).	SCC.	Vector GIS mapping data detailing property and road outlines.

Data	Data type	Data source	Description
Catchment characteristics.	Database data.	FEH CD-ROM.	Catchment specific (531650, 158650) Flood Estimation Handbook (FEH) rainfall characteristics.
1D data			
Main surface water drain.	Surveyed information.	CCTV surveys (AB Pipeline services, March 2013; Dene-Tech, May 2015, and Dene-Tech, April 2017).	The AB Pipeline services survey provided the location of the main surface water drain and the pipe diameters. The condition of the pipe; whether cracks, roots or silt are present and the percent blockage was also provided for each pipe. The number of incoming connections was recorded. In May 2015 Dene-Tech undertook a CCTV survey covering three lengths of the main surface water drain near Westway Common. This provided information on sections of the drain which was missing from the AB Pipeline survey. Dene-Tech conducted a manhole survey in April 2017 in the area around Banstead Road, Campbell Road and Milton Road. This survey confirmed manhole locations, pipe invert levels and flow directions. Note: In most cases invert levels remain un-surveyed.
Surface water gully locations.	GIS (Shapefile).	SCC.	Locations of SCC owned gullies. It should be noted that only locations are provided; connectivity, size and gulley type are unknown.
Soakaway locations.	GIS (Shapefile).	SCC.	Data provides location of soakaways only; some are on the route of the main surface water drain. Others are located elsewhere in the catchment with no information on connectivity or drainage area. Infiltration rate and the dimensions of the soakaways also remains unknown unless where specified below.
Soakaway dimensions.	Surveyed information.	Soakaway survey (Dene-Tech, April 2017).	The survey provides information about one of the soakaways on Banstead Road.
Coulsdon Common soakaway.	Surveyed information.	Coulsdon Common soakaway survey (Dene-Tech, May 2015).	The survey provides information about that condition, construction and dimensions of the soakaway, as well as a measured infiltration rate.
Money Pit location and dimensions.	Surveyed information.	Money Pit survey (Dene-Tech, May 2015).	The construction material, function and condition of the asset as well as the dimensions of the Money Pit are identified. The locations of any incoming pipes, their invert levels and their connectivity into the main surface water system is also detailed. It is noted that uncertainty remained regarding the presence, size and invert level of the outgoing pipe because of siltation at the time of the survey.

Data	Data type	Data source	Description
Coulsdon Common ditch dimensions.	Surveyed information.	Site visit (April, 2017).	Channel cross sections were recorded along the length of the ditch. It was ensured measurements were taken wherever the channel cross section changed.
Foul water sewers.	GIS (Shapefile) and pdf scanned images.	Thames Water data and Croydon Borough Council old maps (dated 1968).	Thames water foul sewer network only. Thames Water do not have any asset data of surface water sewer networks draining into the Caterham-on-the-Hill catchment.
Infoworks Collection Systems (CS) Beddington Catchment Thames Water sewer model	Infoworks ICM model.	Atkins, 2017.	An ICM of the Caterham Bourne catchment is currently being built by Atkins. This model includes the foul sewer network in Caterham-on-the-Hill; however, no surface water networks are modelled in this area. The foul water network originates from an Infoworks CS Beddington Catchment Thames Water sewer model. The foul water network has been reduced to cover the study area and any part of the network that would impact the study area. Other than this, no changes have been made to the foul model. The Caterham Bourne ICM has not yet been published.
2D data			
Light Detection and Ranging (LiDAR) composite Digital Terrain Model (DTM).	ESRI ASCII file.	Environment Agency.	1 m cell size DTM covering Caterham-on-the-Hill and Old Coulsdon.
Historical flood record data			
June 2016 radar rainfall data	Spreadsheet	Hyrad Display Client, 2016 (as provided by SCC).	Recorded rainfall depth (mm) in 15-minute intervals from 00:00 07/06/16 to 23:45 07/06/26 for grid squares TQ32040 54845 – TQ34491 57092.
Historical flood records.	GIS (Shapefile).	SCC master property flooding database.	The extent of historical flood events as recorded by SCC in the master property flooding database.
Investigation into surface water flooding in Caterham-on-the-Hill and historical flood records.	Report.	Caterham-on-the-Hill Surface Water Management Study (Atkins, 2016).	A drainage asset data review, a highways drainage survey, a flood risk review, conceptual option development and high level economic appraisal were all undertaken as part of this study. The report also includes a review of historic flood events including the areas affected in December 2013.
Historical flood records of the June 2016 floods.	Reports.	Section 19 Flood Investigation Report Caterham-on-the-Hill (SCC, 2016) and Section 19 Flood Investigation Report Caterham Drive (CC,2017).	Investigation into the surface water flash flood event that occurred on the 7th June 2016.
Historical flood records of the June 2016 floods and	Anecdotal evidence from residents.	Residents, facilitated by the flood forum at an event held by the Caterham and Old Coulsdon Flood Action	The residents of Caterham-on-the-Hill identified the location of where they had been flooded and the depth at which they had been flooded in the 2016 flood

Data	Data type	Data source	Description
other historical floods.		Groups, SCC and Atkins (10/05/17).	event. This evidence was subsequently collated and digitised. Where applicable, residents also provided information about other flood events.

Model hydrology

The hydrology of the Caterham-on-the-Hill surface water catchment is modelled using a "rain-on-mesh" method, applying Revitalised Flood Hydrograph model (ReFH) design rainfall events directly onto the 2D modelled ground surface. ReFH design rainfall events are calculated from the Flood Estimation Handbook (FEH) catchment descriptors.

No hydrograph inflows are required in this model as the flooding mechanism is solely surface water; no fluvial systems are present.

Foul water sub-catchments, including their hydrological properties and the manholes to which they drain have been imported from the Thames Water CS model. Rainfall was applied to both the foul water sub-catchments and the 2D mesh zone. Consequently, there is some duplication of rainfall within the model. The duplication of rainfall covers a total of a 0.2 km^2 surface area. This is under 5% of the total modelled surface area. The runoff surface area within each foul sub-catchment was imported directly from the Thames Water CS model, therefore it was decided this would not be modified. The percentage of duplication is small and it is not within the scope of the project to modify the data. Furthermore, it is not expected to have any significant impact on the baseline and option model results and thus on the business case.

Deriving a runoff percentage

Standard percentage runoff (SPR) is used in hydraulic modelling to calculate rainfall runoff from pervious surfaces when using the UKWIR Model. The SPR of a catchment represents the average proportion of rainfall that runs off a surface

The Flood Estimation Handbook (FEH) CD-ROM provides a SPR value calculated from the HOST (Hydrology of Soil Types) classification of around 39% for the Caterham-on-the-Hill catchment.

80% of the Caterham-on-the-Hill catchment is covered by soilscape 8 (Figure 1) (Cranfield University, 2017), which has a HOST classification of 25. The remaining catchment area is covered by soilscape 3 (Cranfield University, 2017), which has a HOST classification of 1. Table 2 documents the recommended SPR values for those two HOST classes, as taken from the FEH. The SPRHOST value of 39% from the FEH CD-ROM thus reflects a balance between HOST 1 and HOST 25.

Table 2 - Recommended SPR values for HOST classes (taken from Table 2.2 in FEH Volume 4 (Plate C.1 of FEH Volume 4 is the HOST map for the UK)).

Host class	SPR %
1	2.0
25	49.6

The impact of varying SPRHOST values in the Caterham-on-the-Hill ICM was assessed by applying the radar rainfall data from the June 2016 storm event. The depth of flooding that resulted from SPRHOST values of both 30%, 39%, 50% and 60% were compared to the depth of flooding information acquired from residents at the Flood Forum Meeting (10/05/17). The results indicated that when the model was run with the validation rainfall, the model was not very sensitive to changes in SPRHOST.

Given the results above and that most of the catchment is covered by soil with a HOST classification of 25, a SPR of 50% was taken forward and used in the model. Further consideration and / or sensitivity testing of SPR values could be undertaken as part of the Outline Business Case (OBC) stage.

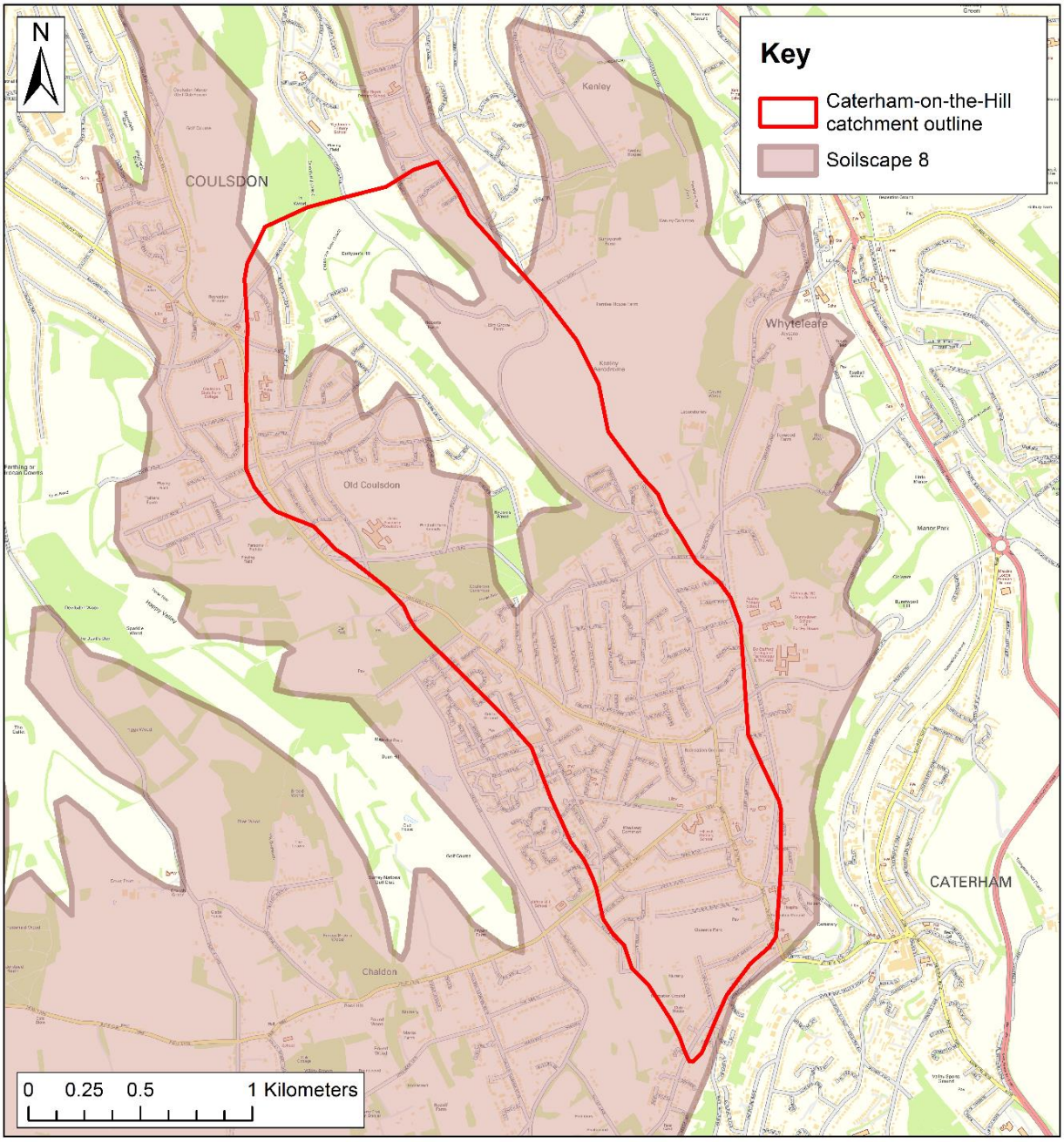


Figure 1 - Map of soilscape 8 (Cranfield University, 2017).

Model hydraulics

The drainage hydraulics of Caterham-on-the-Hill were modelled as described below and as shown in Figures 6 and 7.

The modelled surface is represented using a 2D triangulated mesh built using 1 m resolution LiDAR DTM data. The mesh is "conditioned" using OSMM to ensure that any significant features affecting drainage are effectively resolved in the mesh, such as kerb-lines which are lowered by 50 mm. Roads and house roofs are represented by infiltration zones, set to have 100% runoff. Ground roughness is represented using a

Manning's n coefficient of 0.10, reduced on roads to 0.01. A high roughness value was selected for the ground surface to replicate the effect that fenced gardens have on slowing down the surface water runoff. A value of 1.0 has been used for buildings, this removes inertia through buildings without removing the volume available for storage in the floodplain. The 2D mesh represents overland flows, and generates runoff when rainfall is applied to the 2D surface.

Caterham-on-the-Hill has one main surface water drain. This is represented in 1D and has been modelled using a series of conduits and manholes. The culvert dimensions and invert levels were obtained from survey data (AB Pipeline services, March 2013 and Dene-Tech, May 2015 and April 2017). A large proportion of the invert levels had to be assumed as the data was not available. The roughness of the pipes is modelled using the Colebrook-White coefficient of 1.5 mm, representing smooth concrete sewers. The 2D mesh is connected to the 1D surface water drain through 2D manholes allowing integrated flow between the 1D and 2D domains.

The Money Pit was modelled using a series of enlarged culverts (matching overall asset dimensions recorded in the survey conducted in 2015 (Dene-Tech, May 2015)), see Figure 2. The money pit has been conceptualised following a simplified approach, where head loss between higher and lower culvert sections is not accurately accounted for. Atkins considers the simplified approach to be suitable because the downstream pipe will form the main control on flow. The enlarged culverts are connected by seven 2D manholes to ensure the Money Pit is linked to the 2D modelled surface. This also matches the number of manhole covers reported in the survey. Water can flood out of the modelled manholes, simulating what happened during the June 2016 flood event.

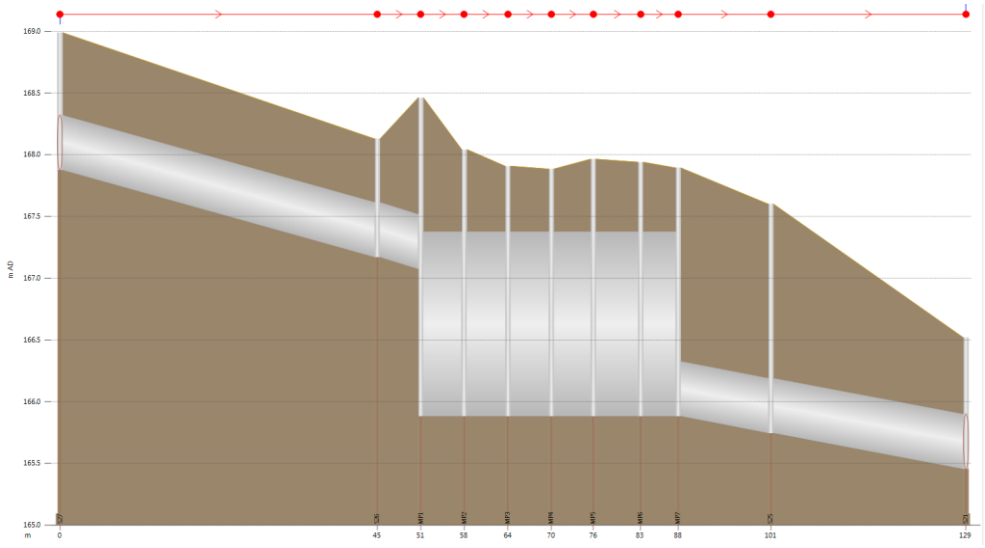


Figure 2 - The Money Pit model set up.

Five soakaways located along the main surface water drain have been modelled using storage nodes (Figure 3). The Dene-Tech, May 2017 survey concluded that two out of the three soakaways in the Banstead Road / Milton Road area were in-accessible on site. The one soakaway which could be surveyed was found to have approximately 2 m of water in its base. Given the lack of rain before the survey, this implied the soakaway is not functioning correctly as it appears to only be storing water rather than facilitating the soaking away of water. This has been replicated in the model as shown in Table 3.

The Stites Hill Road soakaway represents the end of SCC's main surface water drain. It has been modelled as a node with modified sustainable drainage systems (SuDS) parameters. These define the loss rates through the bottom and the sides of the soakaway and the porosity of the fill material. The porosity and loss rates of the soakaway were adapted from the findings of the Coulsdon Common Soakaway survey (Dene-Tech, May 2015), see Table 3.

Table 3 - Method used to model the soakaways.

Name	Surveyed dimensions	Survey comments	Modelling method
Stites Hill Road soakaway.	Cover level: 152.40 m AOD; Soakaway diameter: 1.50 m; Soakaway depth: 6.05 m.	The soakaway has holes in the chamber wall. The surveyors were unable to assess the depth of the silt at the base of the soakaway. The depth of the soakaway measured is to the top of the silt. Depth of water when surveyed of 0.65 m.	Modelled as a manhole with the following soakaway parameters: Base area: 1.77 m^2; Perimeter: 4.71 m; Infiltration loss coefficient: 508 mm/hr; Porosity: 0.314.
Soakaway 1.	Not surveyed.	The soakaway was under a vehicle, and could not be surveyed.	No information was available; therefore, soakaway 1 has been approximated to soakaway 2.
Soakaway 2.	Cover level: 165.17 m AOD; Soakaway diameter: 0.62 m; Soakaway depth: 4.35 m.	The soakaway was surveyed only from the top (there were no steps to access the chamber). The chamber is cone shaped. There was 2.1 m depth of water in the soakaway at the time of survey after a period of dry weather. It is therefore assumed that the soakaway does not function correctly.	Conservatively modelled as a storage node with the following storage array: Shaft area: 0.3 m^2; Base area: 0.3 m^2; Depth of storage: 4.35 m. Modelling the soakaway in this way means that there is no infiltration and the chamber is acting as a storage area only.
Soakaway 4.	Not surveyed.	The survey team was unable to locate the soakaway.	No information was available; therefore, soakaway 4 has been approximated to soakaway 2.
Soakaway 6.	Not surveyed.	No survey has been commissioned for this soakaway.	No information was available; therefore, soakaway 6 has been approximated to soakaway 2.

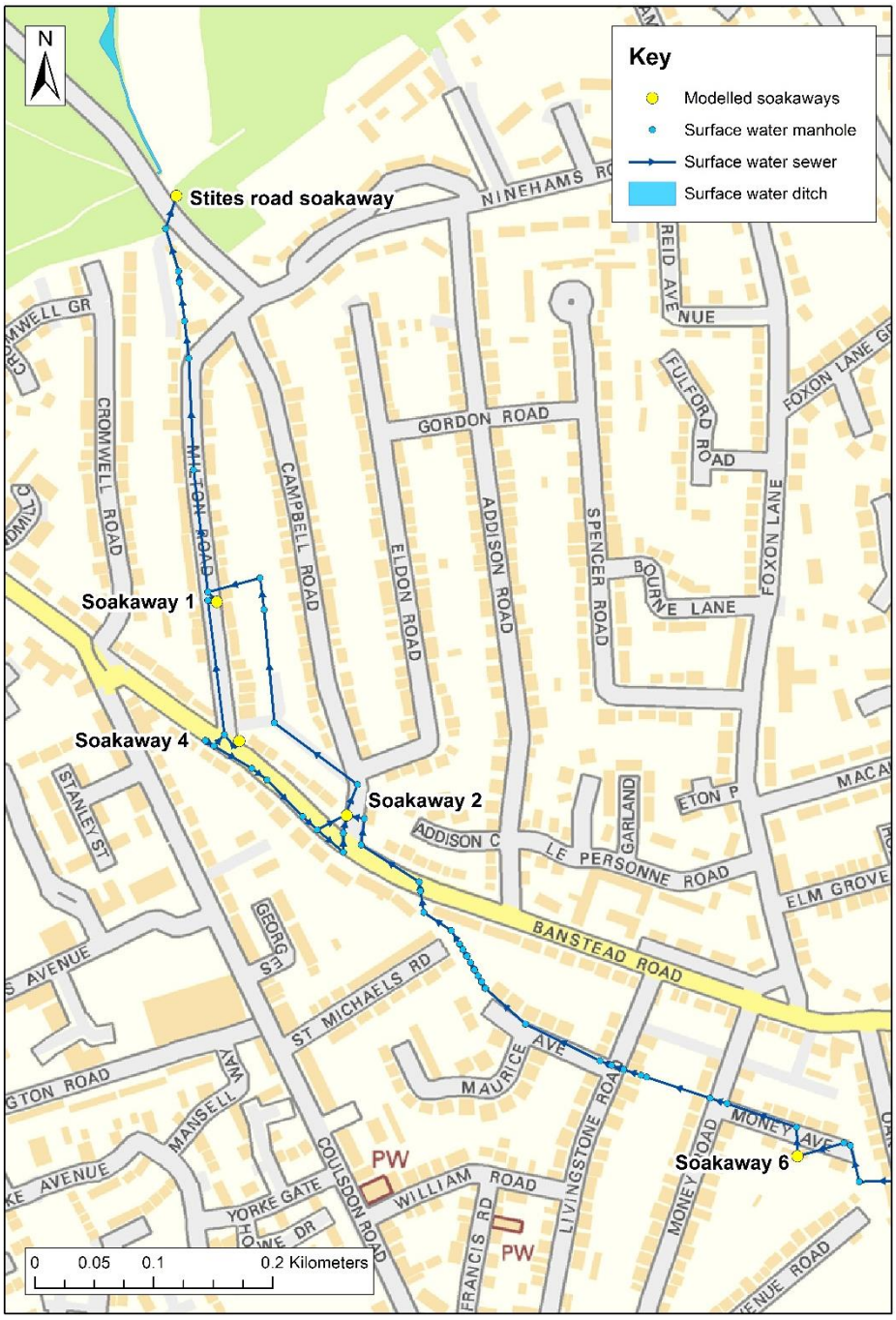


Figure 3 - Location of the modelled soakaways.

Downstream of the Stites Hill Road soakaway, the drainage ditch across Coulsdon Common has been modelled as a 1D river reach. The 1D river reach is linked to the 2D mesh using bank-lines and inline banks at the upstream and downstream extents to allow integrated flow between the 1D and 2D domains. The cross-sections used to construct this river reach were obtained from measurements made while on a site visit.

Further downstream of the drainage ditch, the surface water sewer network detailed in the old maps from Croydon Borough Council (dated 1968) is modelled using conduits and manholes linked to the 2D domain, allowing integrated flow between 1D and 2D domains. It should be noted that there is no information regarding the surface water sewer network downstream of Caterham Drive, neither from Croydon Borough Council maps, nor Thames Water asset data. The end of the sewer is represented in the model as a 2D

outfall, allowing the water to outfall onto the 2D mesh and flow overland (Figure 6). This outfall is located 75 m downstream of the most northerly extent of Caterham Drive, and therefore is not expected to affect modelled flood risk within the study area.

The foul water network has been imported into the model from the Infoworks CS Beddington Catchment Thames Water model. All the nodes within the 2D domain have been modified so that their flood type is "2D" rather than "Lost". By connecting the manholes to the 2D zone, integrated flow is allowed between the 1D and 2D domains. The rest of the foul water network remains unchanged as it is located outside of the study area. It is noted that the flood type of the manholes outside the study area remains modelled as "Lost". When a manhole is modelled as "Lost", the flood water is permanently lost from the system when surcharging occurs. A better representation of flooding would be achieved by setting the flood type as "Stored", as this retains the flood water, returning it to the drainage system when levels in the pipe network fall. As these manholes are all located outside of the study area, the impact of this manhole type is considered to have a negligible impact on modelled surface water flooding in our area of interest.

Model assumptions

The main assumptions made in building the Caterham-on-the-Hill ICM were:

- The SPRHOST value of 50% (which determines the rainfall lost to infiltration), verified as appropriate using both soils data and flood records from June 2016 is assumed to be appropriate.
- Gullies have not been included in the model. While SCC gully locations are known; their connectivity is unknown and this, along with their size and associated gradients, would have to be assumed.
- The surface water network connectivity is unknown north of Caterham Drive. For this modelling, the surface water network discharges to the 2D mesh 75 m downstream of the most northerly extent of Caterham Drive.
- The Thames Water CS model of the foul water network represents the foul water system in this area. It is assumed that this is suitable for assessing the risk of foul flooding, with no changes required other than those noted in this report.
- There are two assumptions that have been made in relation to the foul water network connectivity in Caterham-on-the-Hill. These are as described below:
    - The pumping station located at the northern end of Milton Road and the rising main running south along Milton Avenue in the Thames Water data set have been closed and the foul network now connects across Coulson common, from Stites Hill Road to Caterham Drive, as shown in the Croydon Borough Council maps (dated 1968). The foul network connection across Coulson Common has been assumed. The pipe dimensions and invert levels were assumed based on the upstream and downstream connecting conduits. At the time of writing this report, Thames Water are investigating the Coulsdon Common sewer connection but no further information is available.
    - The pumping station marked on old maps as located where the foul sewer network crosses Banstead Road has been reported as decommissioned. It has been confirmed that the Thames Water data reflects this. The Thames Water data shows that the pipe which would have been located where the rising main for a pumping station would have been is ~ 16 m below ground, along Wellington Road. This has been assumed to be correct, although we note that it is very deep for a sewer. To date, no confirmation of this sewer depth has been received from Thames Water. It should be noted that this foul water pipe crosses the surface water catchment boundary into the neighbouring catchment located to the west.
- The Stites Hill Road soakaway has been modelled to replicate its real-life functionality. Assumptions have been made with regards to the parameters of the soakaway, calculated to replicate the loss rate surveyed (Dene-Tech, May 2015). The exact soakaway area is unknown because of the unknown locations and number of the drainage perforations in the concrete structure.
- Soakaways 1, 2, 4 and 6 have been modelled as storage areas. Three out of the four soakaways were not surveyed. The one surveyed soakaway had approximately 2 m of water in its base; due to the lack of rain before the survey, this implied the soakaway is not functioning correctly. It appeared to be storing water rather than facilitating the water soaking away. Therefore, it was assumed these soakaways are only functioning as storage areas. Their dimensions were all assumed to be the same as the surveyed soakaway.

Model validation

Atkins have validated the model using rainfall data and resident flood records from the June 2016 flood event (Figure 4).

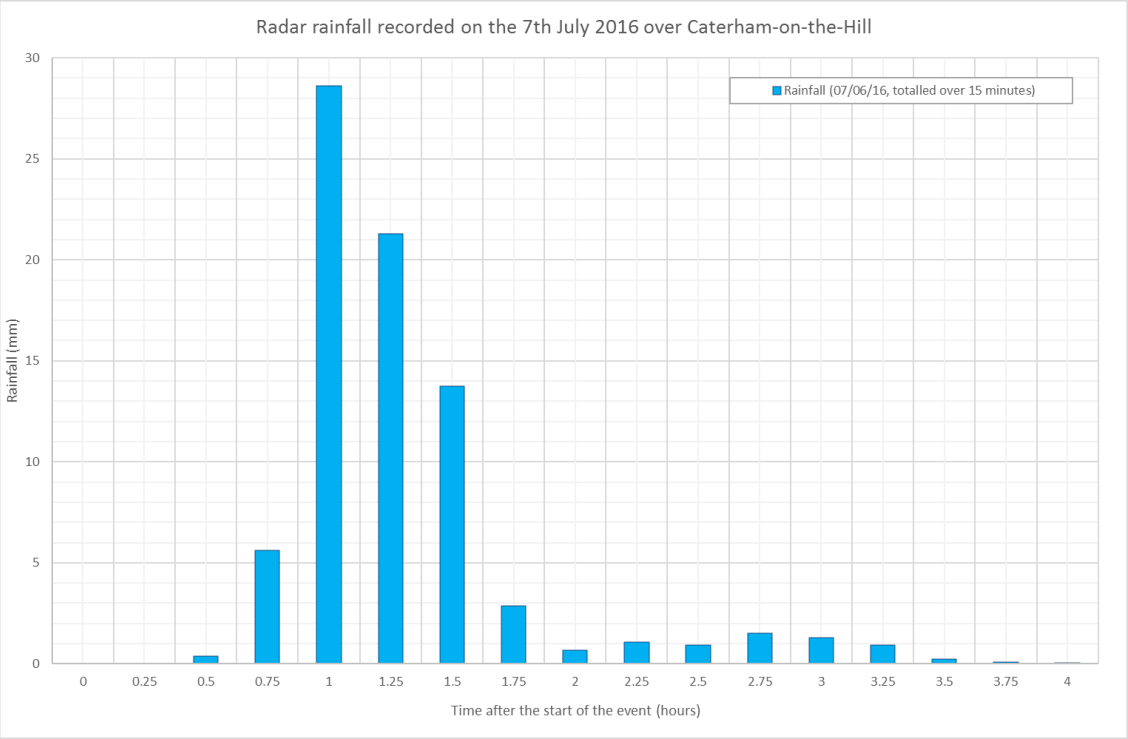


Figure 4 - Radar rainfall recorded on 07/07/2016 (Hyrad Display Client, 2016).

The ICM was run using the June 2016 rainfall data (Figure 4). The results of this simulation were compared to the records of flooding gathered from local residents at an event held by Caterham and Old Coulsdon Flood Action Group, SCC and Atkins (10/05/17). The model replicated flooding at 73% of the properties reported as internally flooding during the June 2016 flood event (as identified at the flood forum event). Of the remaining properties reported to have flooded internally, 60% are located on Cromwell Road and Banstead Road, with the other properties scattered throughout the property.

The model was subsequently tested by applying a 50% increase to the recorded rainfall. This demonstrated that even with a large increase in rainfall, the reported flooding was still not replicated in the model. The lack of representation in these areas is attributed to the absence of high resolution features in the model; features such as fences, brick walls, house walls and local drainage infrastructure.

Based on an appropriate simulation of the flooding experienced along the main surface water flow path through the Caterham-on-the-Hill catchment and along Caterham Drive, the validation of the model is considered successful. However, the model was only validated against one event and evidence is anecdotal rather than gauged.

Critical duration

The critical storm duration of the Caterham-on-the-Hill ICM was found to be a 60-minute summer storm. The critical duration was assessed based on highest modelled peak flows at four separate locations in the Caterham-on-the-Hill ICM. These were:

- Queens Park Road;
- Coulsdon Common western flow path;
- Coulsdon Common eastern flow path; and
- Downstream of Caterham Drive.

Model stability

Model stability is good, with a low Mass Error Balance (0.01%), and a low mass error of 0.21 m^3 for the Maintain 1% (1 in 100) AEP flood event.

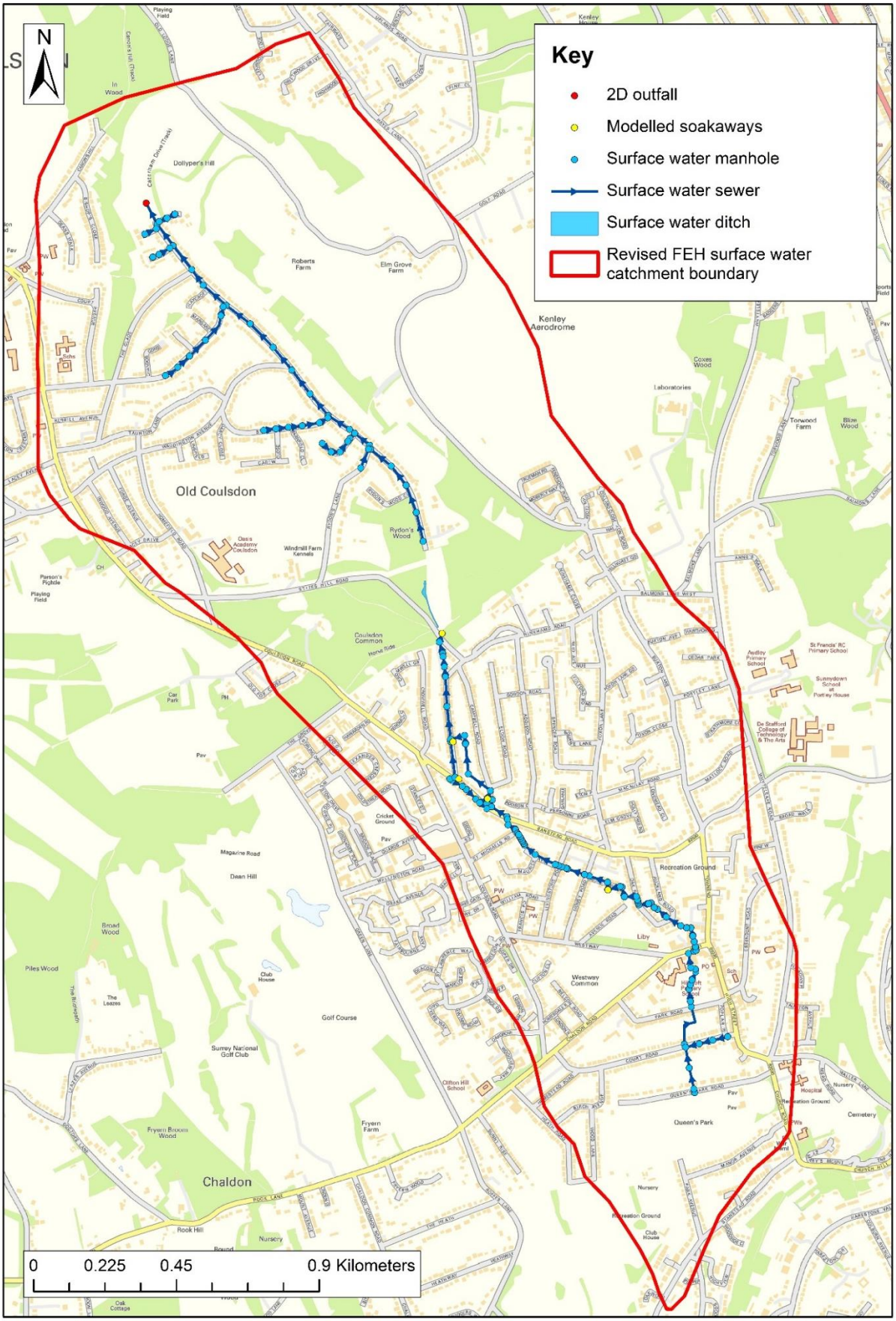


Figure 5 – Surface water network.

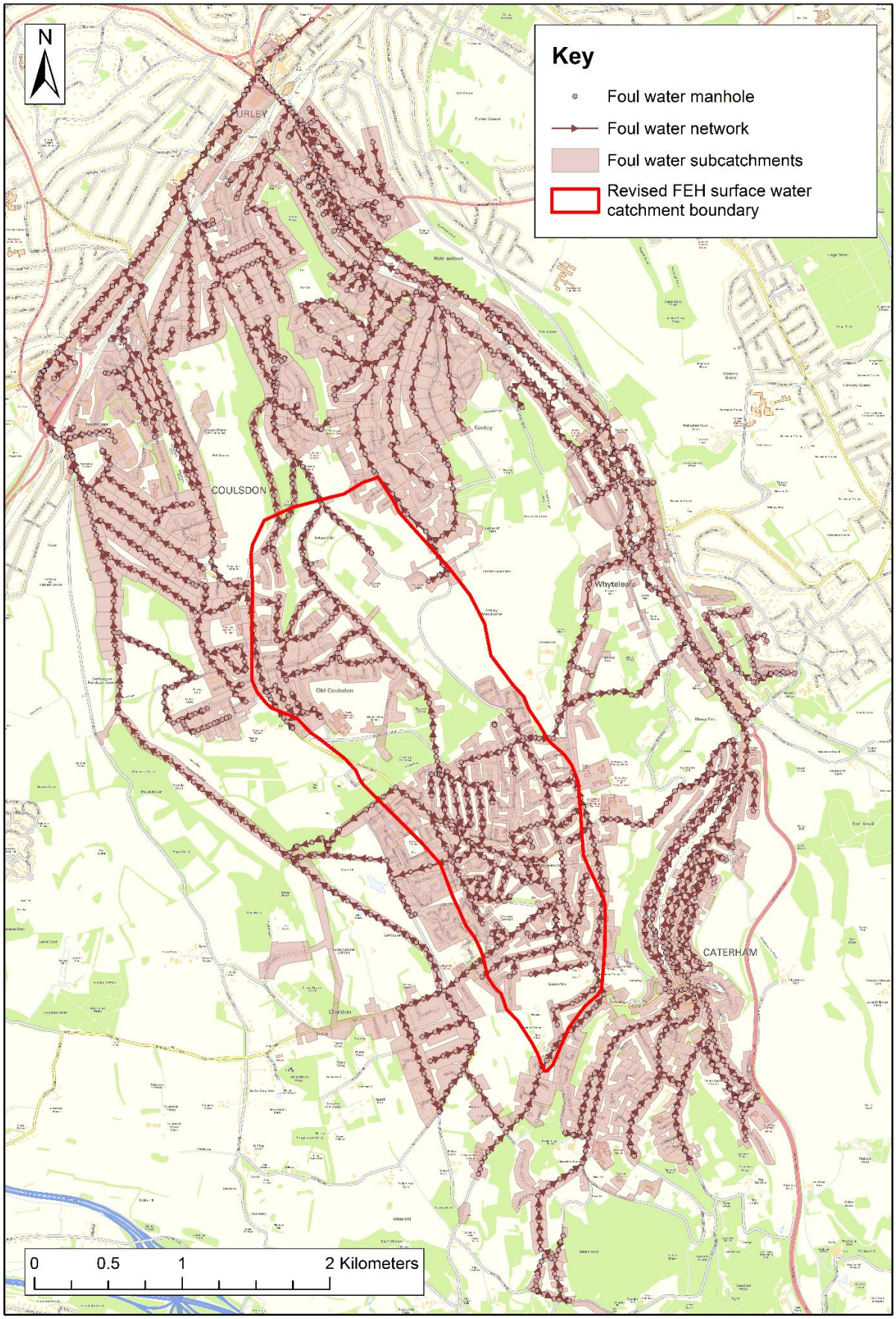


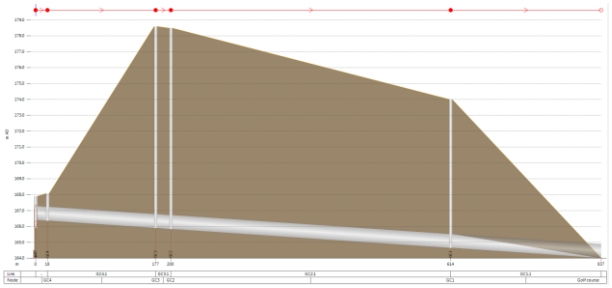
Figure 6 – Foul water network.

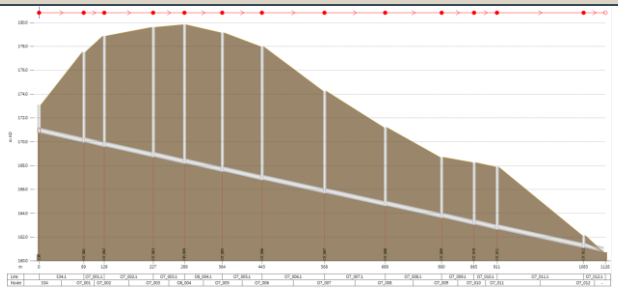
Options modelling

Table 4 sets out the changes made to the existing model in order to simulate the impact of the short-listed options. Please see Figure 9 for an indicative location of each option.

Table 4 - Modelled options

Option		Change from existing model	Reason / justification
No.	Description		
1	Queen's Park recreation ground storage area.	A 250 m long porous wall (with a porosity of 0%) was built into the model in Queens Park recreation ground parallel to Queens Park Road, to replicate the functionality of an impermeable bund. This bund was modelled with a height of 1 m. A 150 mm diameter pipe was added to convey flow from the storage area directly into the upstream part of the SCC main surface water drain.	The bund length and height was determined to maximise the storage volume and based on the modelled volume of water in this upstream part of the catchment.
2	Hillcroft Primary School underground storage area.	Two underground storage areas have been modelled using an over-sized culvert arrangement. Alternative modelling methods were tested; while this method does not account for head losses when water flows into and out of the storage area, it provided the best representation of the proposed storage arrangement. Inflow culverts with a diameter of 300 mm divert flow from the main surface water drain into two culverts with the following dimensions: Width: 32.0 m; height: 0.8 m; and length: 49 m. Width: 49.0 m; height: 0.8 m; and length: 46.0 m. This equates to a total storage volume of 3,057 m^3. Outflow culverts modelled with a diameter of 150 mm direct flow from the storage area back into the main surface water drain.	There is a foul Thames Water sewer which runs through the centre of the Hillcroft Primary School playing field. It is most likely that this would need to be diverted if a single surface water storage area was to be build. For the purpose of option modelling at this stage, it was therefore assumed that two separate storage areas would be constructed, either-side of the foul water sewer.
3	Coulsdon Common western flow path storage areas.	Two porous walls, 36 m (upstream) and 48 m (downstream) long, both with porosities of 0% (fully impermeable) were built into the model to replicate the functionality of two bunded flood storage areas operating in cascade. The upstream porous wall is modelled to have a crest level of 149.5 m AOD (a maximum of 1.2 m above existing ground level), while the downstream porous wall is modelled to have a crest level of 147.8 m AOD (a maximum of 1.4 m above existing ground level). A 150 mm diameter pipe conveys flow through each of the porous walls to allow the storage areas to drain. The pipes drain through the embankments and directly onto the ground surface on the downstream side as there is no known underground surface water system crossing Coulsdon Common. If the water level in the storage areas exceeds the bund crest levels, water is able to flow directly over the bunds.	Because of the existing topography, creation of a single storage area would necessitate construction of a very high bund, which would be both costly to construct and have adverse visual impacts. A cascade of two smaller storage areas has therefore been tested in the model. Crest heights were derived from a review of both ground levels and modelled volumes of water to be stored. In this area, the volumes of water requiring storage far exceed the space available for storage.
4	Coulsdon Common eastern flow path storage areas.	Three porous walls, all with porosities of 0% (fully impermeable) were built into the model to replicate the functionality of three bunded flood storage areas operating in cascade. Modelled dimensions were as follows:	Because of the existing topography, creation of a single storage area would necessitate construction of a very high bund, which would be both costly to construct and have adverse visual

Option		Change from existing model	Reason / justification
No.	Description		
		Upstream bund: 71 m long, crest level of 158 m AOD, giving a maximum height of 2.4 m above existing ground level. Middle bund: 66 m long, crest level of 154 m AOD, giving a maximum height of 2.4 m above existing ground level. Downstream bund: 66 m long, crest level of 149 m AOD, giving a maximum height of 2.5 m above existing ground level. In order to allow the storage areas to drain, a 225 mm diameter pipe conveys flow through the upstream porous wall, and a 150 mm pipe through the middle porous wall. The pipes drain through the embankments and directly onto the ground surface on the downstream side as there is no known underground surface water system in this area. A 150 mm diameter pipe conveys flow from the downstream storage area into the surface water drainage system under Caterham Drive.	impacts. A cascade of two smaller storage areas has therefore been tested in the model. Crest heights were derived from a review of both ground levels and modelled volumes of water to be stored. In this area, the volumes of water requiring storage far exceed the space available for storage.
5	Removal of the Money Pit.	The Money Pit has been removed and replaced by a continuous 450 mm pipe.	The main surface water drain in this location has a diameter of 450 mm, therefore this pipe size has been chosen for consistency.
6	Diversion of flow out of the catchment, from downstream of the Money Pit to west of Green Lane.	A new 900 mm diameter pipe has been added to the model from the downstream end of the Money Pit, under St. Michaels Road and Wellington Road, discharging onto the Surrey National Golf Club. This pipe would be required to cross the surface water catchment boundary; as a result, in order to drain the water by gravity, in places the pipe would be in excess of 10 m deep (Figure 7).  **Figure 7 – Option 6 long section of new pipe.** It is assumed that the water discharging from this pipe would have to be stored on the golf course to ensure that this option did not make flood risk worse elsewhere. At this stage, this storage has not been investigated or modelled.	A 900 mm pipe was chosen to model the likely maximum volume that could be taken from the system at this point and diverted into the neighbouring catchment.
7	Diversion of flow down Foxton Lane to join the eastern flow path.	A new 450 mm diameter pipe has been added to the model from the main surface water drain at Manhole S34 to drain north along Money Road, down Foxton Road and then Ninehams Close, out-falling in Coulson Common in the same location as the eastern flow path. This pipe would be required to cross the surface water catchment boundary, and as a result, in order to drain the water by gravity, in places the pipe would be in excess of 10 m deep (Figure 8).	The main surface water drain in this location has a diameter of 450 mm, therefore this pipe size has been chosen for consistency.

Option		Change from existing model	Reason / justification
No.	Description		
		 **Figure 8 – Option 7 long section of new pipe.** To ensure that this option does not make flooding worse elsewhere, this option has been combined with option 4, to store the additional water along the Coulsdon Common eastern flow path.	

Please note that the locations of the proposed options are indicative

Figure 9 – Modelled options.

Future model development

Table 5 identifies possible future additions to the model, listing data sources, quality (where known) and the benefits of model development.

Table 5 - Datasets which have the potential to provide benefits to the model.

Feature / assets	Data source and quality	Benefits of inclusion
Short-term flow survey along the main surface water drain.	Survey.	To provide data for model calibration. This will increase the confidence in model results.
Thames water foul network connectivity along Wellington Road.	Thames Water to confirm location, diameter and invert levels of foul sewer in this area.	At present a proportion of the foul water network in Caterham-on-the-Hill drains into the neighbouring catchment. This removes a volume of foul water from the Caterham-on-the-Hill catchment. If the connection is not represented correctly and the foul water drains through the Caterham-on-the-Hill catchment, this adds a volume of water to the system and could affect the modelled risk of foul water flooding.
Updated information on the foul sewer connection under Coulsdon Common.	Thames Water investigations (once complete).	Confirmation of flow of sewerage across Coulsdon Common.
Soakaway parameters.	Survey and infiltration testing.	Several soakaways could not be accessed or located, therefore they have been assumed to replicate storage areas in the model. If the rate of infiltration is included in the model, localised surface water flooding could be reduced. This is however unlikely to make a significant difference to flood risk during intense rainfall events.
Soakaways not included in the model.	Survey and infiltration testing of significant soakaways in Caterham-on-the-Hill.	Only soakaways connected into the main surface water drain have been included in the model. There are many additional soakaways that have not been included in the model. If included in the model storage volume and infiltration would increase, potentially impacting localised surface water flood depths and areas.
Small scale / local ground and drainage features	Mapping and local survey of gullies, walls and garden fencing.	Neither small scale drainage features (e.g. gullies) or localised ground features (e.g. walls and fences) have not been included in the modelling. This could have an impact on the flow direction and velocity of the surface water runoff. It could also affect the rate and volume of water which can enter the main surface water drain. Inclusion of these features would enable refinement of the modelled surface water depths and outlines. It is however very rare for the industry to incorporate such a high level of detail in the hydraulic model because it is not proportionate given the uncertainties associated with the other assumptions, for example percentage runoff rates.

Appendix B: Long list of options

Technical note

Project:	Caterham-on-the-Hill Initial Assessment	**To:**	Surrey County Council
Subject:	Long list of options	**From:**	Beth Waring
Date:	July 2017	**cc:**	Clare Hodgson

Long list of options

Table 1 documents the maintenance options for Caterham-on-the-Hill and Table 2 documents the long list of improvement options identified for managing drainage assets and flood risk. This long list of options includes the options proposed by the residents group.

Table 1 Maintenance of existing assets

Option	Benefits	Constraints	Identified by residents group?	Short Listed?	To be modelled?
Re-instate broken pipes and clear root masses and silt along main storm drain, as identified on the CCTV surveys.	Sewers kept in operational service, with improved flow conveyance. Broken pipes could be a source of silt and debris.	Likely closure of roads while work takes place. Access to residential property gardens may be required.	No	Yes	No
Clean soakaways.	Improved discharge capacity, with reduced risk of surcharging.	Can be difficult to clear / clean deep soakaways. Regular inspection and maintenance required to keep assets clean. Soakaway potential may be limited by underlying geology.	No	Yes	No
More regular gully cleaning, including more robust noticing and planning procedure for the cleaning.	Gullies would operate in storm events, alleviating some of the flood risk. Opportunity for community engagement, with reduced risk of parked cars preventing access to gullies.	Not possible to guarantee access to gullies, especially in roads where off-street parking is not available.	No	Yes	No

Option	Benefits	Constraints	Identified by residents group?	Short Listed?	To be modelled?
Review existing practice and implement a more proactive and regular maintenance regime of the storm water drainage assets.	Improved asset operation to design capacity / level of service, with reduced risk of flooding. Opportunities to identify maintenance efficiencies.	Sufficient funding not always available for maintenance work. Some drainage assets are the responsibility of riparian landowners. Flood risk issues will still occur if the existing assets do not have sufficient capacity to convey water.	No	Yes	No

Table 2 Long list of improvement options

Option Type	Option	Benefits	Constraints	Identified by residents group?	Short Listed?	To be modelled?
Flood storage	Create flood storage area at Queen's Park recreation ground. Initial calculations suggest that the bund would need to be ~1.5m high to provide any meaningful standard of protection.	Stores upstream runoff, reducing discharge downstream and reducing risk of property flooding especially in the upstream catchment. Location is immediately upstream of three roads known to be at risk of flooding. Volume of water to be stored means that the asset would not fall under the Reservoirs Act (1975).	Additional work required to determine option feasibility. Existing gullies / pipe connections in the park may need to be excavated. Capital and ongoing maintenance costs. H&S implications when flood storage is in use. Location is in upper catchment and only accounts for 12% of the whole catchment to Stites Hill Road.	Yes	Yes	Yes

Option Type	Option	Benefits	Constraints	Identified by residents group?	Short Listed?	To be modelled?
	Create underground flood storage area below the Hillcroft Primary School playing field. Likely maximum depth of storage is 1.2m over an area of ~7,000m^2.	Stores runoff with reduced discharge downstream, reducing risk of property flooding.	Additional work required to determine option feasibility. Capital and ongoing maintenance costs.	No	Yes	Yes
	Create flood storage area on the western flow path on Coulsdon Common. Initial calculations suggest that a very high bund would be required to store the volume of water needed to significantly reduce downstream flood risk.	Stores runoff with reduced discharge downstream, reducing risk of property flooding along Caterham Drive and Rydon's Wood Close. Potential opportunities for landscaping enhancement as part of the works.	Additional work required to determine option feasibility – very steep sided valley therefore area over which storage can be achieved is limited without very high bunds. Capital and ongoing maintenance costs; may fall under the Reservoirs Act. Environmental impacts of construction in a wooded area. H&S implications when flood storage is in use.	Yes	Yes	Yes
	Create flood storage area on the eastern flow path on Coulsdon Common. Initial calculations suggest that a very high bund would be required to store the volume of water needed to significantly reduce downstream flood risk.	Stores runoff with reduced discharge downstream, reducing risk of property flooding along Caterham Drive and Rydon's Wood Close. Potential opportunities for landscaping enhancement as part of the works.	Additional work required to determine option feasibility – very steep sided valley therefore area over which storage can be achieved is limited without very high bunds. Capital and ongoing maintenance costs. Environmental impacts of construction in a wooded area. H&S implications when flood storage is in use.	Yes	Yes	Yes

Option Type	Option	Benefits	Constraints	Identified by residents group?	Short Listed?	To be modelled?
	Divert water from the main flow path, to create flood storage area on Westway common.	Stores runoff with reduced discharge downstream, reducing risk of property flooding.	Additional work required to determine option feasibility. This would be dependent on topographic levels. Significant capital and ongoing maintenance costs likely to outweigh option benefits. H&S implications when flood storage is in use.	Yes	No	No
	Create flood storage area downstream of Caterham Drive.	Stores runoff with reduced discharge downstream.	Additional work required to determine option feasibility. Capital and ongoing maintenance costs. H&S implications when flood storage is in use. Will not provide upstream benefits; all benefits from this option would be outside of the study area.	Yes	No	No
Design for exceedance	Install overflow on Coulsdon Common soakaway.	Overflow would allow excess water to be safely conveyed downstream without lifting of the manhole cover, reducing the H&S risk associated with surcharging. Drainage ditch already exists, to which a formal connection could be constructed.	Option in isolation (without addressing soakaway discharge capacity issues) could increase risk of flooding downstream.	No	Yes	No
	Divert water out of the catchment from the Money Pit to Green Lane. Storage would need to be provided to prevent any increasing in flood risk downstream.	Reduces risk of flooding by conveying water out of the catchment.	Diverting water to another catchment could increase flooding elsewhere. Option likely to be prohibitively expensive.	Yes	Yes	Yes

Option Type	Option	Benefits	Constraints	Identified by residents group?	Short Listed?	To be modelled?
	Raise the level of Stites Hill Road and provide a culvert under the road for conveyance in a flood event.	Reduce risk of road flooding.	Likely to be prohibitively expensive for an option which only benefits and the road and not any properties. Risk that water backs up behind the raised road.	No	No	No
	Bolt down the manhole cover on Coulsdon Common soakaway.	Reduced risk of manhole cover lifting when soakaway is surcharged.	If inflow is greater than soakaway discharge capacity, water pressure would build, and resulting surcharge would ultimately be more dangerous than in the existing situation.	No	No	No
	Offline storage at Roberts Farm.	Reduce risk of road flooding to the properties north of Coulsdon Common.	Ground levels may not allow for this; would require further investigation. Potential landowner issues.	No	No	No
	Kerb raising.	Reduced risk of surface water inundation of properties as low depths of flood water would be confined to the road.	Access considerations for cars onto drives, wheelchairs and buggies. Court Road (south side) and Park Road properties at risk of flooding from back gardens, not just the road.	No	No	No
	Divert water out of the catchment from Ninehams Road to the Whyteleafe catchment.	Reduced risk of surface water inundation to the road and adjacent roads, reducing disruption to traffic flow. This could provide benefits to the flooding reported at Buxton Lane roundabout.	Diverting water to another catchment would increase flooding elsewhere.	Yes	No	No

Option Type	Option	Benefits	Constraints	Identified by residents group?	Short Listed?	To be modelled?
Manage debris & silt	Installation of silt trap in manhole chambers upstream of the Money Pit and the Coulsdon Common soakaway.	Traps silt before it reaches and blocks the Money Pit / soakaway. Easier, safer and cheaper to clear compared to clearing assets.	Regular maintenance still required.	No	Yes	No
	Litter campaign.	Reduce quantity of litter which gets into the drainage system, reducing the risk of soakaway blockage and public health issues associated with soakaway surcharge. Opportunity for community engagement.	Difficult to determine effectiveness.	No	Yes	No
	Installation of silt traps downstream of Queen's Park.	Captures and removes silt before it enters the drainage system, reducing the risk of siltation of pipes and soakaways and hence improving conveyance and asset performance.	Siltation not identified as a major issue in the catchment with limited sources of silt in this upstream area. Silt traps require a regular maintenance regime to prevent blockage.	No	No	No
Green infrastructure	Local measures to reduce the volume of surface water runoff in the piped network e.g. rainwater gardens and water-butts.	Reduced risk of system surcharging. Opportunity for environmental, biodiversity and aesthetic benefits. Opportunity for community engagement.	Individual measures will have a negligible impact and so this would need to be applied across the whole area in combination with other management options to be most effective.	No	Yes	Yes
Improve existing assets	Remove the Money Pitt.	Reduces maintenance work for Surrey County Council. Asset does not currently operate as designed. Land could be used more effectively.	Removes some storage volume from the system, however if this were combined with a storage option elsewhere, the impact would be negated.	No	Yes	Yes

Option Type	Option	Benefits	Constraints	Identified by residents group?	Short Listed?	To be modelled?
	Upsizing of existing pipe network or installation of additional pipes, creating a “super sewer” for the urban areas (pipe diameters of 750 mm to 1000 mm).	Improve flow conveyance, potentially reducing flooding that occurs because of the system surcharging.	Risk of increasing downstream flood risk. Likely to be prohibitively expensive as certain areas of the drain would require tunnelling close to housing. Likely closure of roads while construction takes place would be very disruptive to the local community.	No	No	No
	Create a new surface water drain connection from the existing main drain, under Foxton Lane, towards Coulsdon Common.	This would divert some of the surface water flow and reduce the volume of water flowing down the existing surface water drain along Banstead Road.	Likely closure of roads while construction takes place; disruptive to the local community. Could increase flood risk to other locations.	No	No	No
	Excavate Coulsdon Common soakaway and re-build.	Design new soakaway to have a higher discharge capacity, reducing the risk of surcharge.	This is only a short-term solution. Existing poor operation of soakaways in the catchment suggests that underlying ground conditions are not suited to infiltration measures. Unlikely to provide any meaningful increase in the standard of protection.	No	No	No

Appendix C: Option costing

Client/Authority
Surrey County Council
Project name
Caterham on the Hill
Project reference
Base date for estimates (year 0): 2017
Scaling factor (e.g. £m, £k, £): £k
Discount rate: 3.5%

Results £k

PV total costs 100yr	Queen's park flood storage area		Hillcroft School underground storage approach 1	Hillcroft School underground storage approach 2	Coulsdon Common flood storage on western flow path	Coulsdon Common flood storage on eastern flow path	Removal of money pit	Divert water from Money Pit to the golf course	Divert water along Foxton Lane	Combination of option 1, 3 & 4	Combination of option 1, 2, 3 & 4
	Do nothing	Option 1	Option 2a	Option 2b	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9
	0.00	307.88	2671.31	2025.71	301.50	348.29	308.80	2122.45	2412.77	744.21	2353.49

Calendar Year	Appraisal year	Discount Factor	Do Nothing Capital	Do Nothing Maint.	TOTALS: Cash	TOTALS: PV	Option 1 Capital	Option 1 Maint.	TOTALS: Cash	Capital Spend PV	Maintenance PV	Option 2a Capital	Option 2a Maint.	TOTALS: Cash	Capital Spend PV	Maintenance PV	Option 2b Capital	Option 2b Maint.	TOTALS: Cash	Capital Spend PV	Maintenance PV
	100	cash sum	0.00	0.00	0.00	0.00	430.00	192.00	622.00	255.86	52.02	2957.00	480.00	3437.00	2541.25	130.05	2241.00	480.00	2721.00	1895.65	130.05
2017	0	1.000			0.00	0.00			0.00	0.00	0.00			0.00	0.00	0.00			0.00	0.00	0.00
2018	1	0.966			0.00	0.00	60.00		60.00	57.97	0.00	60.00		60.00	57.97	0.00	60.00		60.00	57.97	0.00
2019	2	0.934			0.00	0.00	64.00		64.00	59.74	0.00	170.00		170.00	158.70	0.00	176.00		176.00	164.30	0.00
2020	3	0.902			0.00	0.00	96.00		96.00	86.59	0.00	2527.00		2527.00	2279.21	0.00	1805.00		1805.00	1628.01	0.00
2021	4	0.871			0.00	0.00		2.00	2.00	0.00	1.74		5.00	5.00	0.00	4.36		5.00	5.00	0.00	4.36
2022	5	0.842			0.00	0.00		2.00	2.00	0.00	1.68		5.00	5.00	0.00	4.21		5.00	5.00	0.00	4.21
2023	6	0.814			0.00	0.00		2.00	2.00	0.00	1.63		5.00	5.00	0.00	4.07		5.00	5.00	0.00	4.07
2024	7	0.786			0.00	0.00		2.00	2.00	0.00	1.57		5.00	5.00	0.00	3.93		5.00	5.00	0.00	3.93
2025	8	0.759			0.00	0.00		2.00	2.00	0.00	1.52		5.00	5.00	0.00	3.80		5.00	5.00	0.00	3.80
2026	9	0.734			0.00	0.00		2.00	2.00	0.00	1.47		5.00	5.00	0.00	3.67		5.00	5.00	0.00	3.67
2027	10	0.709			0.00	0.00		2.00	2.00	0.00	1.42		5.00	5.00	0.00	3.54		5.00	5.00	0.00	3.54
2028	11	0.685			0.00	0.00		2.00	2.00	0.00	1.37		5.00	5.00	0.00	3.42		5.00	5.00	0.00	3.42
2029	12	0.662			0.00	0.00		2.00	2.00	0.00	1.32		5.00	5.00	0.00	3.31		5.00	5.00	0.00	3.31
2030	13	0.639			0.00	0.00	20.00	2.00	22.00	12.79	1.28		5.00	5.00	0.00	3.20		5.00	5.00	0.00	3.20
2031	14	0.618			0.00	0.00		2.00	2.00	0.00	1.24		5.00	5.00	0.00	3.09		5.00	5.00	0.00	3.09
2032	15	0.597			0.00	0.00		2.00	2.00	0.00	1.19		5.00	5.00	0.00	2.98		5.00	5.00	0.00	2.98
2033	16	0.577			0.00	0.00		2.00	2.00	0.00	1.15		5.00	5.00	0.00	2.88		5.00	5.00	0.00	2.88
2034	17	0.557			0.00	0.00		2.00	2.00	0.00	1.11		5.00	5.00	0.00	2.79		5.00	5.00	0.00	2.79
2035	18	0.538			0.00	0.00		2.00	2.00	0.00	1.08		5.00	5.00	0.00	2.69		5.00	5.00	0.00	2.69
2036	19	0.520			0.00	0.00		2.00	2.00	0.00	1.04		5.00	5.00	0.00	2.60		5.00	5.00	0.00	2.60
2037	20	0.503			0.00	0.00		2.00	2.00	0.00	1.01		5.00	5.00	0.00	2.51		5.00	5.00	0.00	2.51
2038	21	0.486			0.00	0.00		2.00	2.00	0.00	0.97		5.00	5.00	0.00	2.43		5.00	5.00	0.00	2.43
2039	22	0.469			0.00	0.00		2.00	2.00	0.00	0.94		5.00	5.00	0.00	2.35		5.00	5.00	0.00	2.35
2040	23	0.453			0.00	0.00	20.00	2.00	22.00	9.07	0.91	50.00	5.00	55.00	22.66	2.27	50.00	5.00	55.00	22.66	2.27
2041	24	0.438			0.00	0.00		2.00	2.00	0.00	0.88		5.00	5.00	0.00	2.19		5.00	5.00	0.00	2.19
2042	25	0.423			0.00	0.00		2.00	2.00	0.00	0.85		5.00	5.00	0.00	2.12		5.00	5.00	0.00	2.12
2043	26	0.409			0.00	0.00		2.00	2.00	0.00	0.82		5.00	5.00	0.00	2.04		5.00	5.00	0.00	2.04
2044	27	0.395			0.00	0.00		2.00	2.00	0.00	0.79		5.00	5.00	0.00	1.98		5.00	5.00	0.00	1.98
2045	28	0.382			0.00	0.00		2.00	2.00	0.00	0.76		5.00	5.00	0.00	1.91		5.00	5.00	0.00	1.91
2046	29	0.369			0.00	0.00		2.00	2.00	0.00	0.74		5.00	5.00	0.00	1.84		5.00	5.00	0.00	1.84
2047	30	0.356			0.00	0.00		2.00	2.00	0.00	0.71		5.00	5.00	0.00	1.78		5.00	5.00	0.00	1.78
2048	31	0.346			0.00	0.00		2.00	2.00	0.00	0.69		5.00	5.00	0.00	1.73		5.00	5.00	0.00	1.73
2049	32	0.336			0.00	0.00		2.00	2.00	0.00	0.67		5.00	5.00	0.00	1.68		5.00	5.00	0.00	1.68
2050	33	0.326			0.00	0.00	20.00	2.00	22.00	6.52	0.65		5.00	5.00	0.00	1.63		5.00	5.00	0.00	1.63
2051	34	0.317			0.00	0.00		2.00	2.00	0.00	0.63		5.00	5.00	0.00	1.58		5.00	5.00	0.00	1.58
2052	35	0.307			0.00	0.00		2.00	2.00	0.00	0.61		5.00	5.00	0.00	1.54		5.00	5.00	0.00	1.54
2053	36	0.298			0.00	0.00		2.00	2.00	0.00	0.60		5.00	5.00	0.00	1.49		5.00	5.00	0.00	1.49
2054	37	0.290			0.00	0.00		2.00	2.00	0.00	0.58		5.00	5.00	0.00	1.45		5.00	5.00	0.00	1.45
2055	38	0.281			0.00	0.00		2.00	2.00	0.00	0.56		5.00	5.00	0.00	1.41		5.00	5.00	0.00	1.41
2056	39	0.273			0.00	0.00		2.00	2.00	0.00	0.55		5.00	5.00	0.00	1.37		5.00	5.00	0.00	1.37
2057	40	0.265			0.00	0.00		2.00	2.00	0.00	0.53		5.00	5.00	0.00	1.33		5.00	5.00	0.00	1.33
2058	41	0.257			0.00	0.00		2.00	2.00	0.00	0.51		5.00	5.00	0.00	1.29		5.00	5.00	0.00	1.29
2059	42	0.250			0.00	0.00		2.00	2.00	0.00	0.50		5.00	5.00	0.00	1.25		5.00	5.00	0.00	1.25
2060	43	0.243			0.00	0.00	50.00	2.00	52.00	12.13	0.49	50.00	5.00	55.00	12.13	1.21	50.00	5.00	55.00	12.13	1.21
2061	44	0.236			0.00	0.00		2.00	2.00	0.00	0.47		5.00	5.00	0.00	1.18		5.00	5.00	0.00	1.18
2062	45	0.229			0.00	0.00		2.00	2.00	0.00	0.46		5.00	5.00	0.00	1.14		5.00	5.00	0.00	1.14
2063	46	0.222			0.00	0.00		2.00	2.00	0.00	0.44		5.00	5.00	0.00	1.11		5.00	5.00	0.00	1.11
2064	47	0.216			0.00	0.00		2.00	2.00	0.00	0.43		5.00	5.00	0.00	1.08		5.00	5.00	0.00	1.08
2065	48	0.209			0.00	0.00		2.00	2.00	0.00	0.42		5.00	5.00	0.00	1.05		5.00	5.00	0.00	1.05
2066	49	0.203			0.00	0.00		2.00	2.00	0.00	0.41		5.00	5.00	0.00	1.02		5.00	5.00	0.00	1.02
2067	50	0.197			0.00	0.00		2.00	2.00	0.00	0.39		5.00	5.00	0.00	0.99		5.00	5.00	0.00	0.99
2068	51	0.192			0.00	0.00		2.00	2.00	0.00	0.38		5.00	5.00	0.00	0.96		5.00	5.00	0.00	0.96
2069	52	0.186			0.00	0.00		2.00	2.00	0.00	0.37		5.00	5.00	0.00	0.93		5.00	5.00	0.00	0.93
2070	53	0.181			0.00	0.00	20.00	2.00	22.00	3.61	0.36		5.00	5.00	0.00	0.90		5.00	5.00	0.00	0.90
2071	54	0.175			0.00	0.00		2.00	2.00	0.00	0.35		5.00	5.00	0.00	0.88		5.00	5.00	0.00	0.88
2072	55	0.170			0.00	0.00		2.00	2.00	0.00	0.34		5.00	5.00	0.00	0.85		5.00	5.00	0.00	0.85
2073	56	0.165			0.00	0.00		2.00	2.00	0.00	0.33		5.00	5.00	0.00	0.83		5.00	5.00	0.00	0.83
2074	57	0.160			0.00	0.00		2.00	2.00	0.00	0.32		5.00	5.00	0.00	0.80		5.00	5.00	0.00	0.80
2075	58	0.156			0.00	0.00		2.00	2.00	0.00	0.31		5.00	5.00	0.00	0.78		5.00	5.00	0.00	0.78
2076	59	0.151			0.00	0.00		2.00	2.00	0.00	0.30		5.00	5.00	0.00	0.76		5.00	5.00	0.00	0.76
2077	60	0.147			0.00	0.00		2.00	2.00	0.00	0.29		5.00	5.00	0.00	0.73		5.00	5.00	0.00	0.73
2078	61	0.143			0.00	0.00		2.00	2.00	0.00	0.29		5.00	5.00	0.00	0.71		5.00	5.00	0.00	0.71
2079	62	0.138			0.00	0.00		2.00	2.00	0.00	0.28		5.00	5.00	0.00	0.69		5.00	5.00	0.00	0.69
2080	63	0.134			0.00	0.00	20.00	2.00	22.00	2.69	0.27	50.00	5.00	55.00	6.72	0.67	50.00	5.00	55.00	6.72	0.67
2081	64	0.130			0.00	0.00		2.00	2.00	0.00	0.26		5.00	5.00	0.00	0.65		5.00	5.00	0.00	0.65
2082	65	0.127			0.00	0.00		2.00	2.00	0.00	0.25		5.00	5.00	0.00	0.63		5.00	5.00	0.00	0.63
2083	66	0.123			0.00	0.00		2.00	2.00	0.00	0.25		5.00	5.00	0.00	0.61		5.00	5.00	0.00	0.61
2084	67	0.119			0.00	0.00		2.00	2.00	0.00	0.24		5.00	5.00	0.00	0.60		5.00	5.00	0.00	0.60
2085	68	0.116			0.00	0.00		2.00	2.00	0.00	0.23		5.00	5.00	0.00	0.58		5.00	5.00	0.00	0.58
2086	69	0.112			0.00	0.00		2.00	2.00	0.00	0.22		5.00	5.00	0.00	0.56		5.00	5.00	0.00	0.56
2087	70	0.109			0.00	0.00		2.00	2.00	0.00	0.22		5.00	5.00	0.00	0.55		5.00	5.00	0.00	0.55
2088	71	0.106			0.00	0.00		2.00	2.00	0.00	0.21		5.00	5.00	0.00	0.53		5.00	5.00	0.00	0.53
2089	72	0.103			0.00	0.00		2.00	2.00	0.00	0.21		5.00	5.00	0.00	0.51		5.00	5.00	0.00	0.51
2090	73	0.100			0.00	0.00	20.00	2.00	22.00	2.00	0.20		5.00	5.00	0.00	0.50		5.00	5.00	0.00	0.50
2091	74	0.097			0.00	0.00		2.00	2.00	0.00	0.19		5.00	5.00	0.00	0.49		5.00	5.00	0.00	0.49
2092	75	0.094			0.00	0.00		2.00	2.00	0.00	0.19		5.00	5.00	0.00	0.47		5.00	5.00	0.00	0.47
2093	76	0.092			0.00	0.00		2.00	2.00	0.00	0.18		5.00	5.00	0.00	0.46		5.00	5.00	0.00	0.46
2094	77	0.090			0.00	0.00		2.00	2.00	0.00	0.18		5.00	5.00	0.00	0.45		5.00	5.00	0.00	0.45
2095	78	0.087			0.00	0.00		2.00	2.00	0.00	0.17		5.00	5.00	0.00	0.44		5.00	5.00	0.00	0.44
2096	79	0.085			0.00	0.00		2.00	2.00	0.00	0.17		5.00	5.00	0.00	0.43		5.00	5.00	0.00	0.43
2097	80	0.083			0.00	0.00		2.00	2.00	0.00	0.17		5.00	5.00	0.00	0.42		5.00	5.00	0.00	0.42
2098	81	0.081			0.00	0.00		2.00	2.00	0.00	0.16		5.00	5.00	0.00	0.41		5.00	5.00	0.00	0.41
2099	82	0.079			0.00	0.00		2.00	2.00	0.00	0.16		5.00	5.00	0.00	0.40		5.00	5.00	0.00	0.40
2100	83	0.077			0.00	0.00	20.00	2.00	22.00	1.55	0.15	50.00	5.00	55.00	3.87	0.39	50.00	5.00	55.00	3.87	0.39
2101	84	0.075			0.00	0.00		2.00	2.00	0.00	0.15		5.00	5.00	0.00	0.38		5.00	5.00	0.00	0.38
2102	85	0.074			0.00	0.00		2.00	2.00	0.00	0.15		5.00	5.00	0.00	0.37		5.00	5.00	0.00	0.37
2103	86	0.072			0.00	0.00		2.00	2.00	0.00	0.14		5.00	5.00	0.00	0.36		5.00	5.00	0.00	0.36
2104	87	0.070			0.00	0.00		2.00	2.00	0.00	0.14		5.00	5.00	0.00	0.35		5.00	5.00	0.00	0.35
2105	88	0.068			0.00	0.00		2.00	2.00	0.00	0.14		5.00	5.00	0.00	0.34		5.00	5.00	0.00	0.34
2106	89	0.067			0.00	0.00		2.00	2.00	0.00	0.13		5.00	5.00	0.00	0.33		5.00	5.00	0.00	0.33
2107	90	0.065			0.00	0.00		2.00	2.00	0.00	0.13		5.00	5.00	0.00	0.33		5.00	5.00	0.00	0.33
2108	91	0.063			0.00	0.00		2.00	2.00	0.00	0.13		5.00	5.00	0.00	0.32		5.00	5.00	0.00	0.32
2109	92	0.062			0.00	0.00		2.00	2.00	0.00	0.12		5.00	5.00	0.00	0.31		5.00	5.00	0.00	0.31
2110	93	0.060			0.00	0.00	20.00	2.00	22.00	1.21	0.12		5.00	5.00	0.00	0.30		5.00	5.00	0.00	0.30
2111	94	0.059			0.00	0.00		2.00	2.00	0.00	0.12		5.00	5.00	0.00	0.29		5.00	5.00	0.00	0.29
2112	95	0.057			0.00	0.00		2.00	2.00	0.00	0.11		5.00	5.00	0.00	0.29		5.00	5.00	0.00	0.29
2113	96	0.056			0.00	0.00		2.00	2.00	0.00	0.11		5.00	5.00	0.00	0.28		5.00	5.00	0.00	0.28
2114	97	0.055			0.00	0.00		2.00	2.00	0.00	0.11		5.00	5.00	0.00	0.27		5.00	5.00	0.00	0.27
2115	98	0.053			0.00	0.00		2.00	2.00	0.00	0.11		5.00	5.00	0.00	0.27		5.00	5.00	0.00	0.27
2116	99	0.052			0.00	0.00		2.00	2.00	0.00	0.10		5.00	5.00	0.00	0.26		5.00	5.00	0.00	0.26

Calendar Year	Option 3 Capital	Option 3 Maint.	TOTALS: Cash	Capital Spend PV	Maintenance PV	Option 4 Capital	Option 4 Maint.	TOTALS: Cash	Capital Spend PV	Maintenance PV	Option 5 Capital	Option 5 Maint.	TOTALS: Cash	Capital Spend PV	Maintenance PV
cash sum	401.00	192.00	593.00	249.48	52.02	452.50	192.00	644.50	296.26	52.02	334.00	48.00	382.00	295.79	13.01
2017			0.00	0.00	0.00			0.00	0.00	0.00			0.00	0.00	0.00
2018	60.00		60.00	57.97	0.00	60.00		60.00	57.97	0.00	60.00		60.00	57.97	0.00
2019	64.00		64.00	59.74	0.00	74.50		74.50	69.55	0.00	79.00		79.00	73.75	0.00
2020	97.00		97.00	87.49	0.00	138.00		138.00	124.47	0.00	177.00		177.00	159.64	0.00
2021		2.00	2.00	0.00	1.74		2.00	2.00	0.00	1.74		0.50	0.50	0.00	0.44
2022		2.00	2.00	0.00	1.68		2.00	2.00	0.00	1.68		0.50	0.50	0.00	0.42
2023		2.00	2.00	0.00	1.63		2.00	2.00	0.00	1.63		0.50	0.50	0.00	0.41
2024		2.00	2.00	0.00	1.57		2.00	2.00	0.00	1.57		0.50	0.50	0.00	0.39
2025		2.00	2.00	0.00	1.52		2.00	2.00	0.00	1.52		0.50	0.50	0.00	0.38
2026		2.00	2.00	0.00	1.47		2.00	2.00	0.00	1.47		0.50	0.50	0.00	0.37
2027		2.00	2.00	0.00	1.42		2.00	2.00	0.00	1.42		0.50	0.50	0.00	0.35
2028		2.00	2.00	0.00	1.37		2.00	2.00	0.00	1.37		0.50	0.50	0.00	0.34
2029		2.00	2.00	0.00	1.32		2.00	2.00	0.00	1.32		0.50	0.50	0.00	0.33
2030	20.00	2.00	22.00	12.79	1.28	20.00	2.00	22.00	12.79	1.28	2.00	0.50	2.50	1.28	0.32
2031		2.00	2.00	0.00	1.24		2.00	2.00	0.00	1.24		0.50	0.50	0.00	0.31
2032		2.00	2.00	0.00	1.19		2.00	2.00	0.00	1.19		0.50	0.50	0.00	0.30
2033		2.00	2.00	0.00	1.15		2.00	2.00	0.00	1.15		0.50	0.50	0.00	0.29
2034		2.00	2.00	0.00	1.11		2.00	2.00	0.00	1.11		0.50	0.50	0.00	0.28
2035		2.00	2.00	0.00	1.08		2.00	2.00	0.00	1.08		0.50	0.50	0.00	0.27
2036		2.00	2.00	0.00	1.04		2.00	2.00	0.00	1.04		0.50	0.50	0.00	0.26
2037		2.00	2.00	0.00	1.01		2.00	2.00	0.00	1.01		0.50	0.50	0.00	0.25
2038		2.00	2.00	0.00	0.97		2.00	2.00	0.00	0.97		0.50	0.50	0.00	0.24
2039		2.00	2.00	0.00	0.94		2.00	2.00	0.00	0.94		0.50	0.50	0.00	0.23
2040	20.00	2.00	22.00	9.07	0.91	20.00	2.00	22.00	9.07	0.91	2.00	0.50	2.50	0.91	0.23
2041		2.00	2.00	0.00	0.88		2.00	2.00	0.00	0.88		0.50	0.50	0.00	0.22
2042		2.00	2.00	0.00	0.85		2.00	2.00	0.00	0.85		0.50	0.50	0.00	0.21
2043		2.00	2.00	0.00	0.82		2.00	2.00	0.00	0.82		0.50	0.50	0.00	0.20
2044		2.00	2.00	0.00	0.79		2.00	2.00	0.00	0.79		0.50	0.50	0.00	0.20
2045		2.00	2.00	0.00	0.76		2.00	2.00	0.00	0.76		0.50	0.50	0.00	0.19
2046		2.00	2.00	0.00	0.74		2.00	2.00	0.00	0.74		0.50	0.50	0.00	0.18
2047		2.00	2.00	0.00	0.71		2.00	2.00	0.00	0.71		0.50	0.50	0.00	0.18
2048		2.00	2.00	0.00	0.69		2.00	2.00	0.00	0.69		0.50	0.50	0.00	0.17
2049		2.00	2.00	0.00	0.67		2.00	2.00	0.00	0.67		0.50	0.50	0.00	0.17
2050	20.00	2.00	22.00	6.52	0.65	20.00	2.00	22.00	6.52	0.65	2.00	0.50	2.50	0.65	0.16
2051		2.00	2.00	0.00	0.63		2.00	2.00	0.00	0.63		0.50	0.50	0.00	0.16
2052		2.00	2.00	0.00	0.61		2.00	2.00	0.00	0.61		0.50	0.50	0.00	0.15
2053		2.00	2.00	0.00	0.60		2.00	2.00	0.00	0.60		0.50	0.50	0.00	0.15
2054		2.00	2.00	0.00	0.58		2.00	2.00	0.00	0.58		0.50	0.50	0.00	0.14
2055		2.00	2.00	0.00	0.56		2.00	2.00	0.00	0.56		0.50	0.50	0.00	0.14
2056		2.00	2.00	0.00	0.55		2.00	2.00	0.00	0.55		0.50	0.50	0.00	0.14
2057		2.00	2.00	0.00	0.53		2.00	2.00	0.00	0.53		0.50	0.50	0.00	0.13
2058		2.00	2.00	0.00	0.51		2.00	2.00	0.00	0.51		0.50	0.50	0.00	0.13
2059		2.00	2.00	0.00	0.50		2.00	2.00	0.00	0.50		0.50	0.50	0.00	0.12
2060	20.00	2.00	22.00	4.85	0.49	20.00	2.00	22.00	4.85	0.49	2.00	0.50	2.50	0.49	0.12
2061		2.00	2.00	0.00	0.47		2.00	2.00	0.00	0.47		0.50	0.50	0.00	0.12
2062		2.00	2.00	0.00	0.46		2.00	2.00	0.00	0.46		0.50	0.50	0.00	0.11
2063		2.00	2.00	0.00	0.44		2.00	2.00	0.00	0.44		0.50	0.50	0.00	0.11
2064		2.00	2.00	0.00	0.43		2.00	2.00	0.00	0.43		0.50	0.50	0.00	0.11
2065		2.00	2.00	0.00	0.42		2.00	2.00	0.00	0.42		0.50	0.50	0.00	0.10
2066		2.00	2.00	0.00	0.41		2.00	2.00	0.00	0.41		0.50	0.50	0.00	0.10
2067		2.00	2.00	0.00	0.39		2.00	2.00	0.00	0.39		0.50	0.50	0.00	0.10
2068		2.00	2.00	0.00	0.38		2.00	2.00	0.00	0.38		0.50	0.50	0.00	0.10
2069		2.00	2.00	0.00	0.37		2.00	2.00	0.00	0.37		0.50	0.50	0.00	0.09
2070	20.00	2.00	22.00	3.61	0.36	20.00	2.00	22.00	3.61	0.36	2.00	0.50	2.50	0.36	0.09
2071		2.00	2.00	0.00	0.35		2.00	2.00	0.00	0.35		0.50	0.50	0.00	0.09
2072		2.00	2.00	0.00	0.34		2.00	2.00	0.00	0.34		0.50	0.50	0.00	0.09
2073		2.00	2.00	0.00	0.33		2.00	2.00	0.00	0.33		0.50	0.50	0.00	0.08
2074		2.00	2.00	0.00	0.32		2.00	2.00	0.00	0.32		0.50	0.50	0.00	0.08
2075		2.00	2.00	0.00	0.31		2.00	2.00	0.00	0.31		0.50	0.50	0.00	0.08
2076		2.00	2.00	0.00	0.30		2.00	2.00	0.00	0.30		0.50	0.50	0.00	0.08
2077		2.00	2.00	0.00	0.29		2.00	2.00	0.00	0.29		0.50	0.50	0.00	0.07
2078		2.00	2.00	0.00	0.29		2.00	2.00	0.00	0.29		0.50	0.50	0.00	0.07
2079		2.00	2.00	0.00	0.28		2.00	2.00	0.00	0.28		0.50	0.50	0.00	0.07
2080	20.00	2.00	22.00	2.69	0.27	20.00	2.00	22.00	2.69	0.27	2.00	0.50	2.50	0.27	0.07
2081		2.00	2.00	0.00	0.26		2.00	2.00	0.00	0.26		0.50	0.50	0.00	0.07
2082		2.00	2.00	0.00	0.25		2.00	2.00	0.00	0.25		0.50	0.50	0.00	0.06
2083		2.00	2.00	0.00	0.25		2.00	2.00	0.00	0.25		0.50	0.50	0.00	0.06
2084		2.00	2.00	0.00	0.24		2.00	2.00	0.00	0.24		0.50	0.50	0.00	0.06
2085		2.00	2.00	0.00	0.23		2.00	2.00	0.00	0.23		0.50	0.50	0.00	0.06
2086		2.00	2.00	0.00	0.22		2.00	2.00	0.00	0.22		0.50	0.50	0.00	0.06
2087		2.00	2.00	0.00	0.22		2.00	2.00	0.00	0.22		0.50	0.50	0.00	0.05
2088		2.00	2.00	0.00	0.21		2.00	2.00	0.00	0.21		0.50	0.50	0.00	0.05
2089		2.00	2.00	0.00	0.21		2.00	2.00	0.00	0.21		0.50	0.50	0.00	0.05
2090	20.00	2.00	22.00	2.00	0.20	20.00	2.00	22.00	2.00	0.20	2.00	0.50	2.50	0.20	0.05
2091		2.00	2.00	0.00	0.19		2.00	2.00	0.00	0.19		0.50	0.50	0.00	0.05
2092		2.00	2.00	0.00	0.19		2.00	2.00	0.00	0.19		0.50	0.50	0.00	0.05
2093		2.00	2.00	0.00	0.18		2.00	2.00	0.00	0.18		0.50	0.50	0.00	0.05
2094		2.00	2.00	0.00	0.18		2.00	2.00	0.00	0.18		0.50	0.50	0.00	0.04
2095		2.00	2.00	0.00	0.17		2.00	2.00	0.00	0.17		0.50	0.50	0.00	0.04
2096		2.00	2.00	0.00	0.17		2.00	2.00	0.00	0.17		0.50	0.50	0.00	0.04
2097		2.00	2.00	0.00	0.17		2.00	2.00	0.00	0.17		0.50	0.50	0.00	0.04
2098		2.00	2.00	0.00	0.16		2.00	2.00	0.00	0.16		0.50	0.50	0.00	0.04
2099		2.00	2.00	0.00	0.16		2.00	2.00	0.00	0.16		0.50	0.50	0.00	0.04
2100	20.00	2.00	22.00	1.55	0.15	20.00	2.00	22.00	1.55	0.15	2.00	0.50	2.50	0.15	0.04
2101		2.00	2.00	0.00	0.15		2.00	2.00	0.00	0.15		0.50	0.50	0.00	0.04
2102		2.00	2.00	0.00	0.15		2.00	2.00	0.00	0.15		0.50	0.50	0.00	0.04
2103		2.00	2.00	0.00	0.14		2.00	2.00	0.00	0.14		0.50	0.50	0.00	0.04
2104		2.00	2.00	0.00	0.14		2.00	2.00	0.00	0.14		0.50	0.50	0.00	0.04
2105		2.00	2.00	0.00	0.14		2.00	2.00	0.00	0.14		0.50	0.50	0.00	0.03
2106		2.00	2.00	0.00	0.13		2.00	2.00	0.00	0.13		0.50	0.50	0.00	0.03
2107		2.00	2.00	0.00	0.13		2.00	2.00	0.00	0.13		0.50	0.50	0.00	0.03
2108		2.00	2.00	0.00	0.13		2.00	2.00	0.00	0.13		0.50	0.50	0.00	0.03
2109		2.00	2.00	0.00	0.12		2.00	2.00	0.00	0.12		0.50	0.50	0.00	0.03
2110	20.00	2.00	22.00	1.21	0.12	20.00	2.00	22.00	1.21	0.12	2.00	0.50	2.50	0.12	0.03
2111		2.00	2.00	0.00	0.12		2.00	2.00	0.00	0.12		0.50	0.50	0.00	0.03
2112		2.00	2.00	0.00	0.11		2.00	2.00	0.00	0.11		0.50	0.50	0.00	0.03
2113		2.00	2.00	0.00	0.11		2.00	2.00	0.00	0.11		0.50	0.50	0.00	0.03
2114		2.00	2.00	0.00	0.11		2.00	2.00	0.00	0.11		0.50	0.50	0.00	0.03
2115		2.00	2.00	0.00	0.11		2.00	2.00	0.00	0.11		0.50	0.50	0.00	0.03
2116		2.00	2.00	0.00	0.10		2.00	2.00	0.00	0.10		0.50	0.50	0.00	0.03

Calendar Year	Option 6 Capital	Option 6 Maint.	TOTALS: Cash	Capital Spend PV	Maintenance PV	Option 7 Capital	Option 7 Maint.	TOTALS: Cash	Capital Spend PV	Maintenance PV	Option 8 Capital	Option 8 Maint.	TOTALS: Cash	Capital Spend PV	Maintenance PV	Option 9 Capital	Option 9 Maint.	TOTALS: Cash	Capital Spend PV	Maintenance PV
cash sum	2416.00	192.00	2608.00	2070.43	52.02	2808.50	384.00	3192.50	2308.72	104.04	1056.80	576.00	1632.80	588.15	156.07	2841.60	1056.00	3897.60	2067.37	286.12
2017			0.00	0.00	0.00			0.00	0.00	0.00			0.00	0.00	0.00			0.00	0.00	0.00
2018	60.00		60.00	57.97	0.00	60.00		60.00	57.97	0.00	60.00		60.00	57.97	0.00	60.00		60.00	57.97	0.00
2019	176.00		176.00	164.30	0.00	250.50		250.50	233.84	0.00	162.00		162.00	151.23	0.00	302.80		302.80	282.67	0.00
2020	2000.00		2000.00	1803.89	0.00	2138.00		2138.00	1928.35	0.00	264.80		264.80	238.83	0.00	1708.80		1708.80	1541.24	0.00
2021		2.00	2.00	0.00	1.74		4.00	4.00	0.00	3.49	0	6.00	6.00	0.00	5.23	0.00	11.00	11.00	0.00	9.59
2022		2.00	2.00	0.00	1.68		4.00	4.00	0.00	3.37	0	6.00	6.00	0.00	5.05	0.00	11.00	11.00	0.00	9.26
2023		2.00	2.00	0.00	1.63		4.00	4.00	0.00	3.25	0	6.00	6.00	0.00	4.88	0.00	11.00	11.00	0.00	8.95
2024		2.00	2.00	0.00	1.57		4.00	4.00	0.00	3.14	0	6.00	6.00	0.00	4.72	0.00	11.00	11.00	0.00	8.65
2025		2.00	2.00	0.00	1.52		4.00	4.00	0.00	3.04	0	6.00	6.00	0.00	4.56	0.00	11.00	11.00	0.00	8.35
2026		2.00	2.00	0.00	1.47		4.00	4.00	0.00	2.93	0	6.00	6.00	0.00	4.40	0.00	11.00	11.00	0.00	8.07
2027		2.00	2.00	0.00	1.42		4.00	4.00	0.00	2.84	0	6.00	6.00	0.00	4.25	0.00	11.00	11.00	0.00	7.80
2028		2.00	2.00	0.00	1.37		4.00	4.00	0.00	2.74	0	6.00	6.00	0.00	4.11	0.00	11.00	11.00	0.00	7.53
2029		2.00	2.00	0.00	1.32		4.00	4.00	0.00	2.65	0	6.00	6.00	0.00	3.97	0.00	11.00	11.00	0.00	7.28
2030	20.00	2.00	22.00	12.79	1.28	40.00	4.00	44.00	25.58	2.56	60	6.00	66.00	38.36	3.84	60.00	11.00	71.00	38.36	7.03
2031		2.00	2.00	0.00	1.24		4.00	4.00	0.00	2.47	0	6.00	6.00	0.00	3.71	0.00	11.00	11.00	0.00	6.80
2032		2.00	2.00	0.00	1.19		4.00	4.00	0.00	2.39	0	6.00	6.00	0.00	3.58	0.00	11.00	11.00	0.00	6.57
2033		2.00	2.00	0.00	1.15		4.00	4.00	0.00	2.31	0	6.00	6.00	0.00	3.46	0.00	11.00	11.00	0.00	6.34
2034		2.00	2.00	0.00	1.11		4.00	4.00	0.00	2.23	0	6.00	6.00	0.00	3.34	0.00	11.00	11.00	0.00	6.13
2035		2.00	2.00	0.00	1.08		4.00	4.00	0.00	2.15	0	6.00	6.00	0.00	3.23	0.00	11.00	11.00	0.00	5.92
2036		2.00	2.00	0.00	1.04		4.00	4.00	0.00	2.08	0	6.00	6.00	0.00	3.12	0.00	11.00	11.00	0.00	5.72
2037		2.00	2.00	0.00	1.01		4.00	4.00	0.00	2.01	0	6.00	6.00	0.00	3.02	0.00	11.00	11.00	0.00	5.53
2038		2.00	2.00	0.00	0.97		4.00	4.00	0.00	1.94	0	6.00	6.00	0.00	2.91	0.00	11.00	11.00	0.00	5.34
2039		2.00	2.00	0.00	0.94		4.00	4.00	0.00	1.88	0	6.00	6.00	0.00	2.81	0.00	11.00	11.00	0.00	5.16
2040	20.00	2.00	22.00	9.07	0.91	40.00	4.00	44.00	18.13	1.81	60	6.00	66.00	27.20	2.72	110.00	11.00	121.00	49.86	4.99
2041		2.00	2.00	0.00	0.88		4.00	4.00	0.00	1.75	0	6.00	6.00	0.00	2.63	0.00	11.00	11.00	0.00	4.82
2042		2.00	2.00	0.00	0.85		4.00	4.00	0.00	1.69	0	6.00	6.00	0.00	2.54	0.00	11.00	11.00	0.00	4.65
2043		2.00	2.00	0.00	0.82		4.00	4.00	0.00	1.64	0	6.00	6.00	0.00	2.45	0.00	11.00	11.00	0.00	4.50
2044		2.00	2.00	0.00	0.79		4.00	4.00	0.00	1.58	0	6.00	6.00	0.00	2.37	0.00	11.00	11.00	0.00	4.35
2045		2.00	2.00	0.00	0.76		4.00	4.00	0.00	1.53	0	6.00	6.00	0.00	2.29	0.00	11.00	11.00	0.00	4.20
2046		2.00	2.00	0.00	0.74		4.00	4.00	0.00	1.47	0	6.00	6.00	0.00	2.21	0.00	11.00	11.00	0.00	4.06
2047		2.00	2.00	0.00	0.71		4.00	4.00	0.00	1.43	0	6.00	6.00	0.00	2.14	0.00	11.00	11.00	0.00	3.92
2048		2.00	2.00	0.00	0.69		4.00	4.00	0.00	1.38	0	6.00	6.00	0.00	2.08	0.00	11.00	11.00	0.00	3.80
2049		2.00	2.00	0.00	0.67		4.00	4.00	0.00	1.34	0	6.00	6.00	0.00	2.01	0.00	11.00	11.00	0.00	3.69
2050	20.00	2.00	22.00	6.52	0.65	40.00	4.00	44.00	13.04	1.30	60	6.00	66.00	19.56	1.96	60.00	11.00	71.00	19.56	3.59
2051		2.00	2.00	0.00	0.63		4.00	4.00	0.00	1.27	0	6.00	6.00	0.00	1.90	0.00	11.00	11.00	0.00	3.48
2052		2.00	2.00	0.00	0.61		4.00	4.00	0.00	1.23	0	6.00	6.00	0.00	1.84	0.00	11.00	11.00	0.00	3.38
2053		2.00	2.00	0.00	0.60		4.00	4.00	0.00	1.19	0	6.00	6.00	0.00	1.79	0.00	11.00	11.00	0.00	3.28
2054		2.00	2.00	0.00	0.58		4.00	4.00	0.00	1.16	0	6.00	6.00	0.00	1.74	0.00	11.00	11.00	0.00	3.19
2055		2.00	2.00	0.00	0.56		4.00	4.00	0.00	1.12	0	6.00	6.00	0.00	1.69	0.00	11.00	11.00	0.00	3.09
2056		2.00	2.00	0.00	0.55		4.00	4.00	0.00	1.09	0	6.00	6.00	0.00	1.64	0.00	11.00	11.00	0.00	3.00
2057		2.00	2.00	0.00	0.53		4.00	4.00	0.00	1.06	0	6.00	6.00	0.00	1.59	0.00	11.00	11.00	0.00	2.92
2058		2.00	2.00	0.00	0.51		4.00	4.00	0.00	1.03	0	6.00	6.00	0.00	1.54	0.00	11.00	11.00	0.00	2.83
2059		2.00	2.00	0.00	0.50		4.00	4.00	0.00	1.00	0	6.00	6.00	0.00	1.50	0.00	11.00	11.00	0.00	2.75
2060	20.00	2.00	22.00	4.85	0.49	40.00	4.00	44.00	9.70	0.97	90	6.00	96.00	21.83	1.46	140.00	11.00	151.00	33.97	2.67
2061		2.00	2.00	0.00	0.47		4.00	4.00	0.00	0.94	0	6.00	6.00	0.00	1.41	0.00	11.00	11.00	0.00	2.59
2062		2.00	2.00	0.00	0.46		4.00	4.00	0.00	0.91	0	6.00	6.00	0.00	1.37	0.00	11.00	11.00	0.00	2.52
2063		2.00	2.00	0.00	0.44		4.00	4.00	0.00	0.89	0	6.00	6.00	0.00	1.33	0.00	11.00	11.00	0.00	2.44
2064		2.00	2.00	0.00	0.43		4.00	4.00	0.00	0.86	0	6.00	6.00	0.00	1.29	0.00	11.00	11.00	0.00	2.37
2065		2.00	2.00	0.00	0.42		4.00	4.00	0.00	0.84	0	6.00	6.00	0.00	1.26	0.00	11.00	11.00	0.00	2.30
2066		2.00	2.00	0.00	0.41		4.00	4.00	0.00	0.81	0	6.00	6.00	0.00	1.22	0.00	11.00	11.00	0.00	2.23
2067		2.00	2.00	0.00	0.39		4.00	4.00	0.00	0.79	0	6.00	6.00	0.00	1.18	0.00	11.00	11.00	0.00	2.17
2068		2.00	2.00	0.00	0.38		4.00	4.00	0.00	0.77	0	6.00	6.00	0.00	1.15	0.00	11.00	11.00	0.00	2.11
2069		2.00	2.00	0.00	0.37		4.00	4.00	0.00	0.74	0	6.00	6.00	0.00	1.12	0.00	11.00	11.00	0.00	2.05
2070	20.00	2.00	22.00	3.61	0.36	40.00	4.00	44.00	7.22	0.72	60	6.00	66.00	10.83	1.08	60.00	11.00	71.00	10.83	1.99
2071		2.00	2.00	0.00	0.35		4.00	4.00	0.00	0.70	0	6.00	6.00	0.00	1.05	0.00	11.00	11.00	0.00	1.93
2072		2.00	2.00	0.00	0.34		4.00	4.00	0.00	0.68	0	6.00	6.00	0.00	1.02	0.00	11.00	11.00	0.00	1.87
2073		2.00	2.00	0.00	0.33		4.00	4.00	0.00	0.66	0	6.00	6.00	0.00	0.99	0.00	11.00	11.00	0.00	1.82
2074		2.00	2.00	0.00	0.32		4.00	4.00	0.00	0.64	0	6.00	6.00	0.00	0.96	0.00	11.00	11.00	0.00	1.76
2075		2.00	2.00	0.00	0.31		4.00	4.00	0.00	0.62	0	6.00	6.00	0.00	0.93	0.00	11.00	11.00	0.00	1.71
2076		2.00	2.00	0.00	0.30		4.00	4.00	0.00	0.60	0	6.00	6.00	0.00	0.91	0.00	11.00	11.00	0.00	1.66
2077		2.00	2.00	0.00	0.29		4.00	4.00	0.00	0.59	0	6.00	6.00	0.00	0.88	0.00	11.00	11.00	0.00	1.61
2078		2.00	2.00	0.00	0.29		4.00	4.00	0.00	0.57	0	6.00	6.00	0.00	0.86	0.00	11.00	11.00	0.00	1.57
2079		2.00	2.00	0.00	0.28		4.00	4.00	0.00	0.55	0	6.00	6.00	0.00	0.83	0.00	11.00	11.00	0.00	1.52
2080	20.00	2.00	22.00	2.69	0.27	40.00	4.00	44.00	5.37	0.54	60	6.00	66.00	8.06	0.81	110.00	11.00	121.00	14.78	1.48
2081		2.00	2.00	0.00	0.26		4.00	4.00	0.00	0.52	0	6.00	6.00	0.00	0.78	0.00	11.00	11.00	0.00	1.43
2082		2.00	2.00	0.00	0.25		4.00	4.00	0.00	0.51	0	6.00	6.00	0.00	0.76	0.00	11.00	11.00	0.00	1.39
2083		2.00	2.00	0.00	0.25		4.00	4.00	0.00	0.49	0	6.00	6.00	0.00	0.74	0.00	11.00	11.00	0.00	1.35
2084		2.00	2.00	0.00	0.24		4.00	4.00	0.00	0.48	0	6.00	6.00	0.00	0.72	0.00	11.00	11.00	0.00	1.31
2085		2.00	2.00	0.00	0.23		4.00	4.00	0.00	0.46	0	6.00	6.00	0.00	0.70	0.00	11.00	11.00	0.00	1.27
2086		2.00	2.00	0.00	0.22		4.00	4.00	0.00	0.45	0	6.00	6.00	0.00	0.67	0.00	11.00	11.00	0.00	1.24
2087		2.00	2.00	0.00	0.22		4.00	4.00	0.00	0.44	0	6.00	6.00	0.00	0.66	0.00	11.00	11.00	0.00	1.20
2088		2.00	2.00	0.00	0.21		4.00	4.00	0.00	0.42	0	6.00	6.00	0.00	0.64	0.00	11.00	11.00	0.00	1.17
2089		2.00	2.00	0.00	0.21		4.00	4.00	0.00	0.41	0	6.00	6.00	0.00	0.62	0.00	11.00	11.00	0.00	1.13
2090	20.00	2.00	22.00	2.00	0.20	40.00	4.00	44.00	4.00	0.40	60	6.00	66.00	6.00	0.60	60.00	11.00	71.00	6.00	1.10
2091		2.00	2.00	0.00	0.19		4.00	4.00	0.00	0.39	0	6.00	6.00	0.00	0.58	0.00	11.00	11.00	0.00	1.07
2092		2.00	2.00	0.00	0.19		4.00	4.00	0.00	0.38	0	6.00	6.00	0.00	0.57	0.00	11.00	11.00	0.00	1.04
2093		2.00	2.00	0.00	0.18		4.00	4.00	0.00	0.37	0	6.00	6.00	0.00	0.55	0.00	11.00	11.00	0.00	1.01
2094		2.00	2.00	0.00	0.18		4.00	4.00	0.00	0.36	0	6.00	6.00	0.00	0.54	0.00	11.00	11.00	0.00	0.99
2095		2.00	2.00	0.00	0.17		4.00	4.00	0.00	0.35	0	6.00	6.00	0.00	0.52	0.00	11.00	11.00	0.00	0.96
2096		2.00	2.00	0.00	0.17		4.00	4.00	0.00	0.34	0	6.00	6.00	0.00	0.51	0.00	11.00	11.00	0.00	0.94
2097		2.00	2.00	0.00	0.17		4.00	4.00	0.00	0.33	0	6.00	6.00	0.00	0.50	0.00	11.00	11.00	0.00	0.92
2098		2.00	2.00	0.00	0.16		4.00	4.00	0.00	0.32	0	6.00	6.00	0.00	0.49	0.00	11.00	11.00	0.00	0.89
2099		2.00	2.00	0.00	0.16		4.00	4.00	0.00	0.32	0	6.00	6.00	0.00	0.48	0.00	11.00	11.00	0.00	0.87
2100	20.00	2.00	22.00	1.55	0.15	40.00	4.00	44.00	3.09	0.31	60	6.00	66.00	4.64	0.46	110.00	11.00	121.00	8.51	0.85
2101		2.00	2.00	0.00	0.15		4.00	4.00	0.00	0.30	0	6.00	6.00	0.00	0.45	0.00	11.00	11.00	0.00	0.83
2102		2.00	2.00	0.00	0.15		4.00	4.00	0.00	0.29	0	6.00	6.00	0.00	0.44	0.00	11.00	11.00	0.00	0.81
2103		2.00	2.00	0.00	0.14		4.00	4.00	0.00	0.29	0	6.00	6.00	0.00	0.43	0.00	11.00	11.00	0.00	0.79
2104		2.00	2.00	0.00	0.14		4.00	4.00	0.00	0.28	0	6.00	6.00	0.00	0.42	0.00	11.00	11.00	0.00	0.77
2105		2.00	2.00	0.00	0.14		4.00	4.00	0.00	0.27	0	6.00	6.00	0.00	0.41	0.00	11.00	11.00	0.00	0.75
2106		2.00	2.00	0.00	0.13		4.00	4.00	0.00	0.27	0	6.00	6.00	0.00	0.40	0.00	11.00	11.00	0.00	0.73
2107		2.00	2.00	0.00	0.13		4.00	4.00	0.00	0.26	0	6.00	6.00	0.00	0.39	0.00	11.00	11.00	0.00	0.72
2108		2.00	2.00	0.00	0.13		4.00	4.00	0.00	0.25	0	6.00	6.00	0.00	0.38	0.00	11.00	11.00	0.00	0.70
2109		2.00	2.00	0.00	0.12		4.00	4.00	0.00	0.25	0	6.00	6.00	0.00	0.37	0.00	11.00	11.00	0.00	0.68
2110	20.00	2.00	22.00	1.21	0.12	40.00	4.00	44.00	2.42	0.24	60	6.00	66.00	3.62	0.36	60.00	11.00	71.00	3.62	0.66
2111		2.00	2.00	0.00	0.12		4.00	4.00	0.00	0.24	0	6.00	6.00	0.00	0.35	0.00	11.00	11.00	0.00	0.65
2112		2.00	2.00	0.00	0.11		4.00	4.00	0.00	0.23	0	6.00	6.00	0.00	0.34	0.00	11.00	11.00	0.00	0.63
2113		2.00	2.00	0.00	0.11		4.00	4.00	0.00	0.22	0	6.00	6.00	0.00	0.34	0.00	11.00	11.00	0.00	0.62
2114		2.00	2.00	0.00	0.11		4.00	4.00	0.00	0.22	0	6.00	6.00	0.00	0.33	0.00	11.00	11.00	0.00	0.60
2115		2.00	2.00	0.00	0.11		4.00	4.00	0.00	0.21	0	6.00	6.00	0.00	0.32	0.00	11.00	11.00	0.00	0.59
2116		2.00	2.00	0.00	0.10		4.00	4.00	0.00	0.21	0	6.00	6.00	0.00	0.31	0.00	11.00	11.00	0.00	0.57

Appendix D: Partnership funding calculator

FCRM Partnership Funding Calculator for Flood and Coastal Erosion Risk Management Grant in Aid (FCRM GiA)
Version 8 January 2014

Project Name	Caterham-on-the-Hill Flood Alleviation Scheme: Option 1 - flood storage at Queen's Park recreation ground
Unique Project Number	

All figures are in £'s
Figures in Blue to be entered onto Medium Term Plan

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Key Input cells / Calculated cells

SUMMARY: prospect of FCRM GiA funding

		Scheme Benefit to Cost Ratio:	**4.90** to 1
		Effective return to taxpayer:	**4.90** to 1
Raw Partnership Funding Score	**39%** (1)	*Effective return on contributions:*	**n/a** to 1
External Contribution or saving required to achieve an Adjusted Score of 100%	**198,465** (2)		
Adjusted Partnership Funding Score (PF)	**39%** (3)		
PV FCERM GiA towards the up-front costs of this scheme (PV Cost for Approval)	**-** (4)		

Cell (2) shows the minimum amount of contributions and/or reductions in scheme cost that are required to raise the Adjusted PF Score to at least 100%. Further increases on this will improve this scheme's chances of an FCRM GiA allocation in the desired year. Planned savings and contributions should be entered into cells(9,10,12) and cells(14-17). See NOTE below.

1. Scheme details

Risk Management Authority type of asset maintainer	**LA** (5)	**Yes** (6)	Is evidence available that a Strategic Approach has been taken, and that double counting of benefits has been avoided ?
Duration of Benefits (years)	**100** (7)		
PV Whole-Life Benefits:	**2,411,939** (8)		

All costs and benefits must be on a Present Value (PV) Whole-Life basis over the Duration of Benefits period. Where Contributions are identified these should also be on a Present Value basis.

PV Costs	
PV Appraisal Costs	92,754 (9)
PV design & Construction Costs	234,130 (10)
Sub Total - PV Cost for Approval (appraisal,design,construction)	**326,884** (11)
PV Post-Construction Costs	165,724 (12)
PV Whole-Life Costs:	**492,608** (13)

The total value of any necessary contributions will depend on whether maintenance (ongoing costs) is funded through revenue FCRM GiA, or by other means.

NOTE: This scheme is to be maintained by an RMA other than the EA (ref cell 5). Capital FCRM GiA will fund the appropriate share of the up-front costs (cell 11) with any shortfall needing to be paid for via contributions identified in cells(14-17). Future ongoing costs (cell 12) and any contriubutions towards them are a matter for local agreement by the RMA and should NOT be included in cells(14-17). It is recommended that the RMA takes the opportunities created during scheme development to separately secure contributions towards future ongoing costs (cell12).

PV Contributions secured to date		
PV Local Levy secured to date		(14)
PV Public Contributions secured to date		(15)
PV Private Contributions secured to date		(16)
PV Funding form other Environment Agency functions/sources secured to date		(17)
PV Total Contributions secured to date	0	(18)
WARNING: Contributions less than minimum required in cell (2)		

2. Qualifying benefits under Outcome Measure 2: households better protected against flood risk

Number of households in:	Before			After			Change due to scheme		
20% most deprived areas	-	-	-	-	-	-	0	0	0
21-40% most deprived areas	-	-	-	-	-	-	0	0	0
60% least deprived areas	81	71	186	81	75	174	0	4	-12
At:	Moderate risk	Significant risk	Very significant risk	Moderate risk	Significant risk	Very significant risk	Moderate risk	Significant risk	Very significant risk
Annual damages avoided (£), compared with a household at low risk							150	600	1,350

Change in household damages, in:	Per year	Over lifetime of scheme	**Qual. benefits (discounted)**
20% most deprived areas	£ -	£ -	**OM2 (20%)** £ -
21-40% most deprived areas	£ -	£ -	**OM2 (21-40%)** £ -
60% least deprived areas	-£ 13,800	-£ 1,380,000	**OM2 (60%)** £ 412,114

3. Qualifying benefits under Outcome Measure 3: households better protected against coastal erosion

Number of households in:	Before		Damages per household avoided:			
20% most deprived areas			Annual damages avoided	£ 6,000	£ 6,000	
21-40% most deprived areas			Loss expected in	50	20	years
60% least deprived areas			Present value of Year 1 loss (i.e. first year damages, discounted based on when loss is expected)	£ 1,184	£ 3,015	
	Long-term loss	Medium-term loss		Long-term loss	Medium-term loss	

Change in household damages, in:	Year 1 loss avoided:	Over lifetime of scheme:	**Qual. benefits (discounted):**
20% most deprived areas	£ -	£ -	**OM3 (20%)** **£ -**
21-40% most deprived areas	£ -	£ -	**OM3 (21-40%)** **£ -**
60% least deprived areas	£ -	£ -	**OM3 (60%)** **£ -**

4. Qualifying benefits under Outcome Measure 4: statutory environmental obligations met

Payments under:		Assumed benefits per unit:	**Qual. benefits (discounted):**
OM4a	Hectares of net water-dependent habitat created	£ 15,000	OM4a £ -
OM4b	Hectares of net intertidal habitat created	£ 50,000	OM4b £ -
OM4c	Kilometres of protected river improved	£ 80,000	OM4c £ -
			OM4 **£ -**

5. Qualifying benefits arising from the overall scheme, for entry into the Medium-Term Plan

OM, deprivation:		Qual. benefits:	Payment rate:	FCRM GiA contribution:
OM1		£ 1,999,824	5.56 p in the £1	£ 111,101
OM2	20% most	£ -	45.0	£ -
	21-40%	£ -	30.0	£ -
	Least 60%	£ 412,114	20.0	£ 82,423
OM3	20% most	£ -	45.0	£ -
	21-40%	£ -	30.0	£ -
	Least 60%	£ -	20.0	£ -
OM4		£ -	100.0	£ -
Total		£ 2,411,939		**£ 193,524**

Maximum for Outcomes delivered. The actual value any scheme is elligible for may be less.

Sensitivity Testing. *It is important that users of this calculator appreciate the implications on funding from changes to input data which may become necessary as the project develops and better information is available. Five typical tests are provided below. Users should consider how appropriate these are to their project, what other tests may be appropriate and how best to use the information with all those that may be involved in the project.*

	Raw Score	Contribution for 100% Score (£k)
As scenario above	39%	198,465
Sensitivity 1 - Change in PV Whole Life Cost (25% increase)	14%	350,816
Sensitivity 2 - Change in OM2 - 50% of households in Very Significant (Before) risk may already be in Significant Risk band	-22%	398,118
Sensitivity 3 - Change in OM3 - 50% of households in Medium Term loss (Before) may already be in Long Term loss	39%	198,465
Sensitivity 4 - Increase Duration of Benefits by 25%	#N/A	#N/A
Sensitivity 5 - Reduce Duration of Benefits by 25%	39%	200,761

FCRM Partnership Funding Calculator for Flood and Coastal Erosion Risk Management Grant in Aid (FCRM GiA)
Version 8 January 2014

Project Name Caterham-on-the-Hill Flood Alleviation Scheme: Option 3 - Series of two flood storage areas on Coulsdon Common (western)
Unique Project Number

Key Input cells / Calculated cells

All figures are in £'s
Figures in Blue to be entered onto Medium Term Plan

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SUMMARY: prospect of FCRM GiA funding

		Scheme Benefit to Cost Ratio:	**1.52** to 1
		Effective return to taxpayer:	**1.52** to 1
Raw Partnership Funding Score	**14%** (1)	*Effective return on contributions:*	**n/a** to 1
External Contribution or saving required to achieve an Adjusted Score of 100%	**282,513** (2)		
Adjusted Partnership Funding Score (PF)	**14%** (3)		
PV FCERM GiA towards the up-front costs of this scheme (PV Cost for Approval)	**-** (4)		

Cell (2) shows the minimum amount of contributions and/or reductions in scheme cost that are required to raise the Adjusted PF Score to at least 100%. Further increases on this will improve this scheme's chances of an FCRM GiA allocation in the desired year. Planned savings and contributions should be entered into cells(9,10,12) and cells(14-17). See NOTE below.

1. Scheme details

Risk Management Authority type of asset maintainer	**LA** (5)	**Yes** (6)
Duration of Benefits (years)	**100** (7)	
PV Whole-Life Benefits:	**734,123** (8)	

Is evidence available that a Strategic Approach has been taken, and that double counting of benefits has been avoided ?

All costs and benefits must be on a Present Value (PV) Whole-Life basis over the Duration of Benefits period. Where Contributions are identified these should also be on a Present Value basis.

PV Costs	
PV Appraisal Costs	92,754 (9)
PV design & Construction Costs	235,573 (10)
Sub Total - PV Cost for Approval (appraisal,design,construction)	**328,327** (11)
PV Post-Construction Costs	154,079 (12)
PV Whole-Life Costs:	**482,406** (13)

The total value of any necessary contributions will depend on whether maintenance (ongoing costs) is funded through revenue FCRM GiA, or by other means.

NOTE: This scheme is to be maintained by an RMA other than the EA (ref cell 5). Capital FCRM GiA will fund the appropriate share of the up-front costs (cell 11) with any shortfall needing to be paid for via contributions identified in cells(14-17). Future ongoing costs (cell 12) and any contriubutions towards them are a matter for local agreement by the RMA and should NOT be included in cells(14-17). It is recommended that the RMA takes the opportunities created during scheme development to separately secure contributions towards future ongoing costs (cell12).

PV Contributions secured to date		
PV Local Levy secured to date		(14)
PV Public Contributions secured to date		(15)
PV Private Contributions secured to date		(16)
PV Funding form other Environment Agency functions/sources secured to date		(17)
PV Total Contributions secured to date	0	(18)

WARNING: Contributions less than minimum required in cell (2)

2. Qualifying benefits under Outcome Measure 2: households better protected against flood risk

Number of households in:	Before			After			Change due to scheme		
20% most deprived areas	-	-	-	-	-	-	0	0	0
21-40% most deprived areas	-	-	-	-	-	-	0	0	0
60% least deprived areas	81	71	186	78	75	180	-3	4	-6
At:	Moderate risk	Significant risk	Very significant risk	Moderate risk	Significant risk	Very significant risk	Moderate risk	Significant risk	Very significant risk
Annual damages avoided (£), compared with a household at low risk							150	600	1,350

Change in household damages, in:	Per year	Over lifetime of scheme	Qual. benefits (discounted)
20% most deprived areas	£ -	£ -	**OM2 (20%)** £ -
21-40% most deprived areas	£ -	£ -	**OM2 (21-40%)** £ -
60% least deprived areas	-£ 6,150	-£ 615,000	**OM2 (60%)** £ 183,660

3. Qualifying benefits under Outcome Measure 3: households better protected against coastal erosion

Number of households in:	Before		Damages per household avoided:		
20% most deprived areas			Annual damages avoided	£ 6,000	£ 6,000
21-40% most deprived areas			Loss expected in	50	20 years
60% least deprived areas			Present value of Year 1 loss (i.e. first year damages, discounted based on when loss is expected)	£ 1,184	£ 3,015
	Long-term loss	Medium-term loss		Long-term loss	Medium-term loss

Change in household damages, in:	Year 1 loss avoided:	Over lifetime of scheme:	Qual. benefits (discounted):
20% most deprived areas	£ -	£ -	**OM3 (20%)** **£ -**
21-40% most deprived areas	£ -	£ -	**OM3 (21-40%)** **£ -**
60% least deprived areas	£ -	£ -	**OM3 (60%)** **£ -**

4. Qualifying benefits under Outcome Measure 4: statutory environmental obligations met

Payments under:			Assumed benefits per unit:	Qual. benefits (discounted):
OM4a		Hectares of net water-dependent habitat created	£ 15,000	OM4a £ -
OM4b		Hectares of net intertidal habitat created	£ 50,000	OM4b £ -
OM4c		Kilometres of protected river improved	£ 80,000	OM4c £ -
				OM4 **£ -**

5. Qualifying benefits arising from the overall scheme, for entry into the Medium-Term Plan

OM, deprivation:		Qual. benefits:	Payment rate:		FCRM GiA contribution:
OM1		£ 550,463	5.56	p in the £1	£ 30,581
OM2	20% most	£ -	45.0		£ -
	21-40%	£ -	30.0		£ -
	Least 60%	£ 183,660	20.0		£ 36,732
OM3	20% most	£ -	45.0		£ -
	21-40%	£ -	30.0		£ -
	Least 60%	£ -	20.0		£ -
OM4		£ -	100.0		£ -
Total		£ 734,123			**£ 67,313**

Maximum for Outcomes delivered. The actual value any scheme is elligible for may be less.

Sensitivity Testing. *It is important that users of this calculator appreciate the implications on funding from changes to input data which may become necessary as the project develops and better information is available. Five typical tests are provided below. Users should consider how appropriate these are to their project, what other tests may be appropriate and how best to use the information with all those that may be involved in the project.*

	Raw Score	Contribution for 100% Score (£k)
As scenario above	14%	282,513
Sensitivity 1 - Change in PV Whole Life Cost (25% increase)	5%	389,792
Sensitivity 2 - Change in OM2 - 50% of households in Very Significant (Before) risk may already be in Significant Risk band	-48%	487,288
Sensitivity 3 - Change in OM3 - 50% of households in Medium Term loss (Before) may already be in Long Term loss	14%	282,513
Sensitivity 4 - Increase Duration of Benefits by 25%	#N/A	#N/A
Sensitivity 5 - Reduce Duration of Benefits by 25%	14%	283,563

FCRM Partnership Funding Calculator for Flood and Coastal Erosion Risk Management Grant in Aid (FCRM GiA)
Version 8 January 2014

Project Name Caterham-on-the-Hill Flood Alleviation Scheme: Option 4 - Series of three flood storage areas on Coulsdon Common (eastern)
Unique Project Number

Key Input cells / Calculated cells

All figures are in £'s
Figures in Blue to be entered onto Medium Term Plan

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SUMMARY: prospect of FCRM GiA funding

		Scheme Benefit to Cost Ratio:	**3.99** to 1
		Effective return to taxpayer:	**3.99** to 1
Raw Partnership Funding Score	**33%** (1)	*Effective return on contributions:*	**n/a** to 1
External Contribution or saving required to achieve an Adjusted Score of 100%	**268,908** (2)		
Adjusted Partnership Funding Score (PF)	**33%** (3)		
PV FCERM GiA towards the up-front costs of this scheme (PV Cost for Approval)	**-** (4)		

Cell (2) shows the minimum amount of contributions and/or reductions in scheme cost that are required to raise the Adjusted PF Score to at least 100%. Further increases on this will improve this scheme's chances of an FCRM GiA allocation in the desired year. Planned savings and contributions should be entered into cells(9,10,12) and cells(14-17). See NOTE below.

1. Scheme details

Risk Management Authority type of asset maintainer	**LA** (5)	**Yes** (6)
Duration of Benefits (years)	**100** (7)	
PV Whole-Life Benefits:	**2,222,387** (8)	

Is evidence available that a Strategic Approach has been taken, and that double counting of benefits has been avoided ?

All costs and benefits must be on a Present Value (PV) Whole-Life basis over the Duration of Benefits period. Where Contributions are identified these should also be on a Present Value basis.

PV Costs	
PV Appraisal Costs	92,754 (9)
PV design & Construction Costs	310,423 (10)
Sub Total - PV Cost for Approval (appraisal,design,construction)	**403,177** (11)
PV Post-Construction Costs	154,079 (12)
PV Whole-Life Costs:	**557,256** (13)

The total value of any necessary contributions will depend on whether maintenance (ongoing costs) is funded through revenue FCRM GiA, or by other means.

NOTE: This scheme is to be maintained by an RMA other than the EA (ref cell 5). Capital FCRM GiA will fund the appropriate share of the up-front costs (cell 11) with any shortfall needing to be paid for via contributions identified in cells(14-17). Future ongoing costs (cell 12) and any contriubutions towards them are a matter for local agreement by the RMA and should NOT be included in cells(14-17). It is recommended that the RMA takes the opportunities created during scheme development to separately secure contributions towards future ongoing costs (cell12).

PV Contributions secured to date		
PV Local Levy secured to date		(14)
PV Public Contributions secured to date		(15)
PV Private Contributions secured to date		(16)
PV Funding form other Environment Agency functions/sources secured to date		(17)
PV Total Contributions secured to date	0	(18)

WARNING: Contributions less than minimum required in cell (2)

2. Qualifying benefits under Outcome Measure 2: households better protected against flood risk

Number of households in:	Before			After			Change due to scheme		
20% most deprived areas	-	-	-	-	-	-	0	0	0
21-40% most deprived areas	-	-	-	-	-	-	0	0	0
60% least deprived areas	81	71	186	81	74	174	0	3	-12
At:	Moderate risk	Significant risk	Very significant risk	Moderate risk	Significant risk	Very significant risk	Moderate risk	Significant risk	Very significant risk
Annual damages avoided (£), compared with a household at low risk							150	600	1,350

Change in household damages, in:	Per year	Over lifetime of scheme	Qual. benefits (discounted)
20% most deprived areas	£ -	£ -	**OM2 (20%)** £ -
21-40% most deprived areas	£ -	£ -	**OM2 (21-40%)** £ -
60% least deprived areas	-£ 14,400	-£ 1,440,000	**OM2 (60%)** £ 430,032

3. Qualifying benefits under Outcome Measure 3: households better protected against coastal erosion

Number of households in:	Before		Damages per household avoided:		
20% most deprived areas			Annual damages avoided	£ 6,000	£ 6,000
21-40% most deprived areas			Loss expected in	50	20 years
60% least deprived areas			Present value of Year 1 loss (i.e. first year damages, discounted based on when loss is expected)	£ 1,184	£ 3,015
	Long-term loss	Medium-term loss		Long-term loss	Medium-term loss

Change in household damages, in:	Year 1 loss avoided:	Over lifetime of scheme:	Qual. benefits (discounted):
20% most deprived areas	£ -	£ -	**OM3 (20%)** **£ -**
21-40% most deprived areas	£ -	£ -	**OM3 (21-40%)** **£ -**
60% least deprived areas	£ -	£ -	**OM3 (60%)** **£ -**

4. Qualifying benefits under Outcome Measure 4: statutory environmental obligations met

Payments under:			Assumed benefits per unit:	Qual. benefits (discounted):
OM4a		Hectares of net water-dependent habitat created	£ 15,000	OM4a £ -
OM4b		Hectares of net intertidal habitat created	£ 50,000	OM4b £ -
OM4c		Kilometres of protected river improved	£ 80,000	OM4c £ -
				OM4 **£ -**

5. Qualifying benefits arising from the overall scheme, for entry into the Medium-Term Plan

OM, deprivation:		Qual. benefits:	Payment rate:		FCRM GiA contribution:
OM1		£ 1,792,355	5.56	p in the £1	£ 99,575
OM2	20% most	£ -	45.0		£ -
	21-40%	£ -	30.0		£ -
	Least 60%	£ 430,032	20.0		£ 86,006
OM3	20% most	£ -	45.0		£ -
	21-40%	£ -	30.0		£ -
	Least 60%	£ -	20.0		£ -
OM4		£ -	100.0		£ -
Total		£ 2,222,387			**£ 185,582**

Maximum for Outcomes delivered. The actual value any scheme is elligible for may be less.

Sensitivity Testing. *It is important that users of this calculator appreciate the implications on funding from changes to input data which may become necessary as the project develops and better information is available. Five typical tests are provided below. Users should consider how appropriate these are to their project, what other tests may be appropriate and how best to use the information with all those that may be involved in the project.*

	Raw Score	Contribution for 100% Score (£k)
As scenario above	33%	268,908
Sensitivity 1 - Change in PV Whole Life Cost (25% increase)	12%	443,550
Sensitivity 2 - Change in OM2 - 50% of households in Very Significant (Before) risk may already be in Significant Risk band	-21%	486,591
Sensitivity 3 - Change in OM3 - 50% of households in Medium Term loss (Before) may already be in Long Term loss	33%	268,908
Sensitivity 4 - Increase Duration of Benefits by 25%	#N/A	#N/A
Sensitivity 5 - Reduce Duration of Benefits by 25%	33%	271,520

FCRM Partnership Funding Calculator for Flood and Coastal Erosion Risk Management Grant in Aid (FCRM GiA)
Version 8 January 2014

Project Name	Caterham-on-the-Hill Flood Alleviation Scheme: Option 8 - Combination of Option 1, 3 and 4
Unique Project Number	

Key Input cells / Calculated cells

All figures are in £'s
Figures in Blue to be entered onto Medium Term Plan

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SUMMARY: prospect of FCRM GiA funding

		Scheme Benefit to Cost Ratio:	**4.23** to 1
		Effective return to taxpayer:	**4.23** to 1
Raw Partnership Funding Score	**26%** (1)	*Effective return on contributions:*	**n/a** to 1
External Contribution or saving required to achieve an Adjusted Score of 100%	**529,360** (2)		
Adjusted Partnership Funding Score (PF)	**26%** (3)		
PV FCERM GiA towards the up-front costs of this scheme (PV Cost for Approval)	**-** (4)		

Cell (2) shows the minimum amount of contributions and/or reductions in scheme cost that are required to raise the Adjusted PF Score to at least 100%. Further increases on this will improve this scheme's chances of an FCRM GiA allocation in the desired year. Planned savings and contributions should be entered into cells(9,10,12) and cells(14-17). See NOTE below.

1. Scheme details

Risk Management Authority type of asset maintainer	**LA** (5)	**Yes** (6)
Duration of Benefits (years)	**100** (7)	
PV Whole-Life Benefits:	**5,035,223** (8)	

Is evidence available that a Strategic Approach has been taken, and that double counting of benefits has been avoided ?

All costs and benefits must be on a Present Value (PV) Whole-Life basis over the Duration of Benefits period. Where Contributions are identified these should also be on a Present Value basis.

PV Costs	
PV Appraisal Costs	92,754 (9)
PV design & Construction Costs	624,101 (10)
Sub Total - PV Cost for Approval (appraisal,design,construction)	**716,855** (11)
PV Post-Construction Costs	473,882 (12)
PV Whole-Life Costs:	**1,190,737** (13)

The total value of any necessary contributions will depend on whether maintenance (ongoing costs) is funded through revenue FCRM GiA, or by other means.

PV Contributions secured to date	
PV Local Levy secured to date	(14)
PV Public Contributions secured to date	(15)
PV Private Contributions secured to date	(16)
PV Funding form other Environment Agency functions/sources secured to date	(17)
PV Total Contributions secured to date	0 (18)
WARNING: Contributions less than minimum required in cell (2)	

NOTE: This scheme is to be maintained by an RMA other than the EA (ref cell 5). Capital FCRM GiA will fund the appropriate share of the up-front costs (cell 11) with any shortfall needing to be paid for via contributions identified in cells(14-17). Future ongoing costs (cell 12) and any contriubutions towards them are a matter for local agreement by the RMA and should NOT be included in cells(14-17). It is recommended that the RMA takes the opportunities created during scheme development to separately secure contributions towards future ongoing costs (cell12).

2. Qualifying benefits under Outcome Measure 2: households better protected against flood risk

Number of households in:	Before			After			Change due to scheme		
20% most deprived areas	-	-	-	-	-	-	0	0	0
21-40% most deprived areas	-	-	-	-	-	-	0	0	0
60% least deprived areas	81	71	169	78	82	159	-3	11	-10
At:	Moderate risk	Significant risk	Very significant risk	Moderate risk	Significant risk	Very significant risk	Moderate risk	Significant risk	Very significant risk
Annual damages avoided (£), compared with a household at low risk							150	600	1,350

Change in household damages, in:	Per year	Over lifetime of scheme	Qual. benefits (discounted)
20% most deprived areas	£ -	£ -	**OM2 (20%)** £ -
21-40% most deprived areas	£ -	£ -	**OM2 (21-40%)** £ -
60% least deprived areas	-£ 7,350	-£ 735,000	**OM2 (60%)** £ 219,496

3. Qualifying benefits under Outcome Measure 3: households better protected against coastal erosion

Number of households in:	Before	
20% most deprived areas		
21-40% most deprived areas		
60% least deprived areas		
	Long-term loss	Medium-term loss

Damages per household avoided:		
Annual damages avoided	£ 6,000	£ 6,000
Loss expected in	50	20 years
Present value of Year 1 loss (i.e. first year damages, discounted based on when loss is expected)	£ 1,184	£ 3,015
	Long-term loss	Medium-term loss

Change in household damages, in:	Year 1 loss avoided:	Over lifetime of scheme:	Qual. benefits (discounted):
20% most deprived areas	£ -	£ -	**OM3 (20%)** **£ -**
21-40% most deprived areas	£ -	£ -	**OM3 (21-40%)** **£ -**
60% least deprived areas	£ -	£ -	**OM3 (60%)** **£ -**

4. Qualifying benefits under Outcome Measure 4: statutory environmental obligations met

Payments under:		Assumed benefits per unit:	Qual. benefits (discounted):
OM4a	Hectares of net water-dependent habitat created	£ 15,000	OM4a £ -
OM4b	Hectares of net intertidal habitat created	£ 50,000	OM4b £ -
OM4c	Kilometres of protected river improved	£ 80,000	OM4c £ -
			OM4 **£ -**

5. Qualifying benefits arising from the overall scheme, for entry into the Medium-Term Plan

OM, deprivation:		Qual. benefits:	Payment rate:	FCRM GiA contribution:
OM1		£ 4,815,727	5.56 p in the £1	£ 267,540
OM2	20% most	£ -	45.0	£ -
	21-40%	£ -	30.0	£ -
	Least 60%	£ 219,496	20.0	£ 43,899
OM3	20% most	£ -	45.0	£ -
	21-40%	£ -	30.0	£ -
	Least 60%	£ -	20.0	£ -
OM4		£ -	100.0	£ -
Total		£ 5,035,223		**£ 311,440**

Maximum for Outcomes delivered. The actual value any scheme is elligible for may be less.

Sensitivity Testing. *It is important that users of this calculator appreciate the implications on funding from changes to input data which may become necessary as the project develops and better information is available. Five typical tests are provided below. Users should consider how appropriate these are to their project, what other tests may be appropriate and how best to use the information with all those that may be involved in the project.*

	Raw Score	Contribution for 100% Score (£k)
As scenario above	26%	529,360
Sensitivity 1 - Change in PV Whole Life Cost (25% increase)	9%	811,696
Sensitivity 2 - Change in OM2 - 50% of households in Very Significant (Before) risk may already be in Significant Risk band	3%	693,938
Sensitivity 3 - Change in OM3 - 50% of households in Medium Term loss (Before) may already be in Long Term loss	26%	529,360
Sensitivity 4 - Increase Duration of Benefits by 25%	#N/A	#N/A
Sensitivity 5 - Reduce Duration of Benefits by 25%	26%	530,469

FCRM Partnership Funding Calculator for Flood and Coastal Erosion Risk Management Grant in Aid (FCRM GiA)
Version 8 January 2014

Project Name Caterham-on-the-Hill Flood Alleviation Scheme: Option 9 - Combination of Option 1, 2, 3 and 4
Unique Project Number

Key Input cells / Calculated cells

All figures are in £'s \z\z
Figures in Blue to be entered onto Medium Term Plan

SUMMARY: prospect of FCRM GiA funding

		Scheme Benefit to Cost Ratio:	**2.74** to 1
		Effective return to taxpayer:	**2.74** to 1
Raw Partnership Funding Score	**22%** (1)	*Effective return on contributions:*	**n/a** to 1
External Contribution or saving required to achieve an Adjusted Score of 100%	**2,342,655** (2)		
Adjusted Partnership Funding Score (PF)	**22%** (3)		
PV FCERM GiA towards the up-front costs of this scheme (PV Cost for Approval)	**-** (4)		

Cell (2) shows the minimum amount of contributions and/or reductions in scheme cost that are required to raise the Adjusted PF Score to at least 100%. Further increases on this will improve this scheme's chances of an FCRM GiA allocation in the desired year. Planned savings and contributions should be entered into cells(9,10,12) and cells(14-17). See NOTE below.

1. Scheme details

Risk Management Authority type of asset maintainer	**LA** (5)	**Yes** (6)
Duration of Benefits (years)	**100** (7)	
PV Whole-Life Benefits:	**10,316,573** (8)	

Is evidence available that a Strategic Approach has been taken, and that double counting of benefits has been avoided ?

All costs and benefits must be on a Present Value (PV) Whole-Life basis over the Duration of Benefits period. Where Contributions are identified these should also be on a Present Value basis.

PV Costs	
PV Appraisal Costs	92,754 (9)
PV design & Construction Costs	2,918,251 (10)
Sub Total - PV Cost for Approval (appraisal,design,construction)	**3,011,004** (11)
PV Post-Construction Costs	754,573 (12)
PV Whole-Life Costs:	**3,765,577** (13)

The total value of any necessary contributions will depend on whether maintenance (ongoing costs) is funded through revenue FCRM GiA, or by other means.

PV Contributions secured to date	
PV Local Levy secured to date	(14)
PV Public Contributions secured to date	(15)
PV Private Contributions secured to date	(16)
PV Funding form other Environment Agency functions/sources secured to date	(17)
PV Total Contributions secured to date	0 (18)
WARNING: Contributions less than minimum required in cell (2)	

NOTE: This scheme is to be maintained by an RMA other than the EA (ref cell 5). Capital FCRM GiA will fund the appropriate share of the up-front costs (cell 11) with any shortfall needing to be paid for via contributions identified in cells(14-17). Future ongoing costs (cell 12) and any contriubutions towards them are a matter for local agreement by the RMA and should NOT be included in cells(14-17). It is recommended that the RMA takes the opportunities created during scheme development to separately secure contributions towards future ongoing costs (cell12).

2. Qualifying benefits under Outcome Measure 2: households better protected against flood risk

Number of households in:	Before			After			Change due to scheme		
20% most deprived areas	-	-	-	-	-	-	0	0	0
21-40% most deprived areas	-	-	-	-	-	-	0	0	0
60% least deprived areas	81	71	186	73	84	136	-8	13	-50
At:	Moderate risk	Significant risk	Very significant risk	Moderate risk	Significant risk	Very significant risk	Moderate risk	Significant risk	Very significant risk
Annual damages avoided (£), compared with a household at low risk							150	600	1,350

Change in household damages, in:	Per year	Over lifetime of scheme	**Qual. benefits (discounted)**
20% most deprived areas	£ -	£ -	**OM2 (20%)** £ -
21-40% most deprived areas	£ -	£ -	**OM2 (21-40%)** £ -
60% least deprived areas	-£ 60,900	-£ 6,090,000	**OM2 (60%)** £ 1,818,679

3. Qualifying benefits under Outcome Measure 3: households better protected against coastal erosion

Number of households in:	Before	
20% most deprived areas		
21-40% most deprived areas		
60% least deprived areas		
	Long-term loss	Medium-term loss

Damages per household avoided:		
Annual damages avoided	£ 6,000	£ 6,000
Loss expected in	50	20 years
Present value of Year 1 loss (i.e. first year damages, discounted based on when loss is expected)	£ 1,184	£ 3,015
	Long-term loss	Medium-term loss

Change in household damages, in:	Year 1 loss avoided:	Over lifetime of scheme:	**Qual. benefits (discounted):**
20% most deprived areas	£ -	£ -	**OM3 (20%)** **£ -**
21-40% most deprived areas	£ -	£ -	**OM3 (21-40%)** **£ -**
60% least deprived areas	£ -	£ -	**OM3 (60%)** **£ -**

4. Qualifying benefits under Outcome Measure 4: statutory environmental obligations met

Payments under:		Assumed benefits per unit:	**Qual. benefits (discounted):**
OM4a	Hectares of net water-dependent habitat created	£ 15,000	OM4a £ -
OM4b	Hectares of net intertidal habitat created	£ 50,000	OM4b £ -
OM4c	Kilometres of protected river improved	£ 80,000	OM4c £ -
			OM4 **£ -**

5. Qualifying benefits arising from the overall scheme, for entry into the Medium-Term Plan

OM, deprivation:		Qual. benefits:	Payment rate:	FCRM GiA contribution:
OM1		£ 8,497,894	5.56 p in the £1	£ 472,105
OM2	20% most	£ -	45.0	£ -
	21-40%	£ -	30.0	£ -
	Least 60%	£ 1,818,679	20.0	£ 363,736
OM3	20% most	£ -	45.0	£ -
	21-40%	£ -	30.0	£ -
	Least 60%	£ -	20.0	£ -
OM4		£ -	100.0	£ -
Total		£ 10,316,573		**£ 835,841**

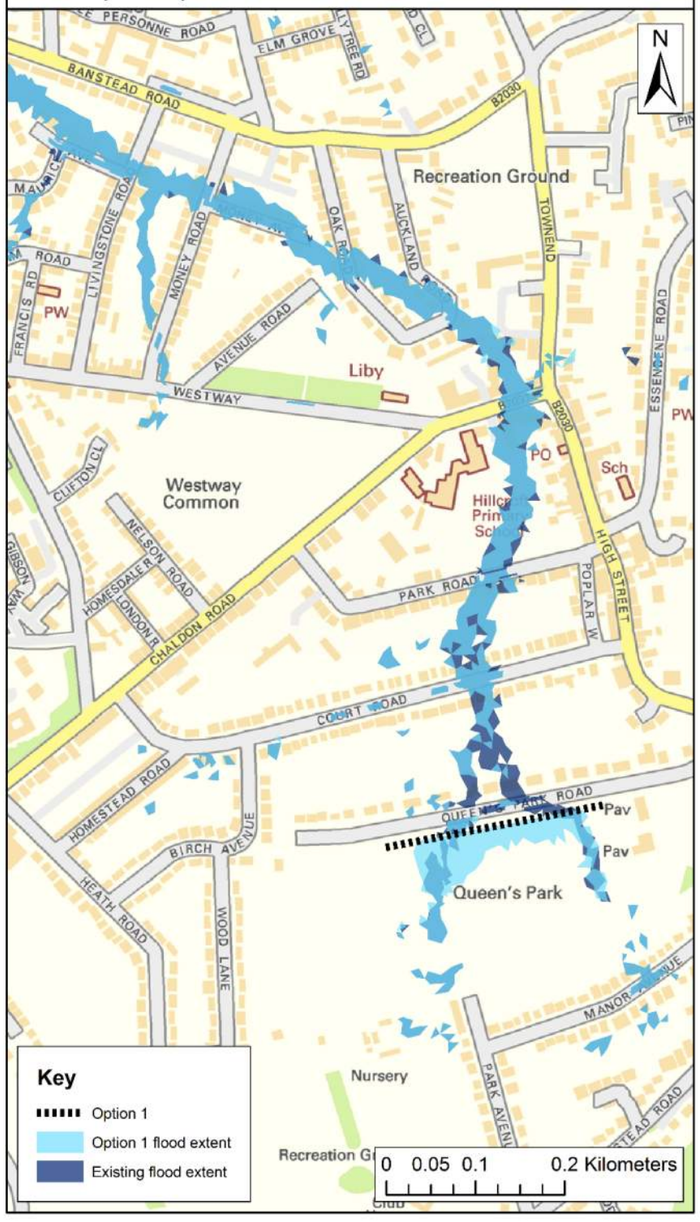
Maximum for Outcomes delivered. The actual value any scheme is elligible for may be less.

Sensitivity Testing. *It is important that users of this calculator appreciate the implications on funding from changes to input data which may become necessary as the project develops and better information is available. Five typical tests are provided below. Users should consider how appropriate these are to their project, what other tests may be appropriate and how best to use the information with all those that may be involved in the project.*

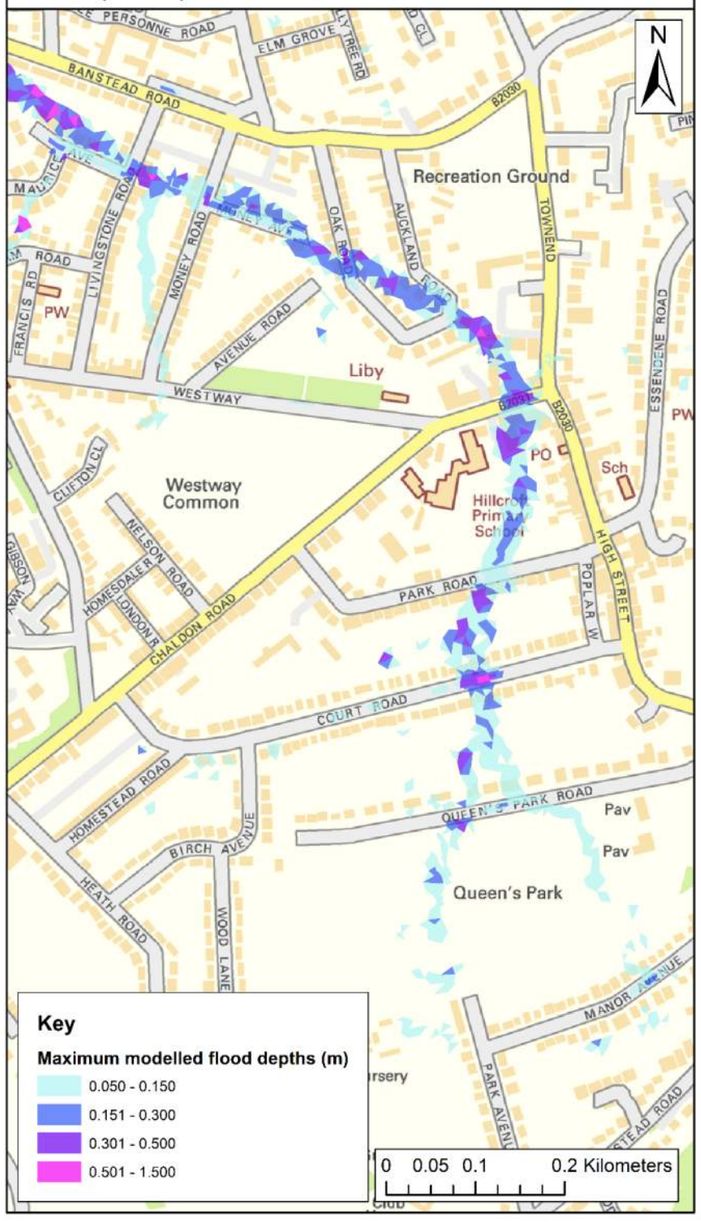
	Raw Score	Contribution for 100% Score (£k)
As scenario above	22%	2,342,655
Sensitivity 1 - Change in PV Whole Life Cost (25% increase)	8%	3,462,998
Sensitivity 2 - Change in OM2 - 50% of households in Very Significant (Before) risk may already be in Significant Risk band	14%	2,583,237
Sensitivity 3 - Change in OM3 - 50% of households in Medium Term loss (Before) may already be in Long Term loss	22%	2,342,655
Sensitivity 4 - Increase Duration of Benefits by 25%	#N/A	#N/A
Sensitivity 5 - Reduce Duration of Benefits by 25%	22%	2,354,865

Appendix E: Mapping of modelled options

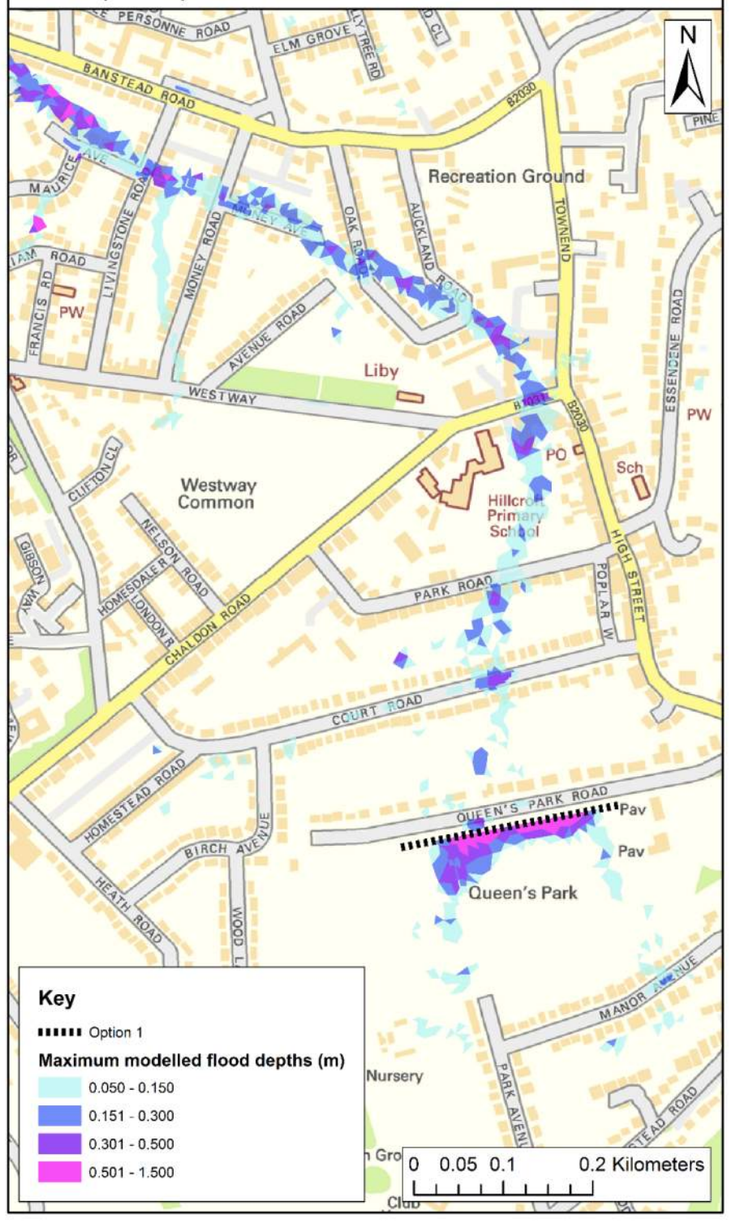
A comparison of the existing and Option 1 flood extents for the 5% (1 in 20) AEP flood event.



The existing flood extent and depth for the 5% (1 in 20) AEP flood event.



The Option 1 flood extent and depth for the 5% (1 in 20) AEP flood event.



Caterham-on-the-Hill Initial Assessment

Modelled flooding is shown only on the main flow route.

Option 1 is flood storage area at Queen's Park recreation ground.

The flood extents shown are the modelled risk of surface water flooding during an Annual Exceedance Probability (AEP) design event, they do not represent a specific historic event.
Property internal flood levels are typically 0.15 m above ground level. The light blue colour band (0.05 - 0.15 m) therefore represents external flooding.

Reference: 5135062

Drawn: BW 12/01/2018

Checked: CH 15/01/2018

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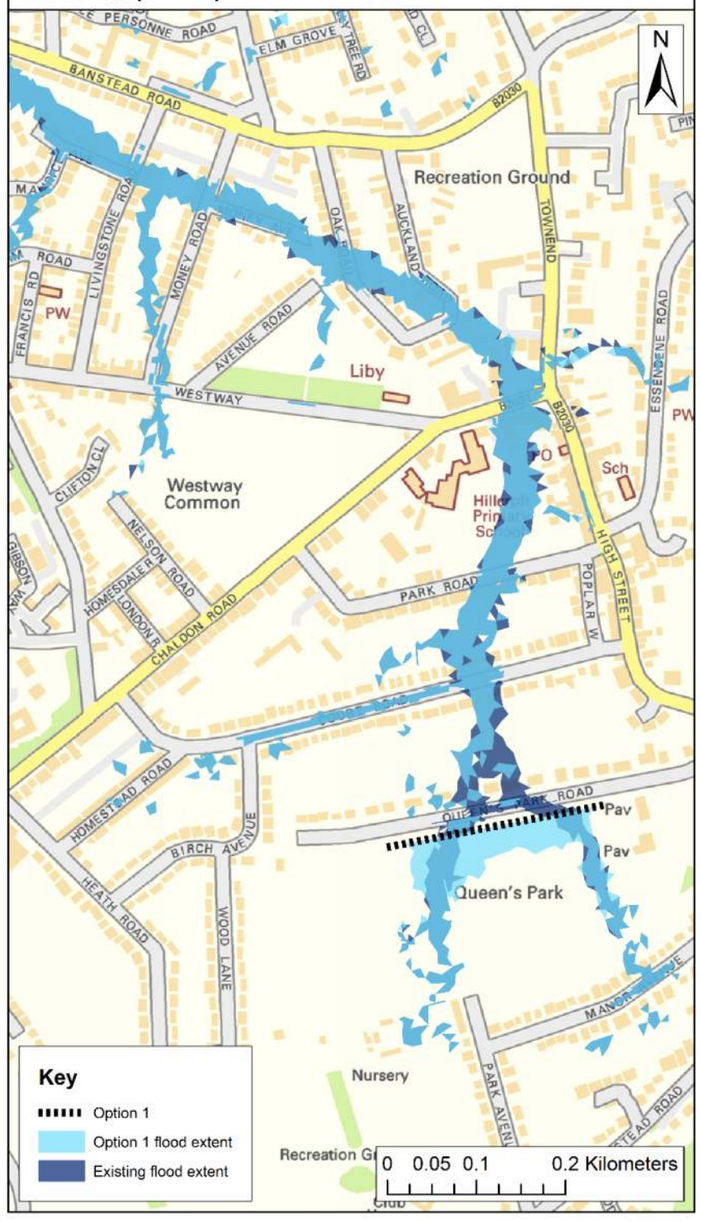
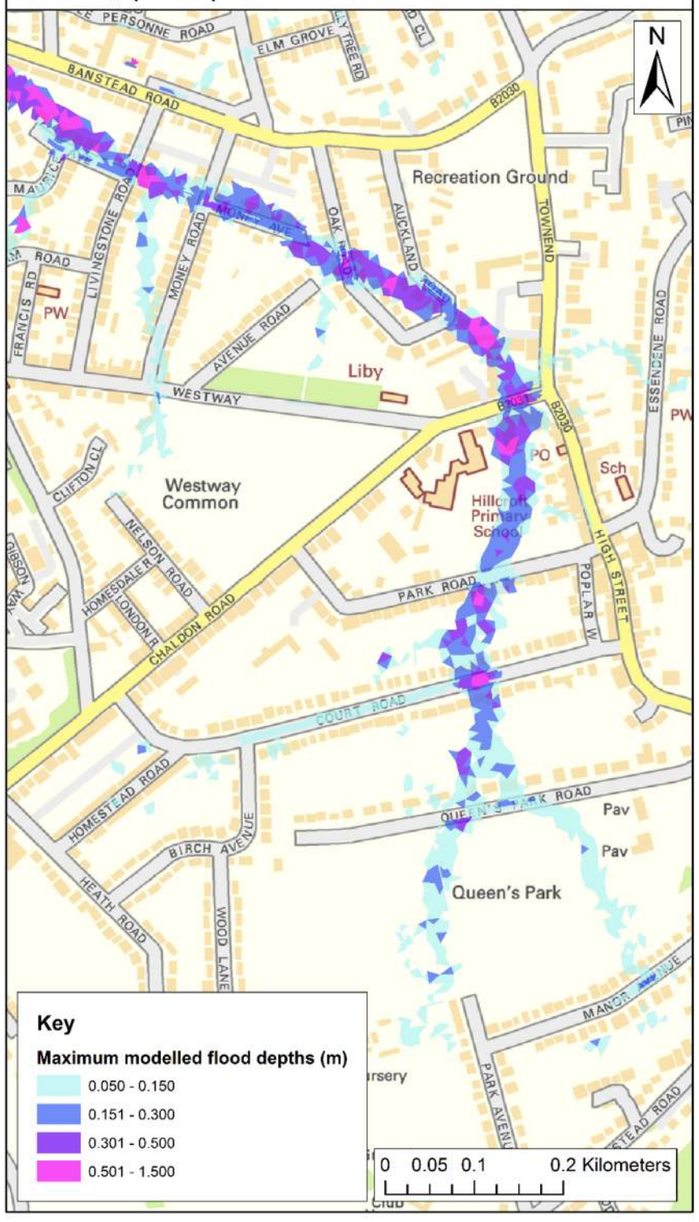
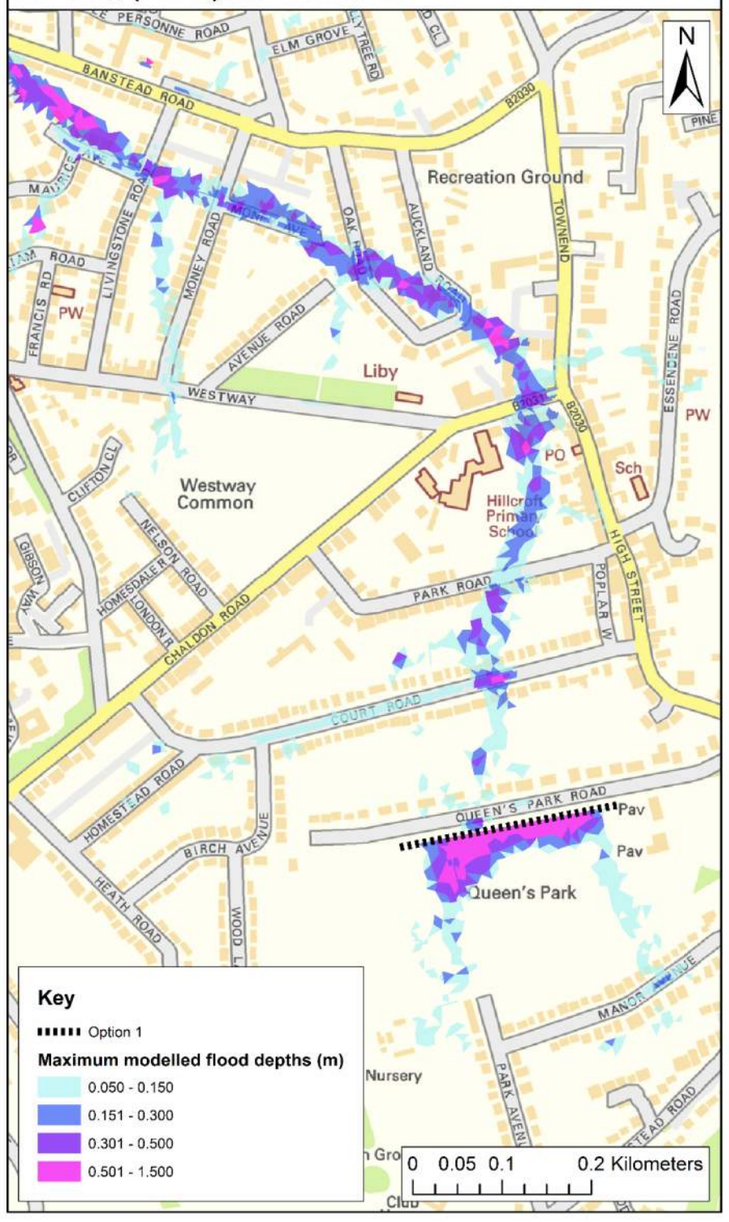
A comparison of the existing and Option 1 flood extents for the 1.33% (1 in 75) AEP flood event.



The existing flood extent and depth for the 1.33% (1 in 75) AEP flood event.



The Option 1 flood extent and depth for the 1.33% (1 in 75) AEP flood event.



Caterham-on-the-Hill Initial Assessment

Modelled flooding is shown only on the main flow route.

Option 1 is flood storage area at Queen's Park recreation ground.

The flood extents shown are the modelled risk of surface water flooding during an Annual Exceedance Probability (AEP) design event, they do not represent a specific historic event.
Property internal flood levels are typically 0.15 m above ground level. The light blue colour band (0.05 - 0.15 m) therefore represents external flooding.

Reference: 5135062
Drawn: BW 12/01/2018
Checked: CH 15/01/2018

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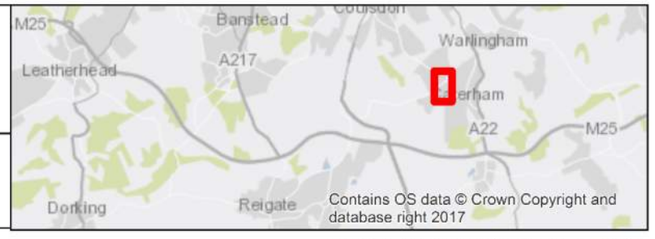

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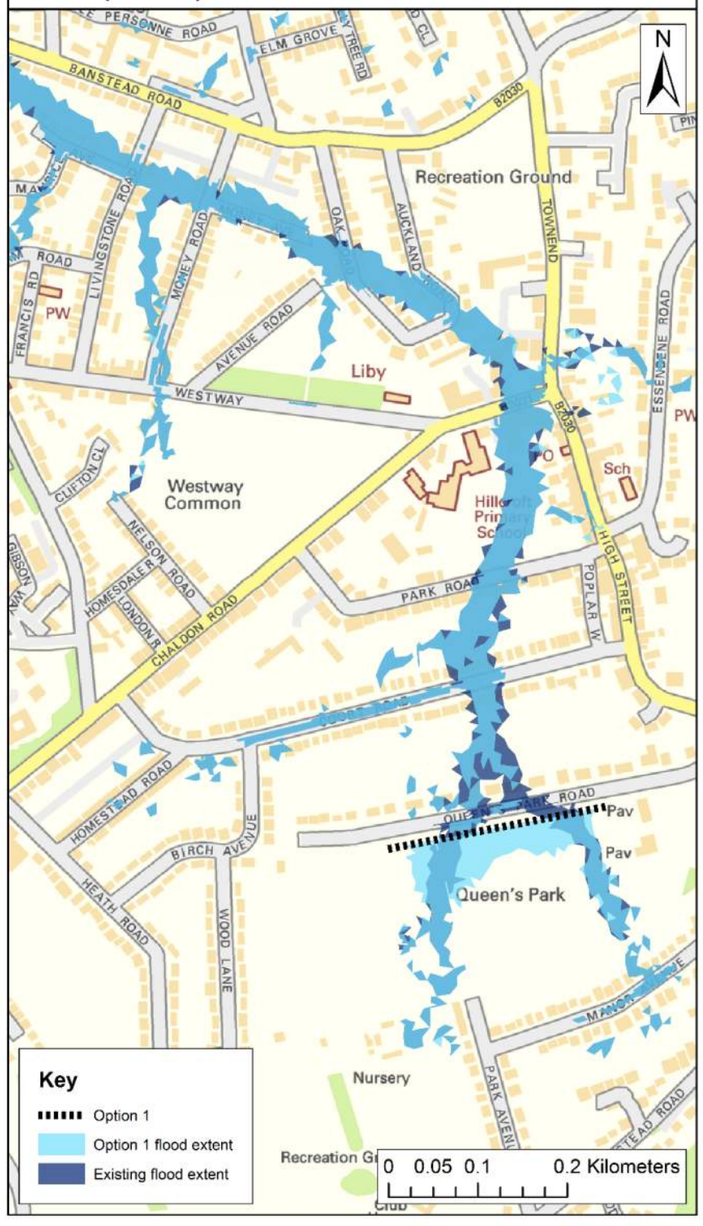
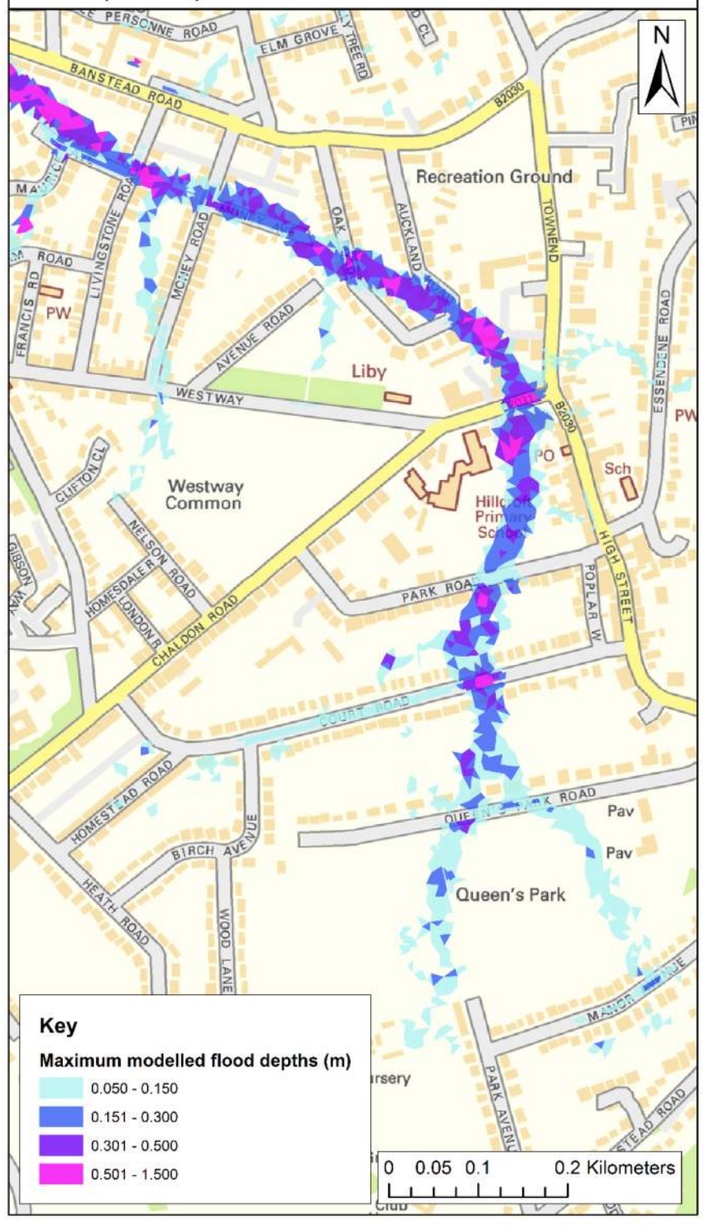
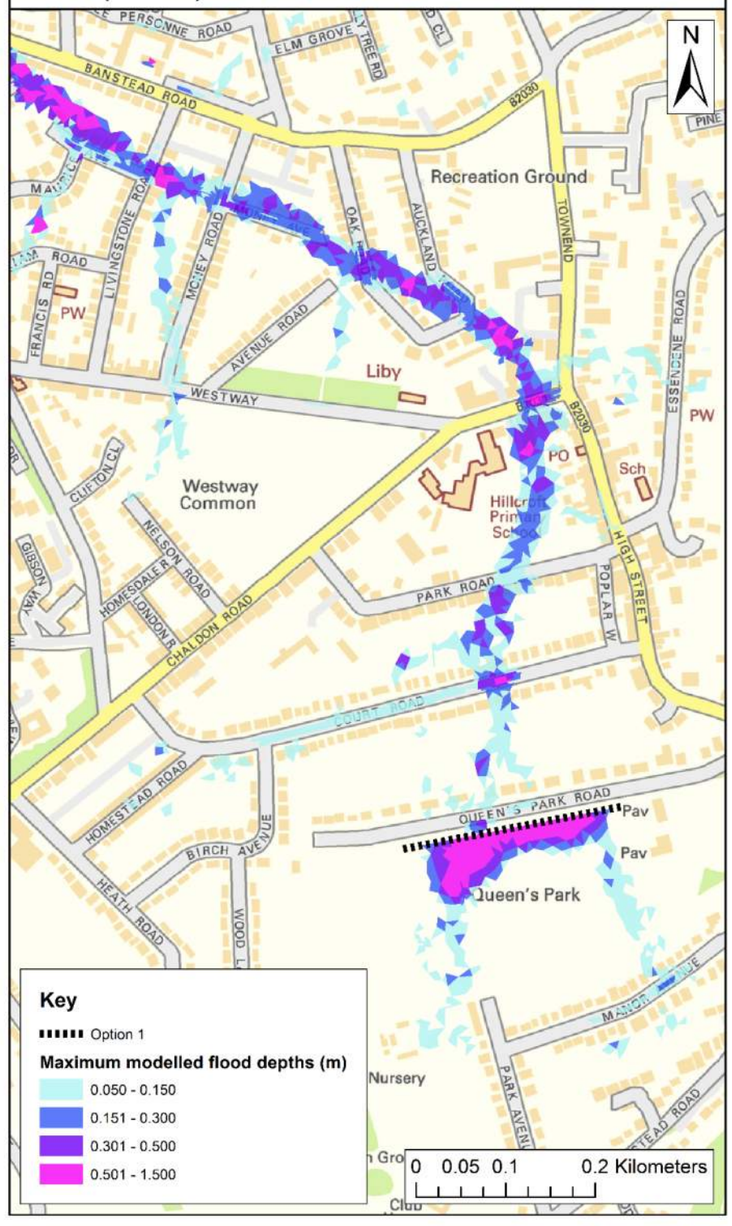
A comparison of the existing and Option 1 flood extents for the 1% (1 in 100) AEP flood event.



The existing flood extent and depth for the 1% (1 in 100) AEP flood event.



The Option 1 flood extent and depth for the 1% (1 in 100) AEP flood event.



Caterham-on-the-Hill Initial Assessment

Modelled flooding is shown only on the main flow route.

Option 1 is flood storage area at Queen's Park recreation ground.

The flood extents shown are the modelled risk of surface water flooding during an Annual Exceedance Probability (AEP) design event, they do not represent a specific historic event.
Property internal flood levels are typically 0.15 m above ground level. The light blue colour band (0.05 - 0.15 m) therefore represents external flooding.

Reference: 5135062
Drawn: BW 12/01/2018
Checked: CH 15/01/2018

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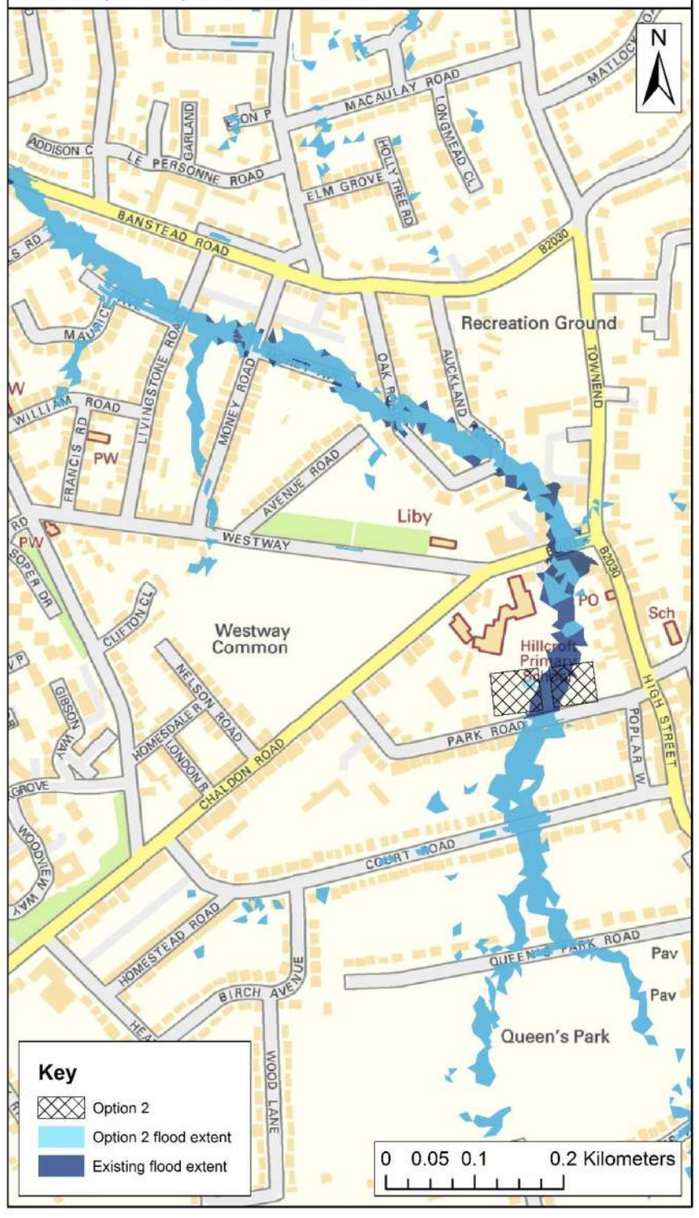
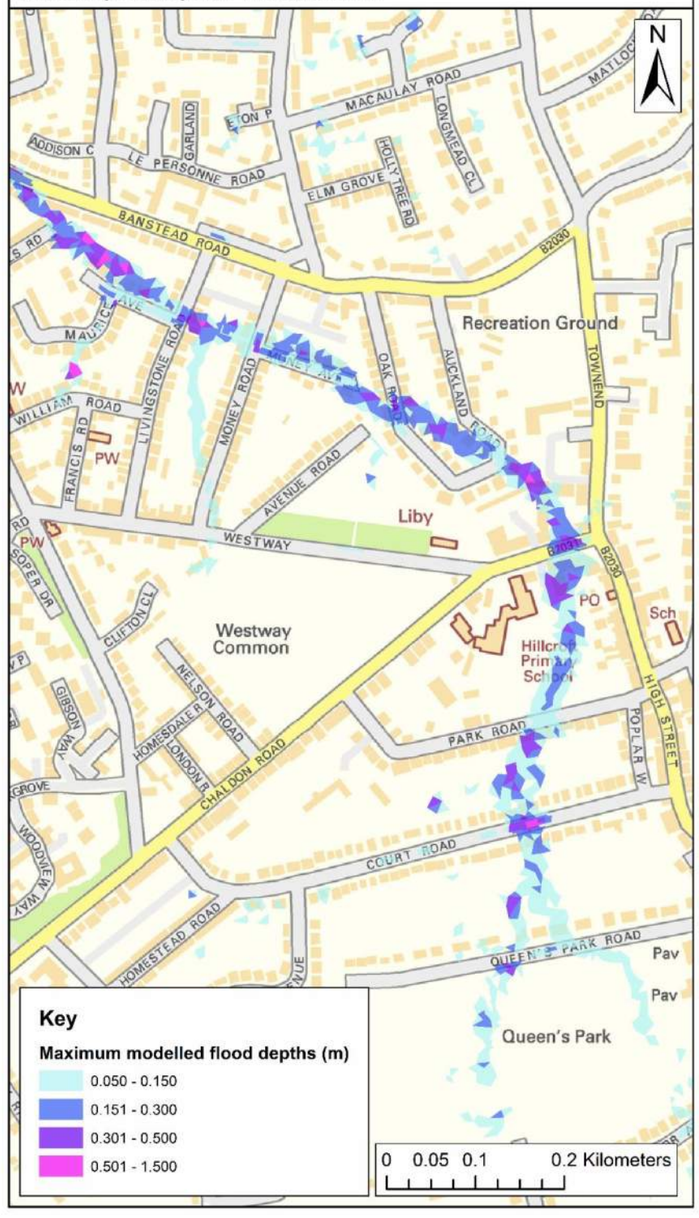
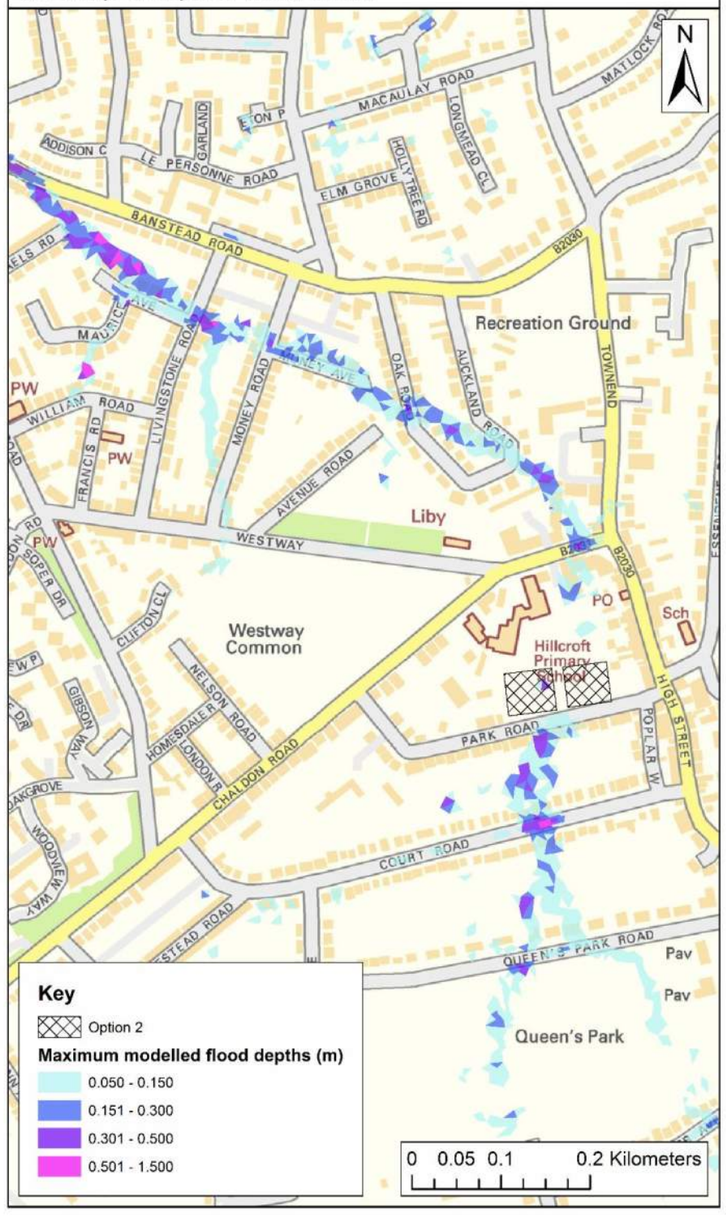
A comparison of the existing and Option 2 flood extents for the 5% (1 in 20) AEP flood event.



The existing flood extent and depth for the 5% (1 in 20) AEP flood event.



The Option 2 flood extent and depth for the 5% (1 in 20) AEP flood event.



Caterham-on-the-Hill Initial Assessment

Modelled flooding is shown only on the main flow route.

Option 2 is flood storage area below the Hillcroft Primary School playing field.

The flood extents shown are the modelled risk of surface water flooding during an Annual Exceedance Probability (AEP) design event, they do not represent a specific historic event.
Property internal flood levels are typically 0.15 m above ground level. The light blue colour band (0.05 - 0.15 m) therefore represents external flooding.

Reference: 5135062
Drawn: BW 12/01/2018
Checked: CH 15/01/2018

SURREY COUNTY COUNCIL

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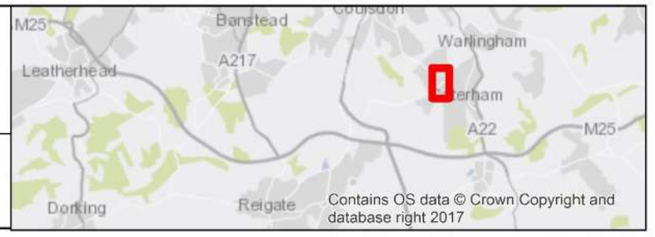

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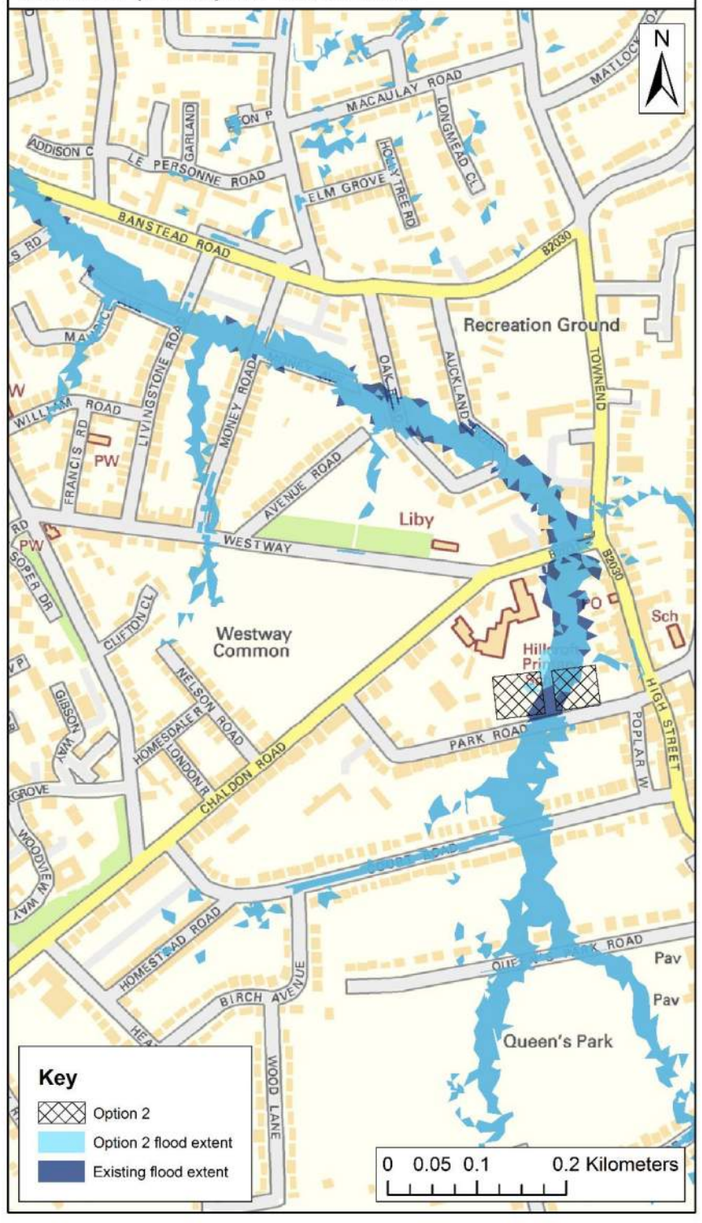
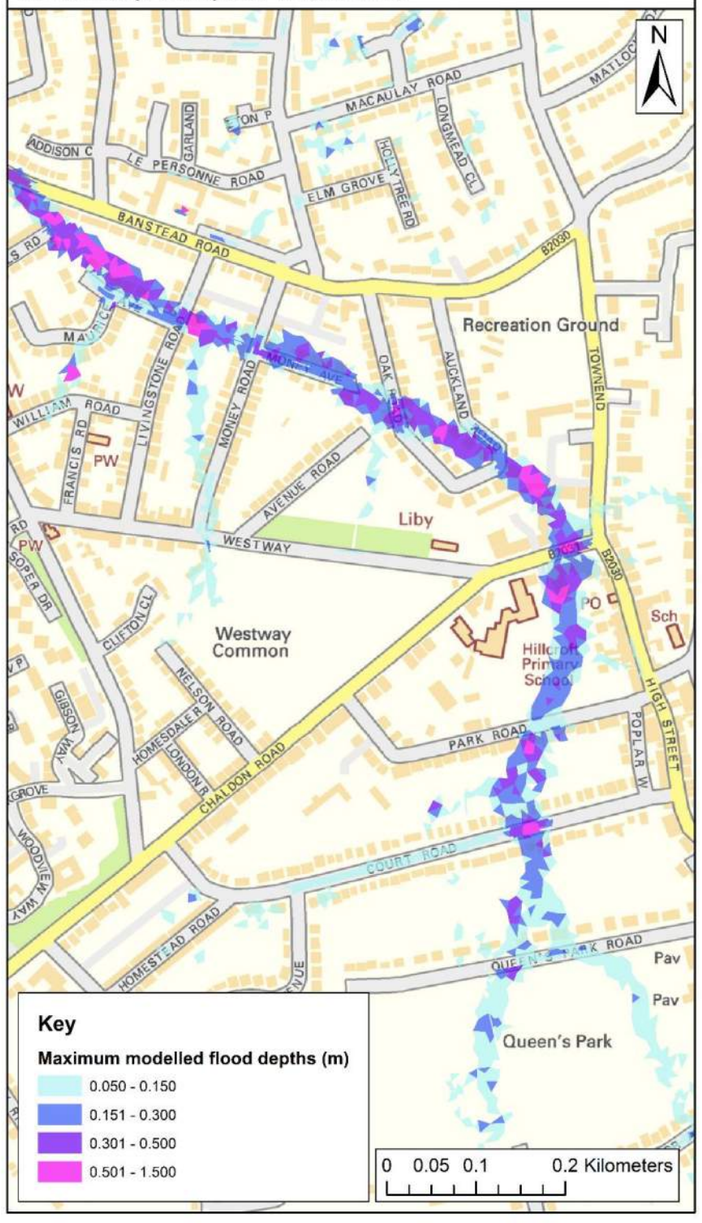
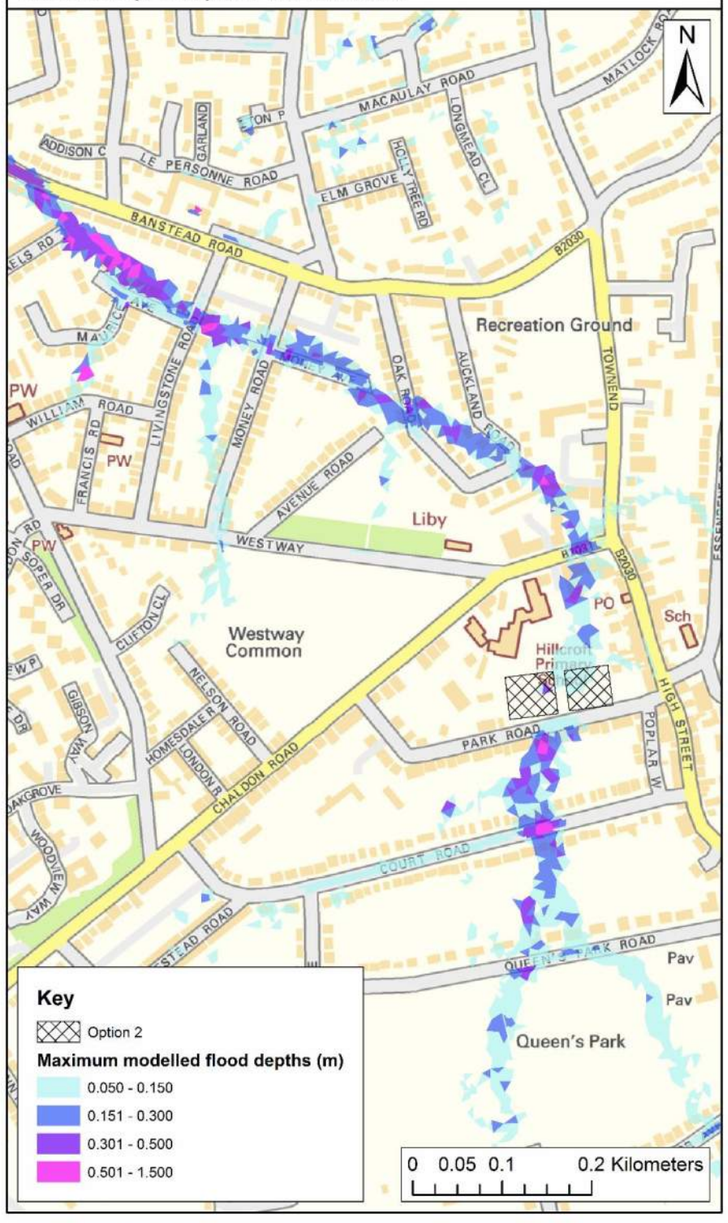
A comparison of the existing and Option 2 flood extents for the 1.33% (1 in 75) AEP flood event.



The existing flood extent and depth for the 1.33% (1 in 75) AEP flood event.



The Option 2 flood extent and depth for the 1.33% (1 in75) AEP flood event.



Caterham-on-the-Hill Initial Assessment

Modelled flooding is shown only on the main flow route.

Option 2 is flood storage area below the Hillcroft Primary School playing field.

The flood extents shown are the modelled risk of surface water flooding during an Annual Exceedance Probability (AEP) design event, they do not represent a specific historic event.
Property internal flood levels are typically 0.15 m above ground level. The light blue colour band (0.05 - 0.15 m) therefore represents external flooding.

Reference: 5135062

Drawn: BW 12/01/2018

Checked: CH 15/01/2018

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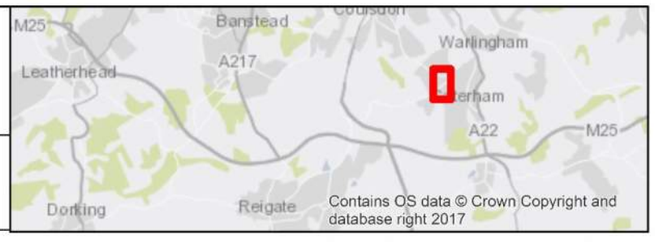

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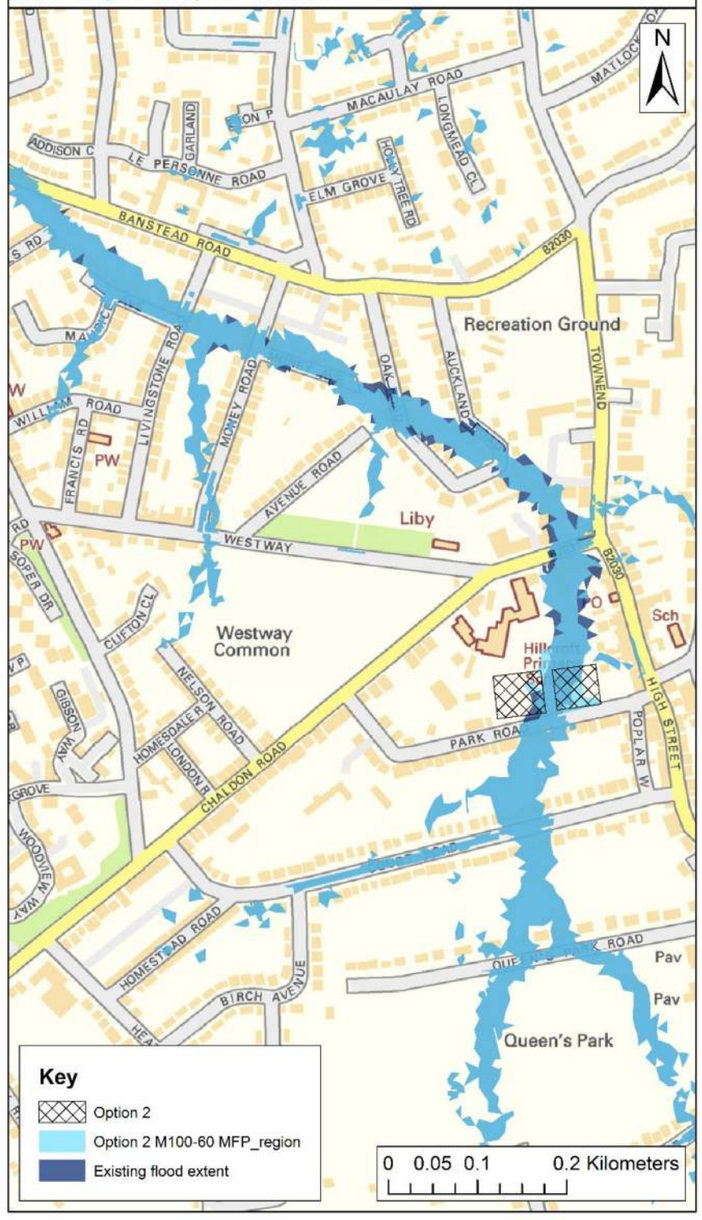
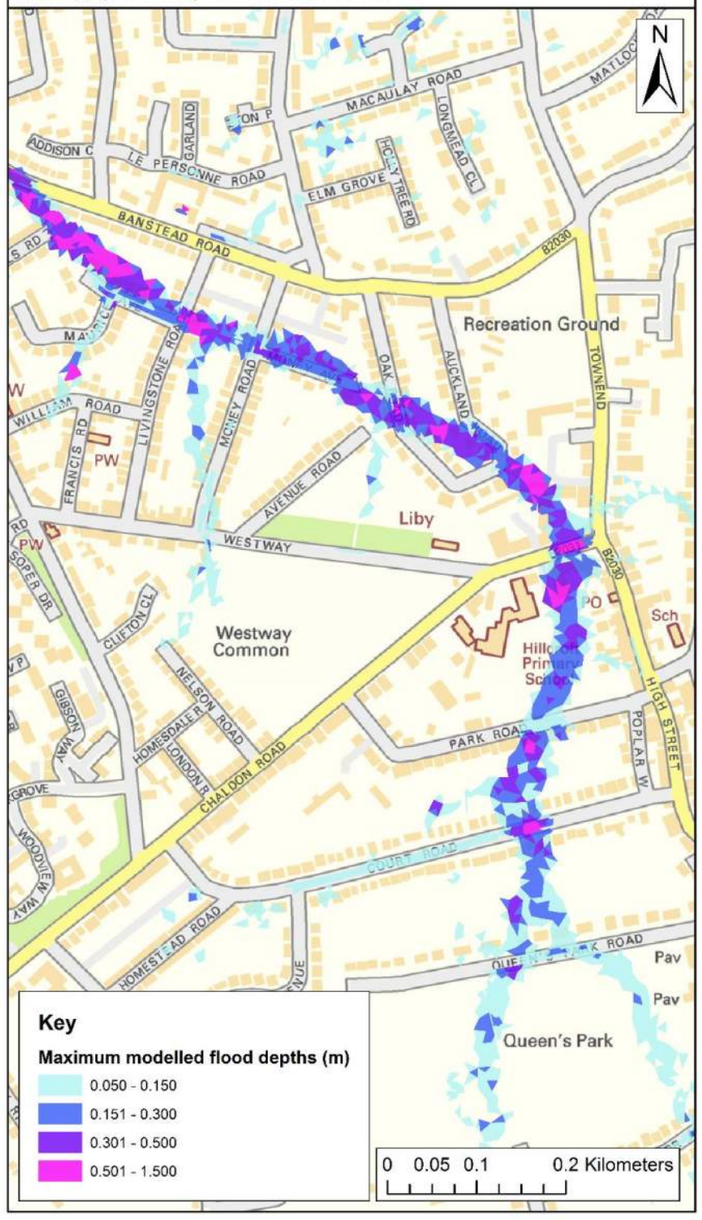
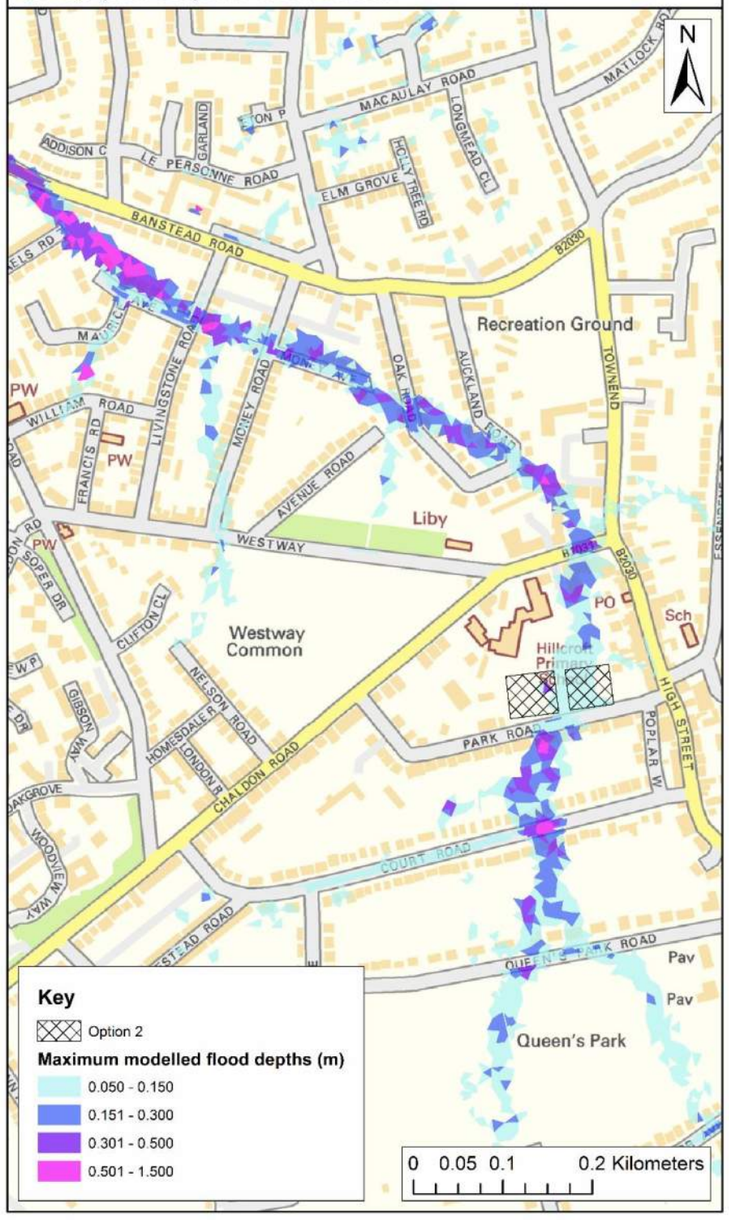
A comparison of the existing and Option 2 flood extents for the 1% (1 in 100) AEP flood event.



The existing flood extent and depth for the 1% (1 in 100) AEP flood event.



The Option 2 flood extent and depth for the 1% (1 in 100) AEP flood event.



Caterham-on-the-Hill Initial Assessment

Modelled flooding is shown only on the main flow route.

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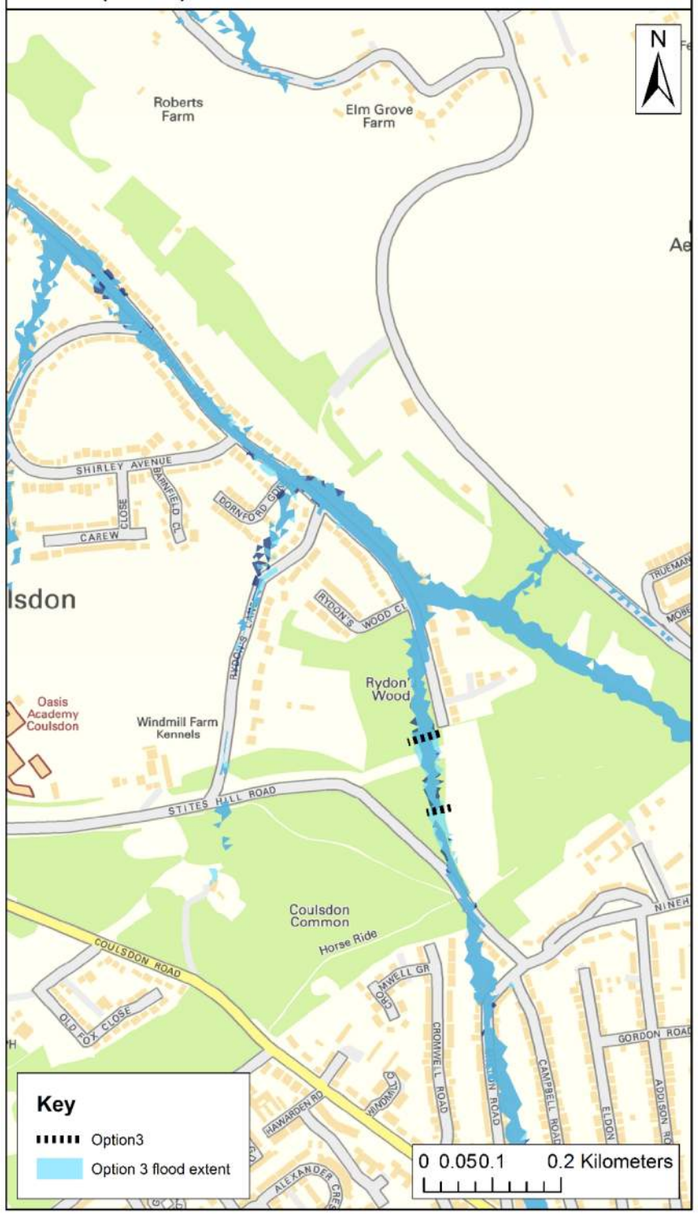
A comparison of the existing and Option 3 flood extents for the 5% (1 in 20) AEP flood event.



The existing flood extent and depth for the 5% (1 in 20) AEP flood event.

The Option 3 flood extent and depth for the 5% (1 in 20) AEP flood event.

Caterham-on-the-Hill Initial Assessment

Modelled flooding is shown only on the main flow route.

Option 3 is flood storage areas on the western flow path on Coulsdon Common.

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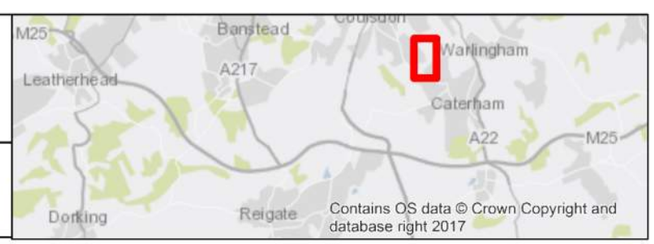

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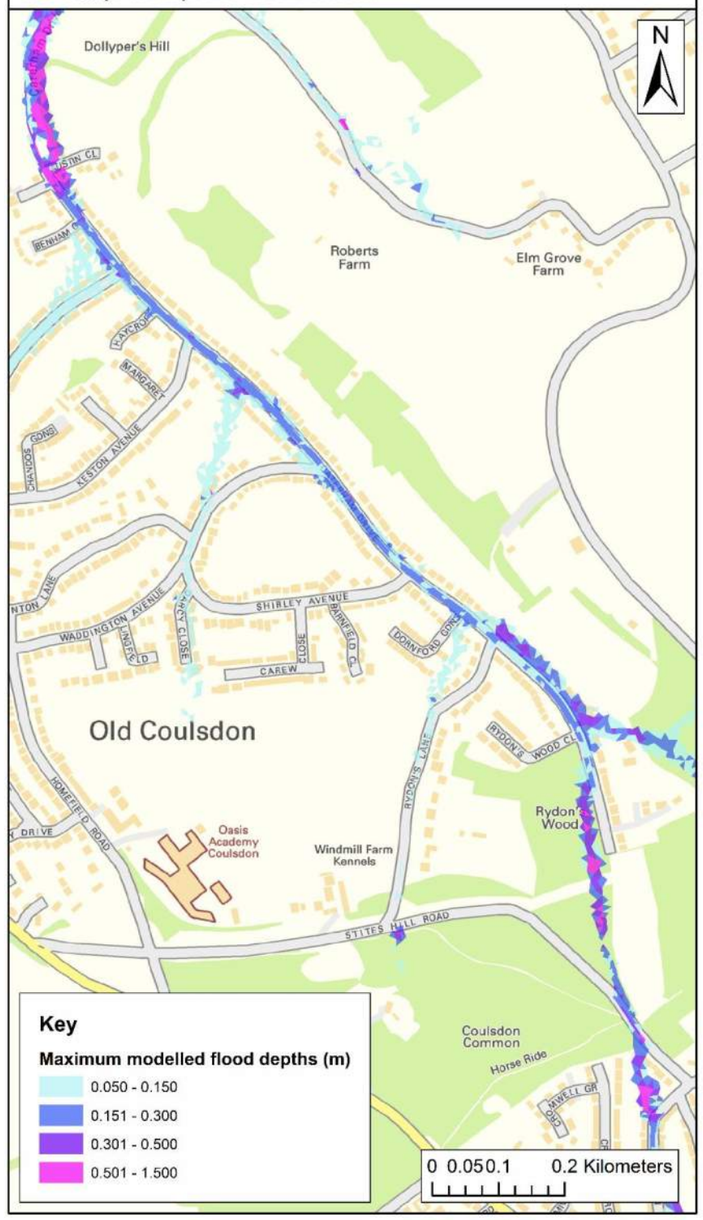
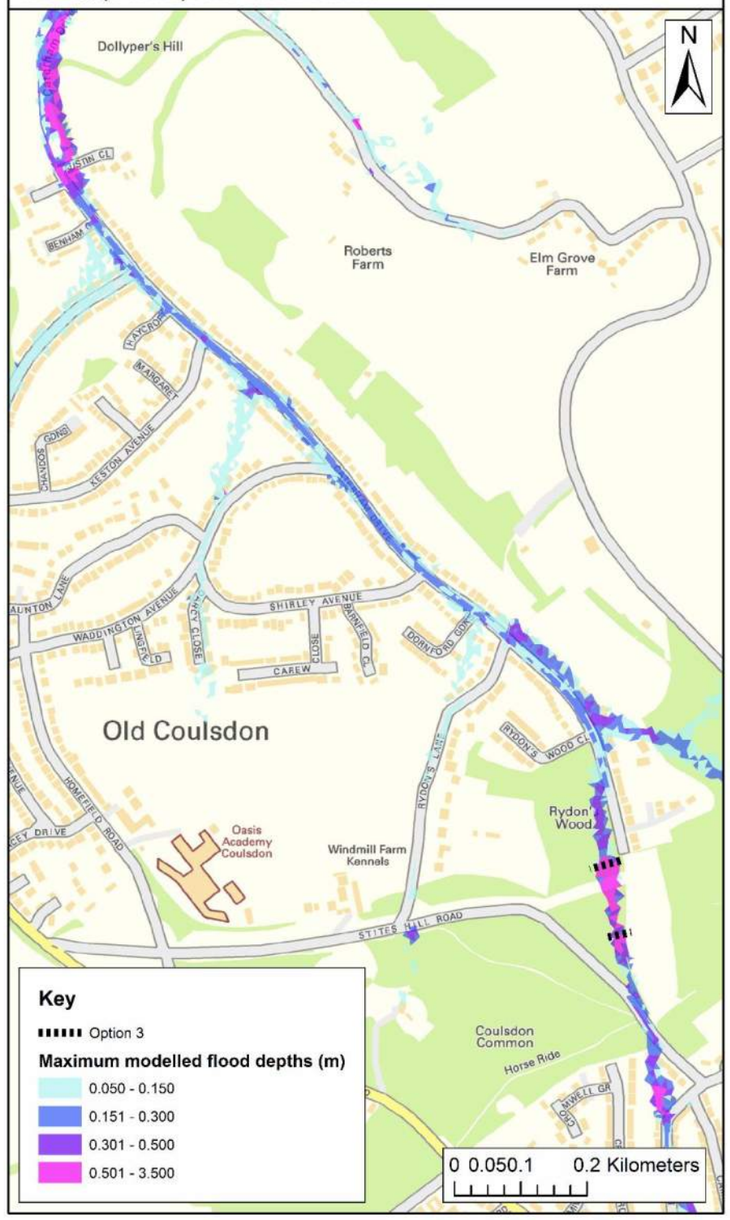


The Option 3 flood extent and depth for the 5% (1 in 20) AEP flood event.



Caterham-on-the-Hill Initial Assessment

Modelled flooding is shown only on the main flow route.

Option 3 is flood storage areas on the western flow path on Coulsdon Common.

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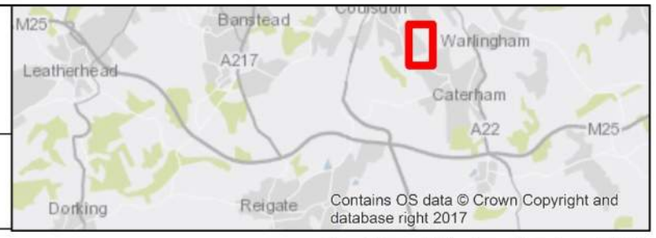

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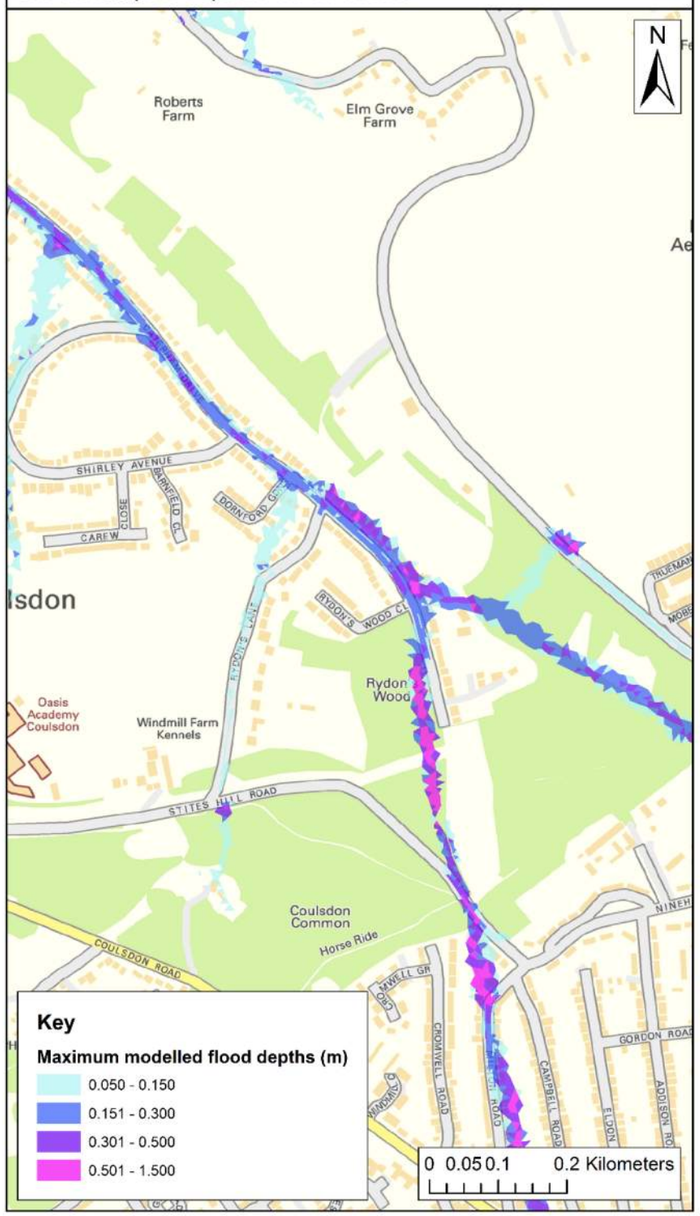

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Caterham-on-the-Hill Initial Assessment

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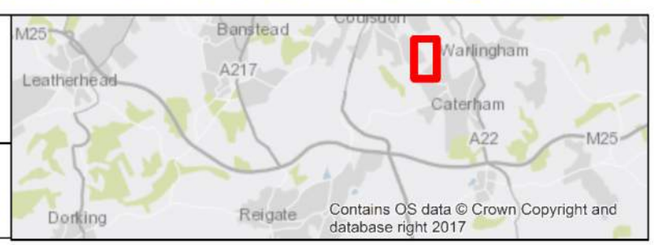

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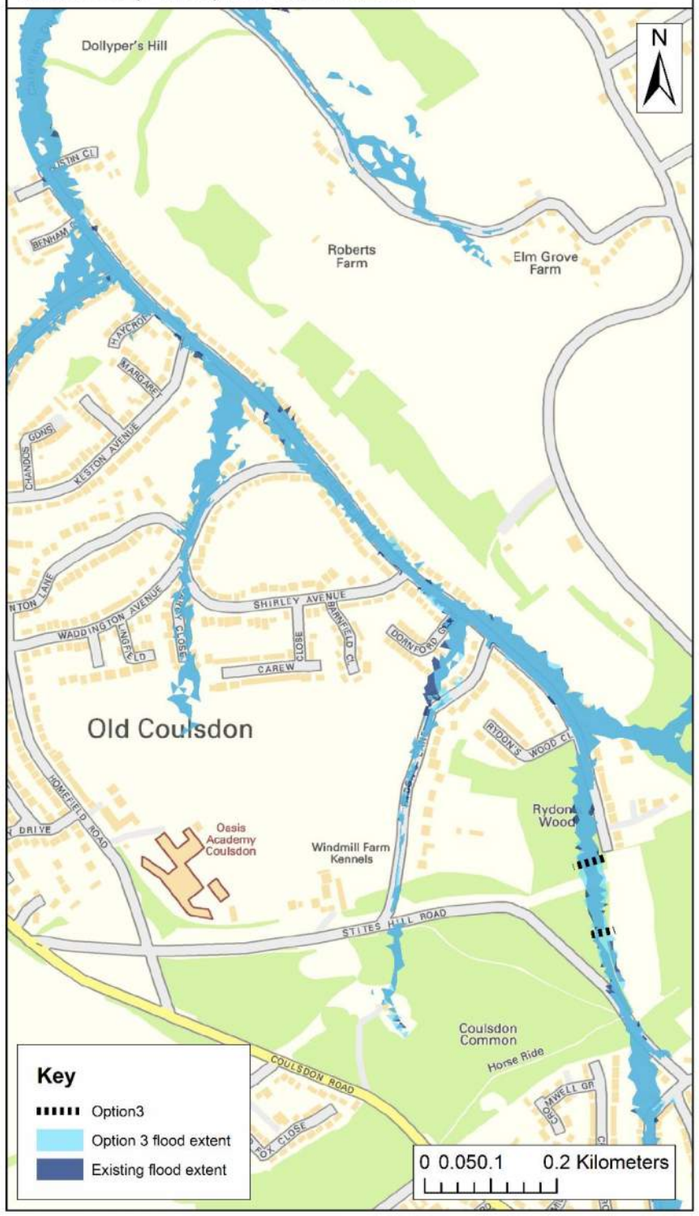

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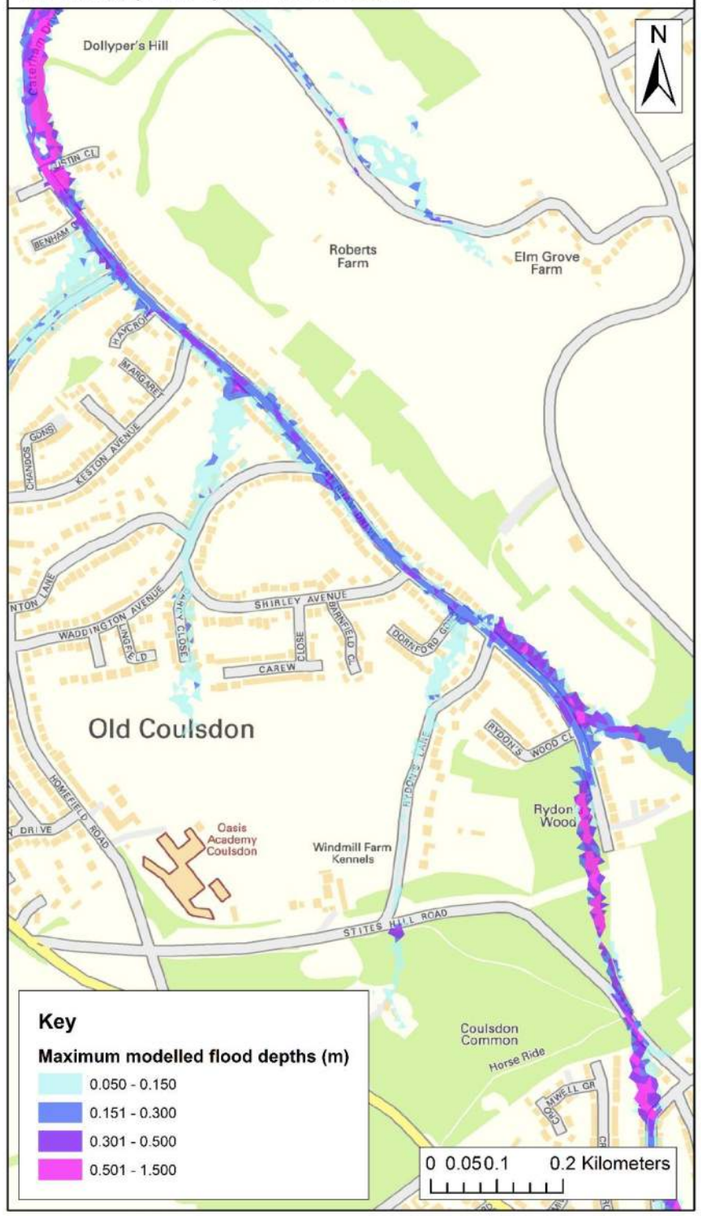

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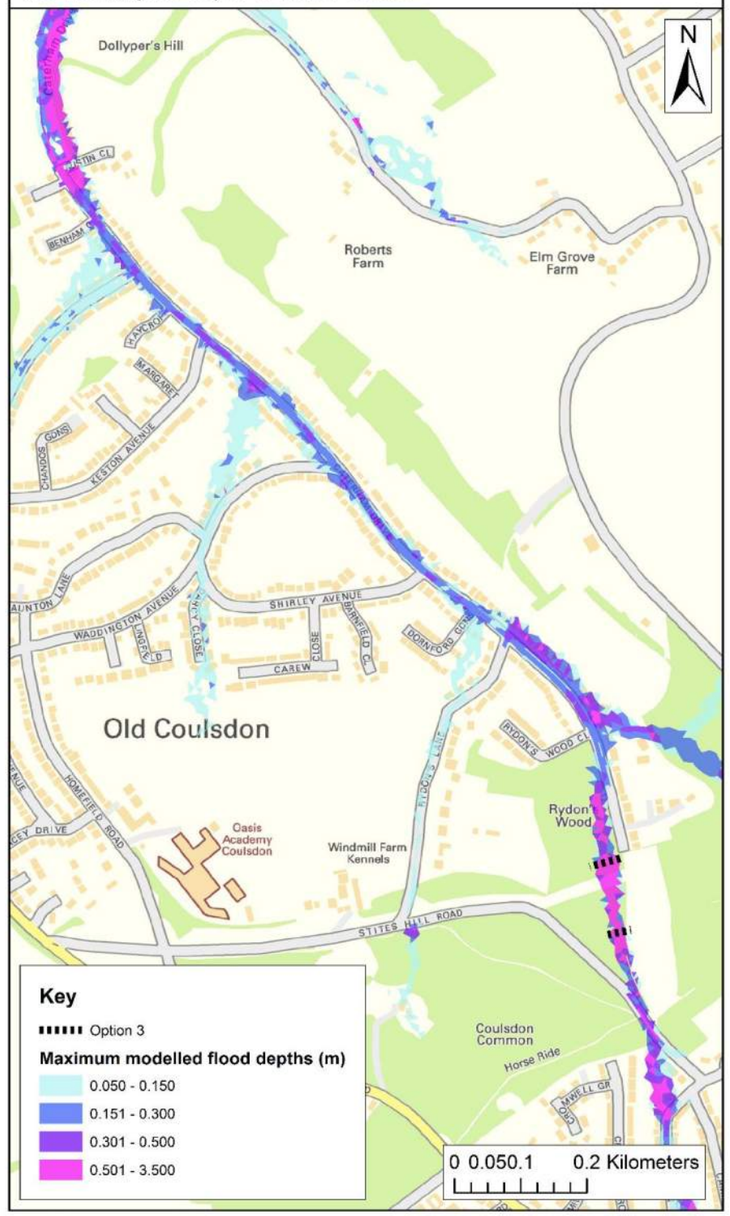

Caterham-on-the-Hill Initial Assessment

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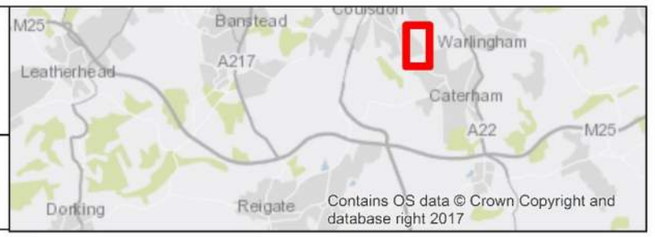

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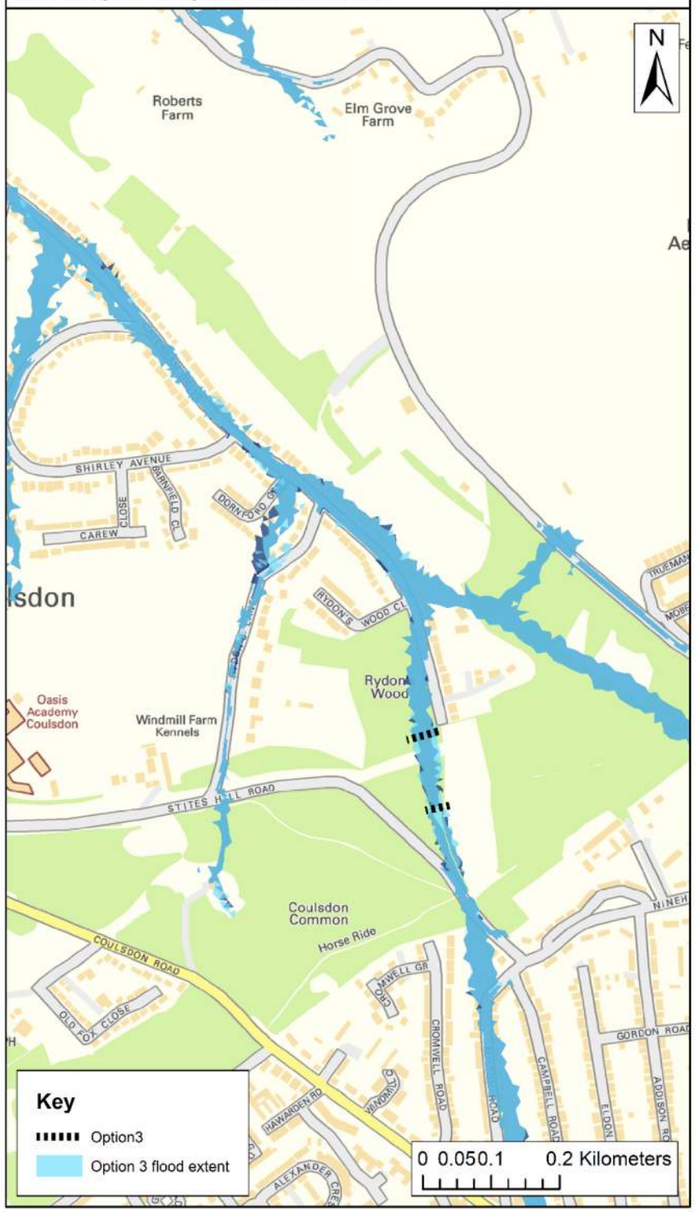
A comparison of the existing and Option 3 flood extents for the 1% (1 in 100) AEP flood event.



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Caterham-on-the-Hill Initial Assessment

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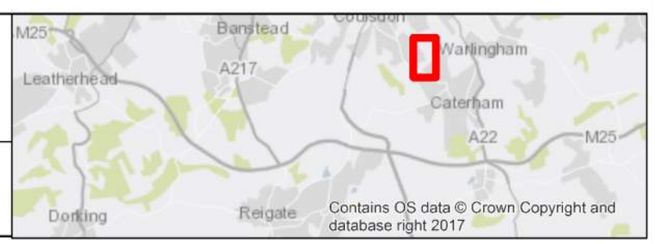

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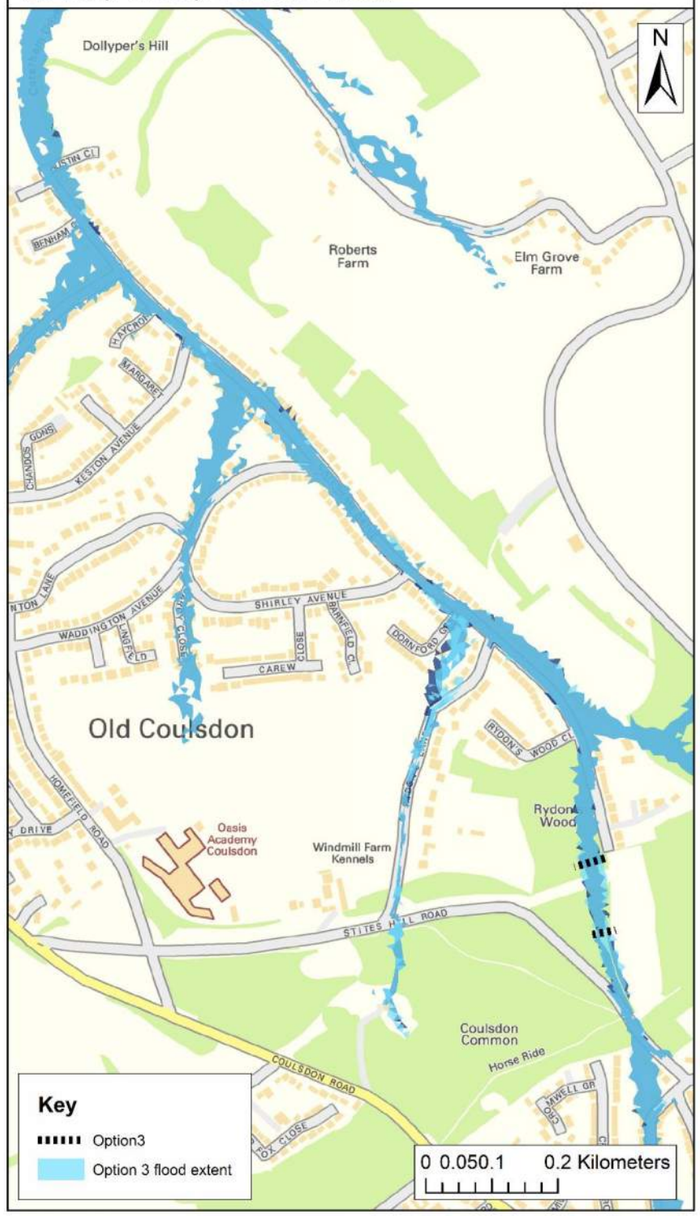
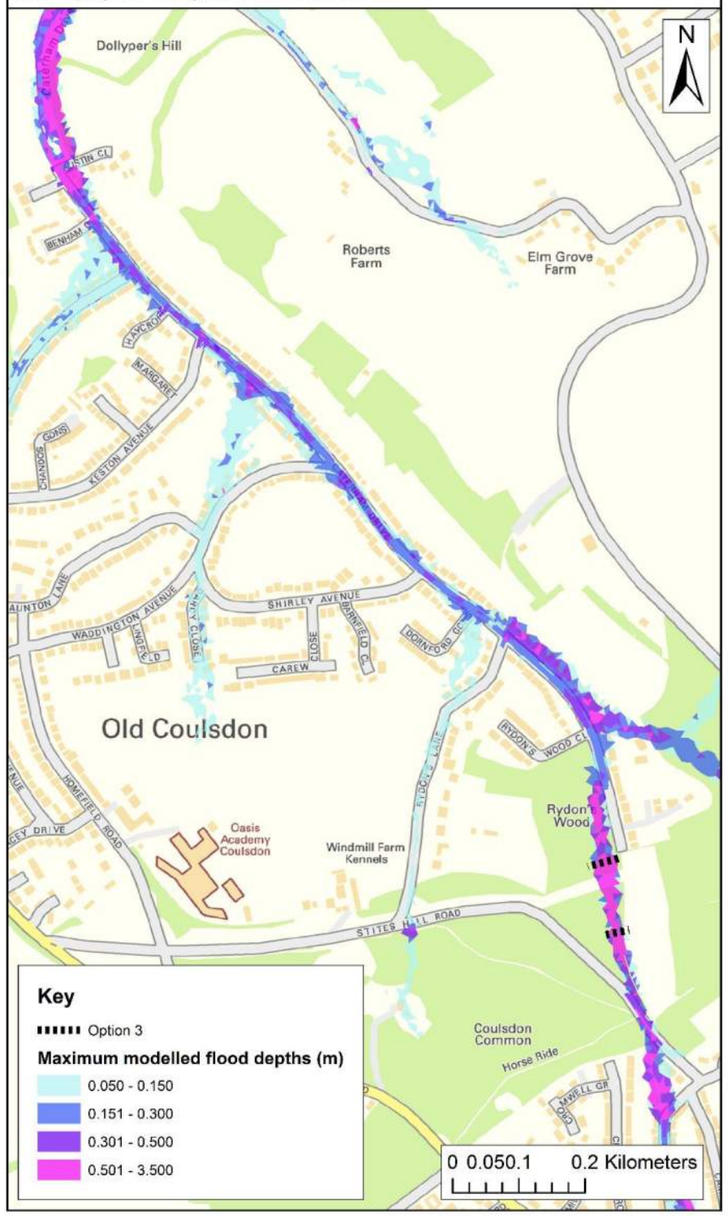


The existing flood extent and depth for the 5% (1 in 100) AEP flood event.

The Option 3 flood extent and depth for the 1% (1 in 100) AEP flood event.



Caterham-on-the-Hill Initial Assessment

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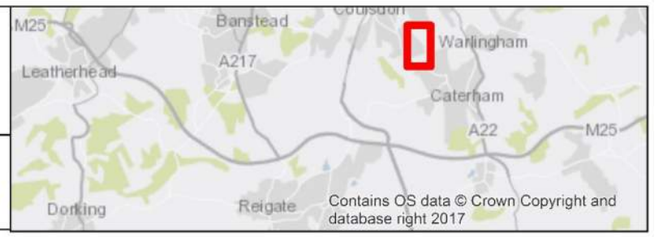

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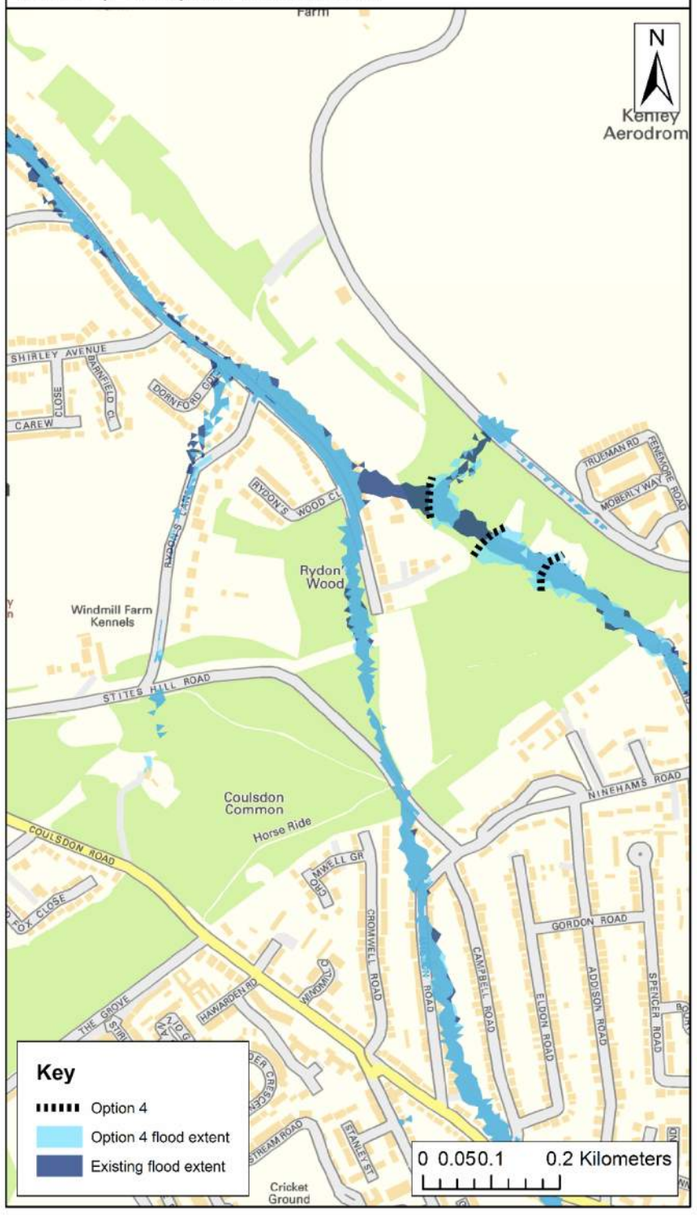
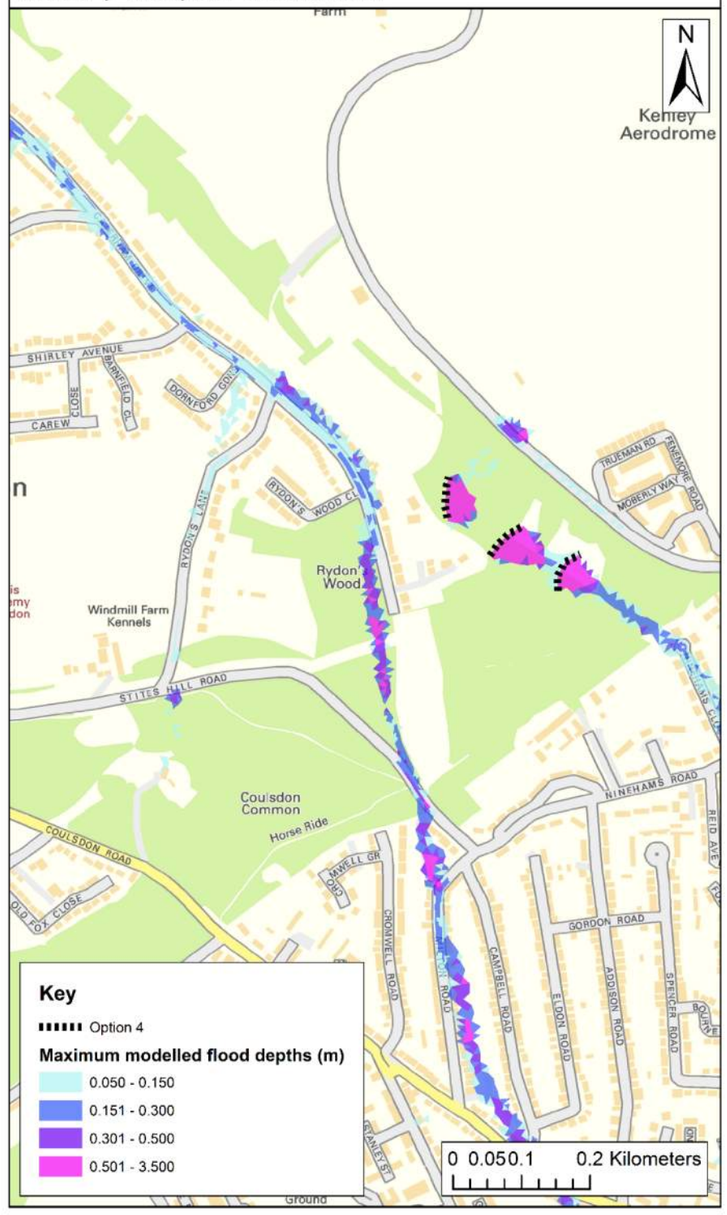
A comparison of the existing and Option 4 flood extents for the 5% (1 in 20) AEP flood event.



The existing flood extent and depth for the 5% (1 in 20) AEP flood event.

The Option 4 flood extent and depth for the 5% (1 in 20) AEP flood event.



Caterham-on-the-Hill Initial Assessment

Modelled flooding is shown only on the main flow route.

Option 4 is flood storage areas on the eastern flow path on Coulsdon Common.

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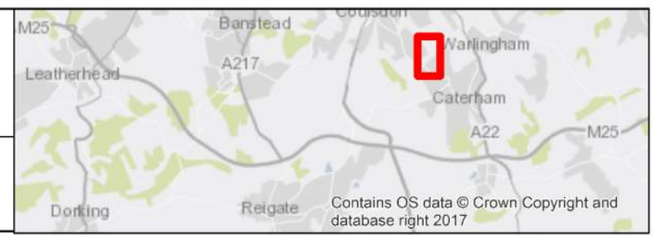

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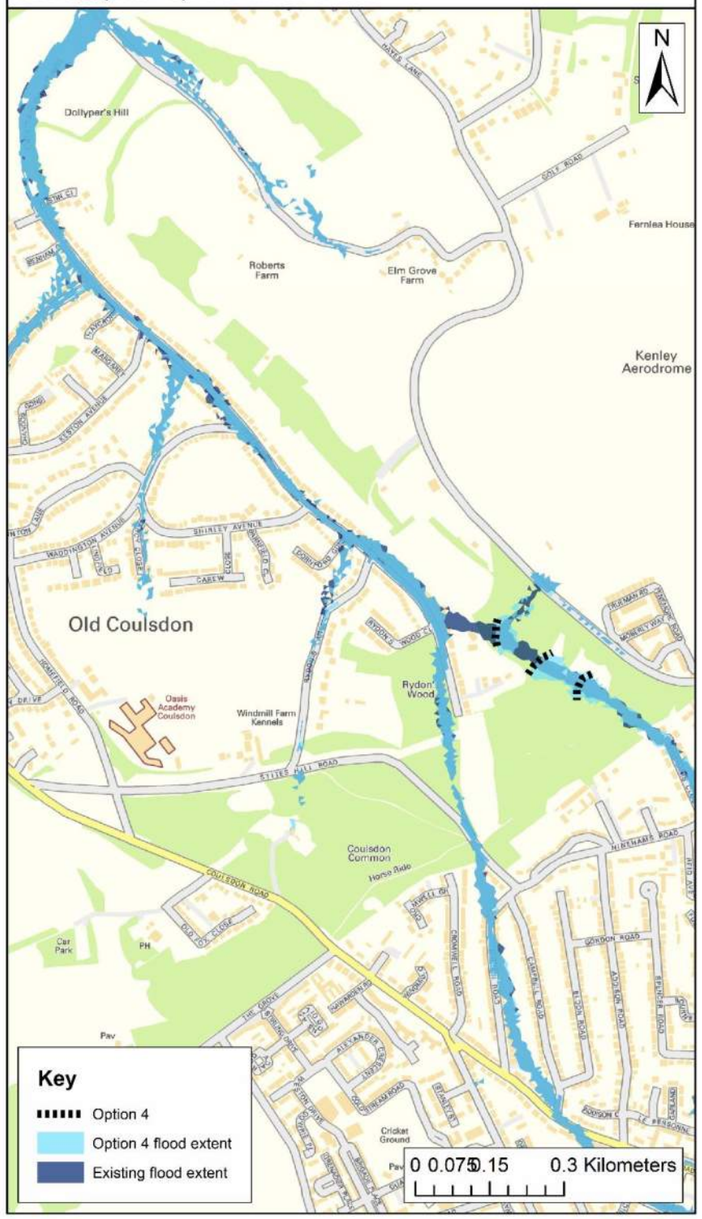
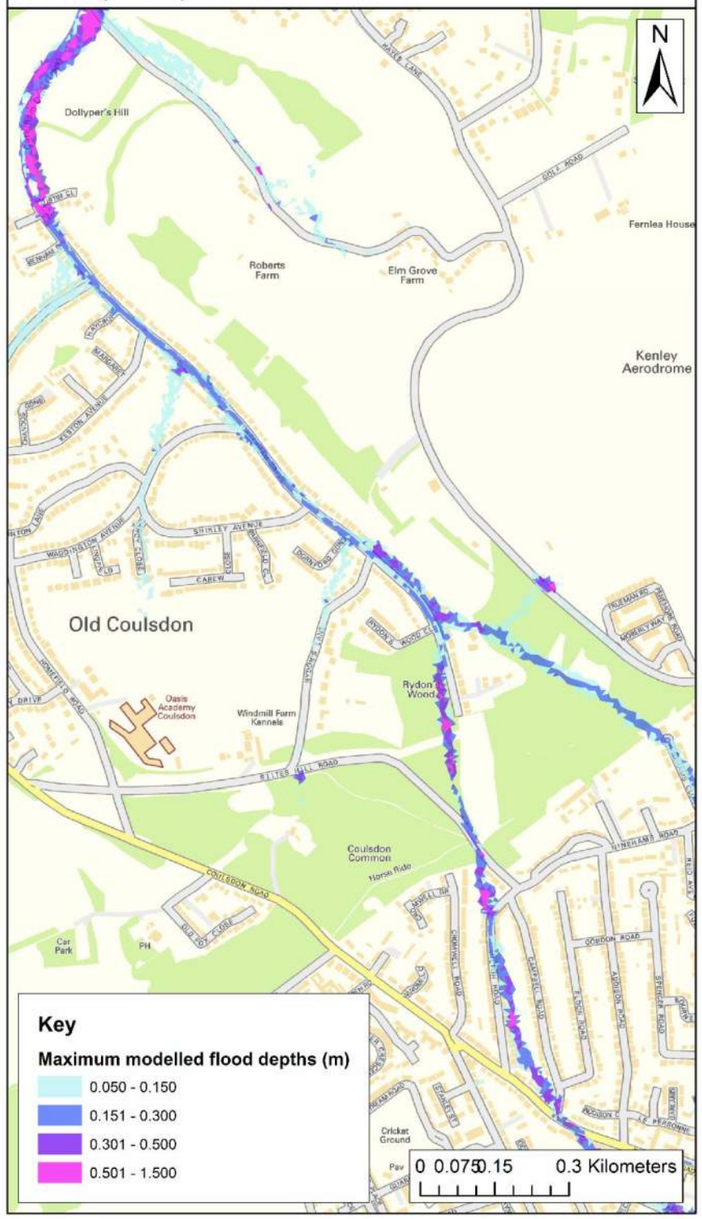


The existing flood extent and depth for the 5% (1 in 20) AEP flood event.



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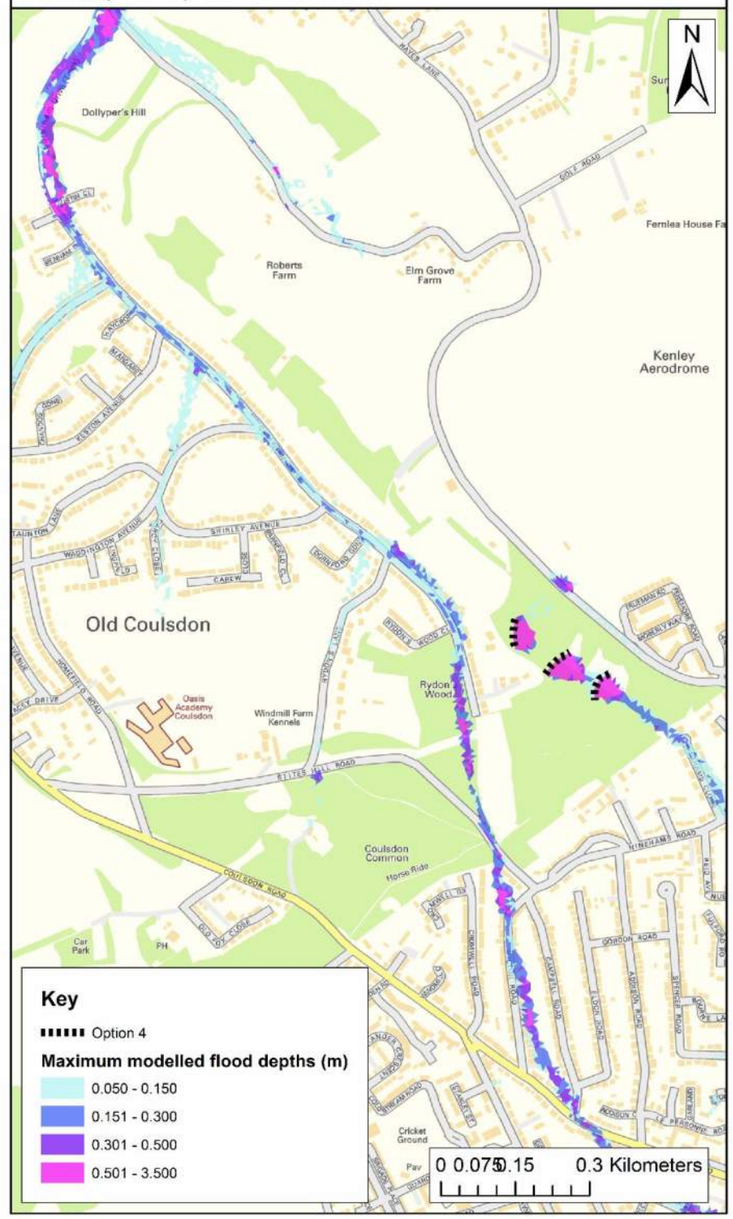

Caterham-on-the-Hill Initial Assessment

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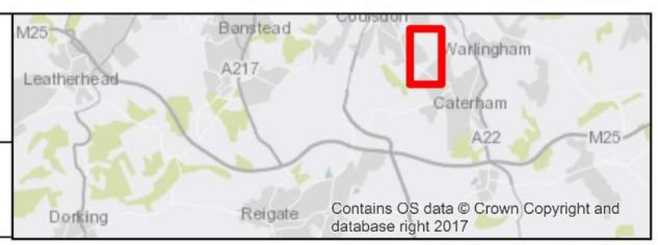

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A comparison of the existing and Option 4 flood extents for the 1.33% (1 in 75) AEP flood event.

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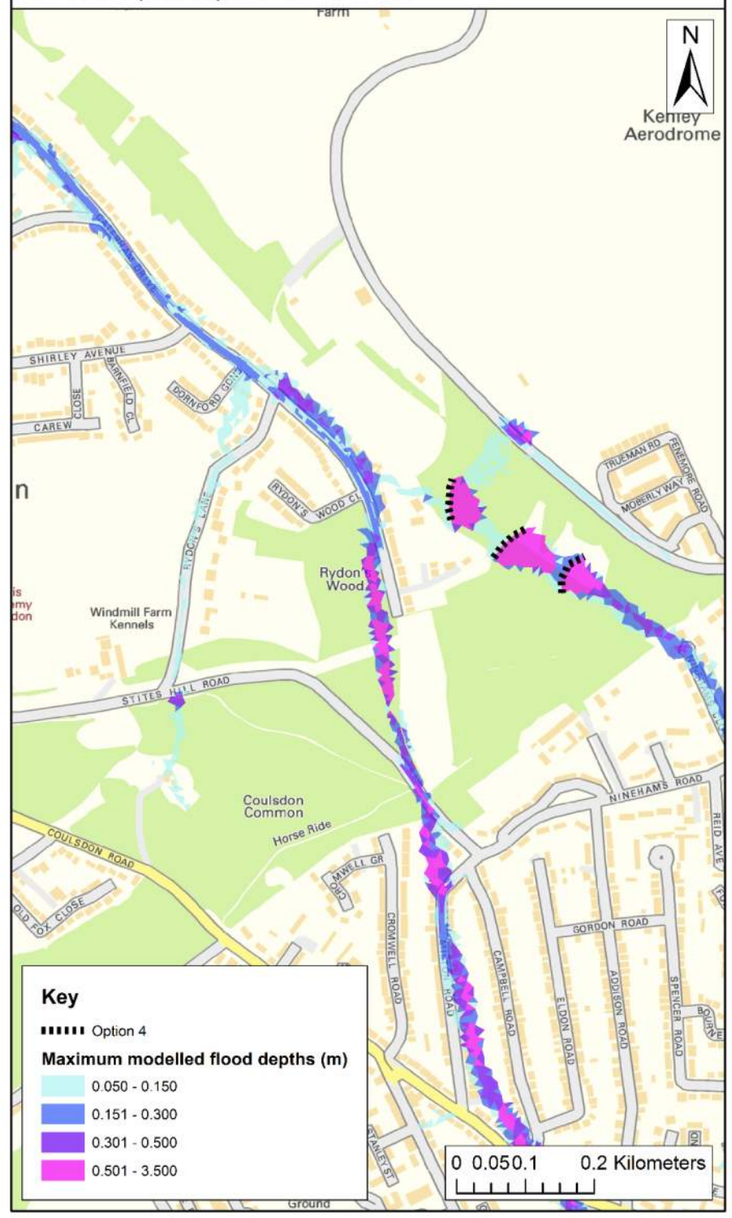

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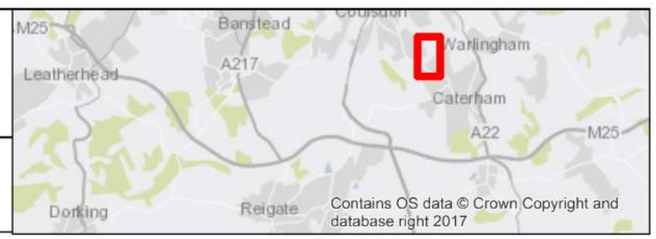

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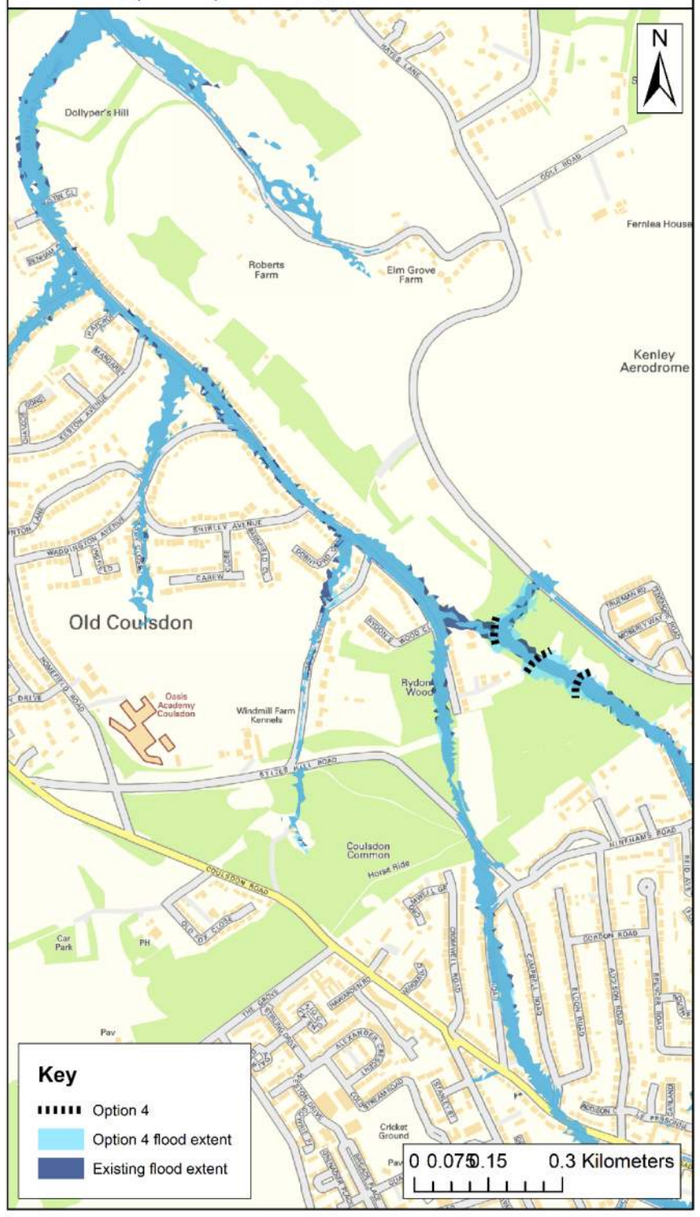

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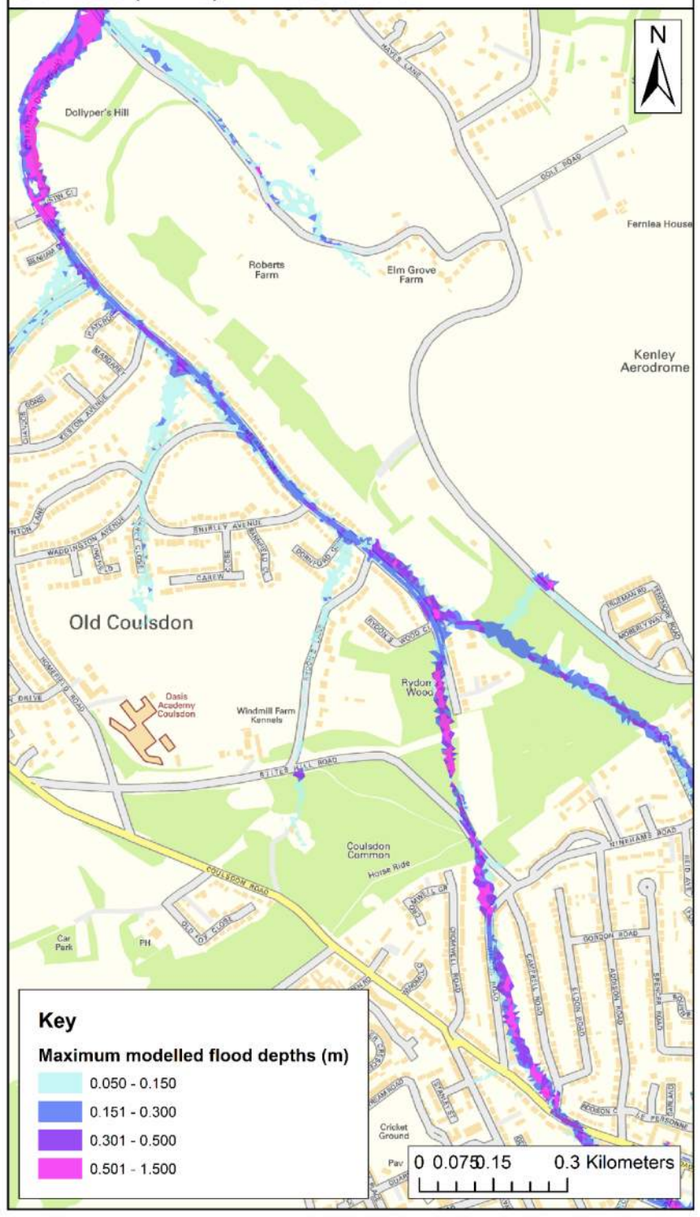

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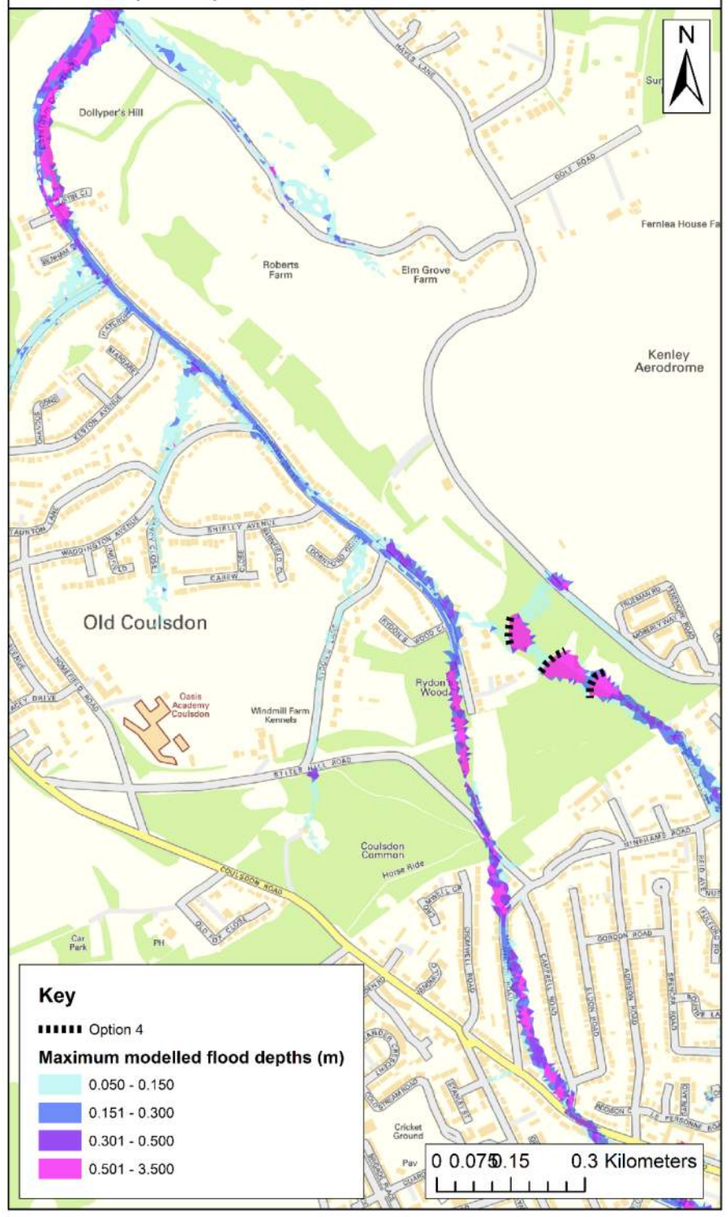

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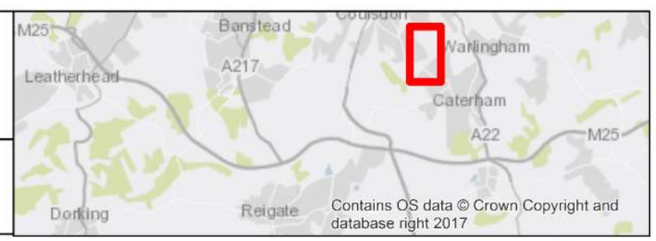

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A comparison of the existing and Option 4 flood extents for the 1% (1 in 100) AEP flood event.

The existing flood extent and depth for the 1% (1 in 100) AEP flood event.

The Option 4 flood extent and depth for the 1% (1 in 100) AEP flood event.

Caterham-on-the-Hill Initial Assessment

Modelled flooding is shown only on the main flow route.

Option 4 is flood storage areas on the eastern flow path on Coulsdon Common.

The flood extents shown are the modelled risk of surface water flooding during an Annual Exceedance Probability (AEP) design event, they do not represent a specific historic event.
Property internal flood levels are typically 0.15 m above ground level. The light blue colour band (0.05 - 0.15 m) therefore represents external flooding.

Reference: 5135062
Drawn: BW 12/01/2018
Checked: CH 15/01/2018

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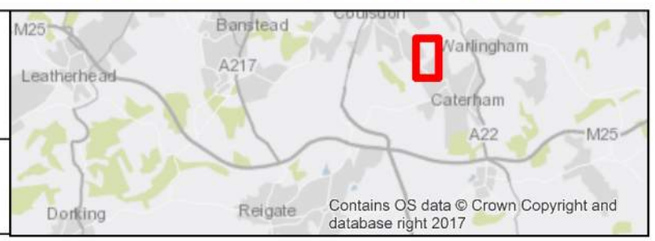

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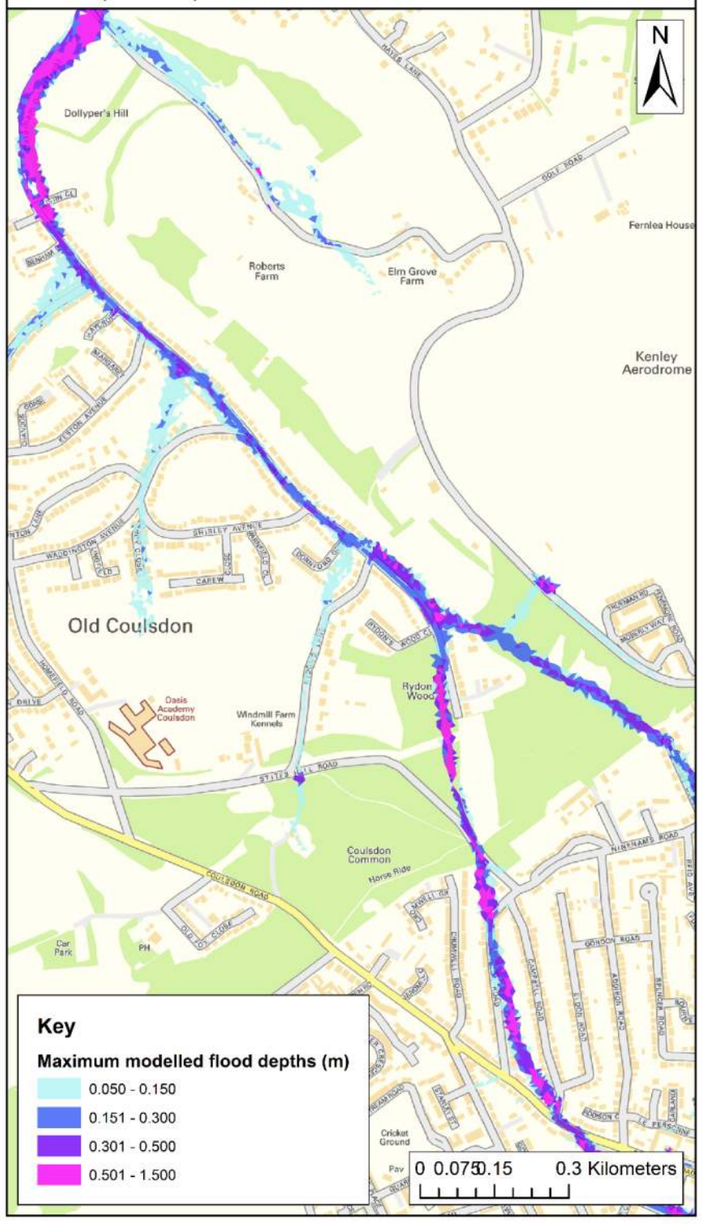
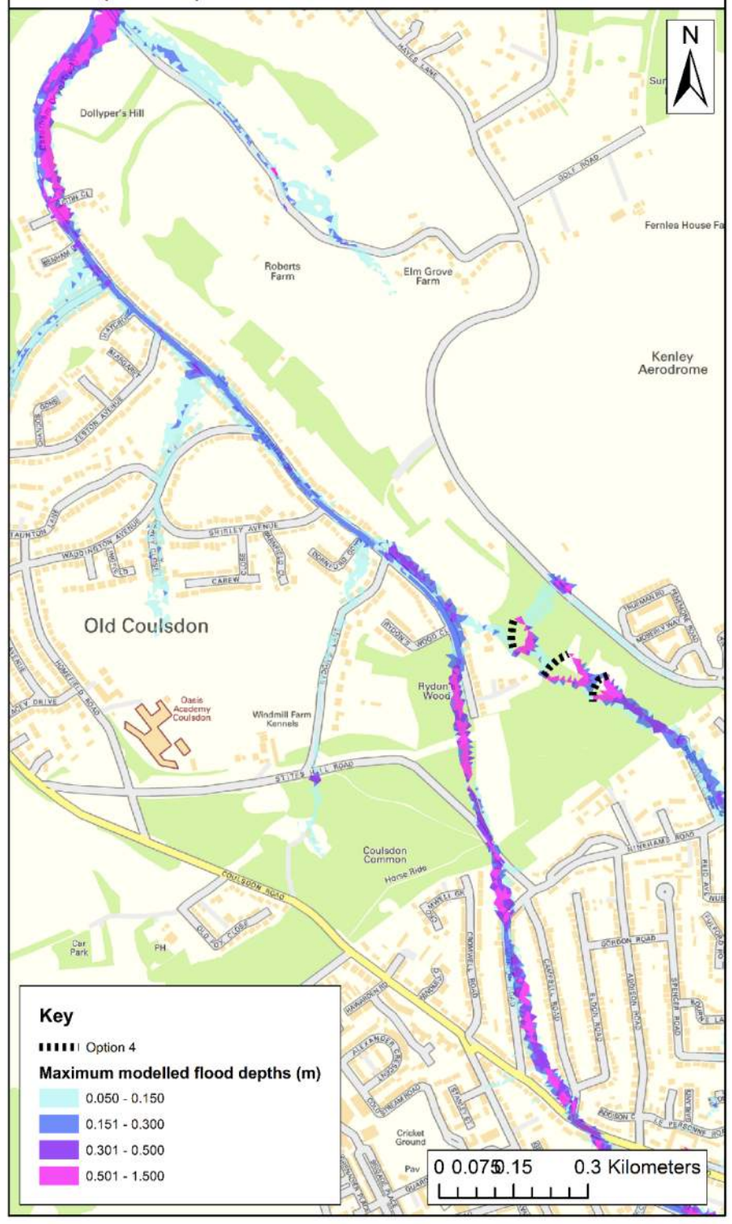


The Option 4 flood extent and depth for the 1% (1 in 100) AEP flood event.



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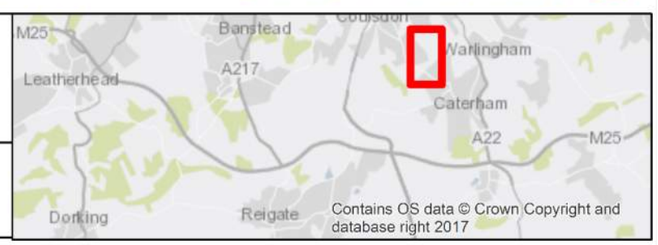

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