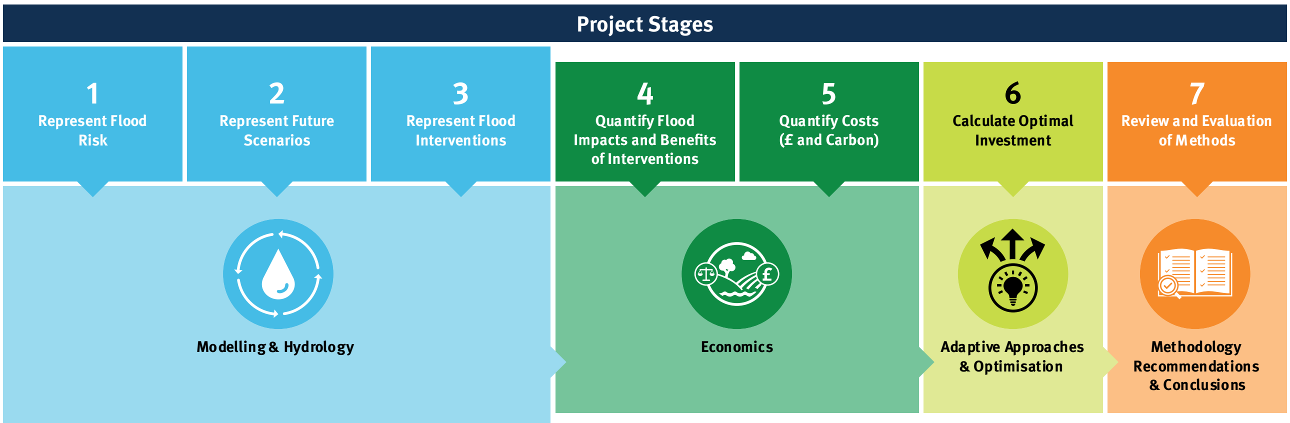
Flood Risk Investment Study

Modelling & Hydrology Technical Report Summary



Overview

The Oxford-Cambridge (OxCam) Arc Flood Risk Investment Study (FRIS) aimed to identify the optimum level of investment in, and timing of, flood protection measures across the OxCam Arc to achieve the highest economic return. The OxCam Arc covers a large part, but not all of, three major UK river catchments. The Thames, the Great Ouse and the Nene. This study only considers the impacts within the OxCam Arc boundaries (Figure 1).

The study modelled current and future flood risk from both rivers and surface water, including tidally influenced river reaches (Figure 1). Climate change and increased built development (new homes, businesses and associated infrastructure) were considered as factors which could have an impact on flood risk now and in the future. Bringing together modelled growth projections and climate change scenarios enabled the project to identify optimum levels and timings of flood risk interventions.

A summary of the hydrological methodology is set out in this summary note. More details can be found in the full Modelling & Hydrology Technical Report. This summary note is part of a series of summary notes which also includes an economic modelling summary, an adaptive approaches & optimisation summary, and an overarching project summary.

Figure 1: River catchments modelled

Climate Change

Fluvial and Sea Level

This study has considered three climate change allowances when predicting anticipated change (the central, upper end, and high ++ – see Table 1). These represent different climate change scenarios based on percentage increases to river flows and an absolute increase to sea levels. They do not consider differences within catchments or future storm and flood duration. These climate change allowances are published by the Environment Agency (Flood risk assessments: climate change allowances, 2020[1]) and were adapted for the project. Climate change allowances were also projected beyond the current guidance timescales to allow the economic assessment to cover the whole study period (100 years from 2020). Only two climate change scenarios were considered for sea level rise impacts. Tables 1 and 2 show the river flow and sea level climate change allowances used.

River basin district	Allowance		Anticipated change to river flows in the '2080s'
Anglian	High++	4.3°C	80%
	Upper end	4°C	65%
	Central	2°C	25%
Thames	High++	4.3°C	80%
	Upper end	4°C	70%
	Central	2°C	25%

Table 1: River flow climate change allowances

Allowance category	Anticipated absolute sea level rise in year 2100 In mm per year (with the total sea level rise in brackets)
Upper end	18.1 (543)
Higher central	13 (390)

Table 2: Sea level rise climate change allowances (Anglian river basin district- the only area affected by sea level rise in the study area)

[1] Flood risk assessments: climate change allowances - GOV.UK (www.gov.uk) - revised in 2021/22 but not incorporated into the study

Surface water

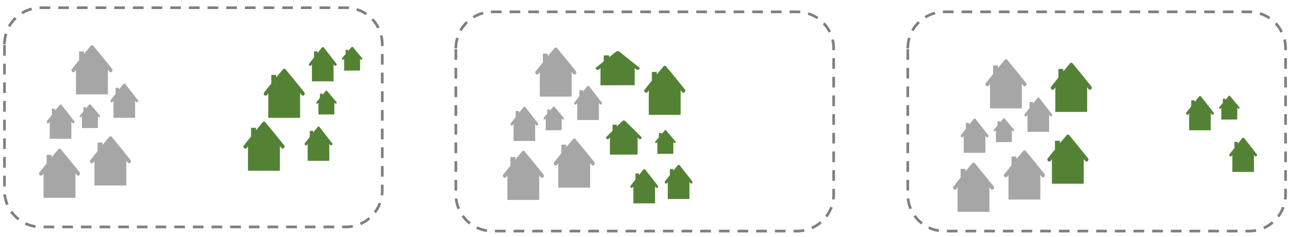
The Environment Agency have also made climate change predictions for the peak intensity of rainfall under different climate change scenarios (Flood risk assessments: Peak rainfall intensity allowance[2]). New modelling was not completed to reflect the increase in rainfall intensity under the climate change scenarios. Instead, the amount of water pooling on the surface during an event was increased by the same percentage as the predicted peak intensity increase, alongside an increased frequency of occurrence. For example, assuming that a 25% intensity increase would result in a 25% increase in pooling surface water, or that an event with a 1% probability of occurring would under climate change increase to a 2% chance.

Built Development Scenarios

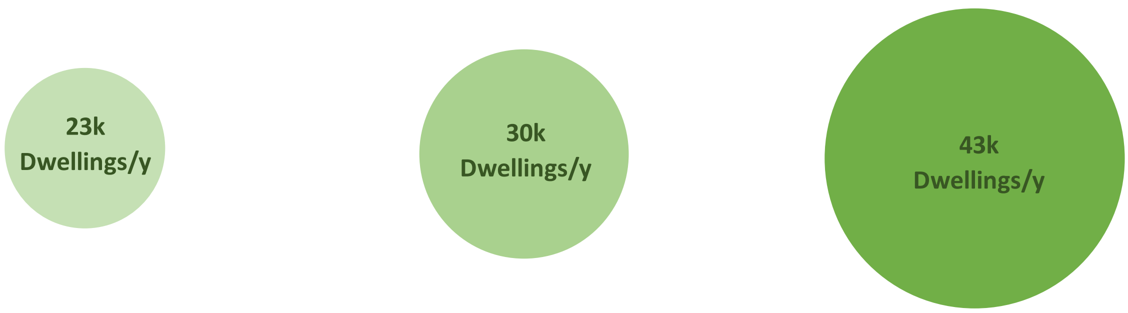
A range of development scenarios for the OxCam Arc were used when undertaking modelling. These were developed by the Infrastructure Transition Research Consortium (ITRC) at Newcastle University. They provide a range of possible future development scenarios rather than representing trajectories indicated in existing Local Development Plans. Multiple (27) future scenarios considering both development type and quantity were created. This was done by feeding population growth estimates into a computer model to estimate the locations of future built development.

Development types

New Town | Urban Extensions | Hybrid



Levels of development



[2] [Flood risk assessments: climate change allowances - GOV.UK (www.gov.uk)](https://www.gov.uk)

Fluvial and tidal

Flood risk modelling approach

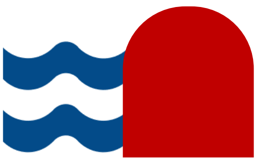
The OxCam Arc spans three significant river catchments; the Nene, the Great Ouse and the Thames. A flood risk modelling approach was needed that would provide sufficient local detail but that could also consider complexities at a regional scale.

Existing linear flood defences were represented in the hydrological model by combining asset information from the Environment Agency and high ground data. Existing in-channel water level data was combined with representative hydrograph profiles in a full hydrodynamic floodplain model. The resolution allowed floodplain features and flow routes to be identified. Peak water levels were identified from the State of the Nation Database (SoN 2018)[3] and were used to provide a consistent set of levels across the study area. An industry standard 2D hydraulic model was used to represent how floodwater spreads across the floodplain. Verification checks with local models (where available) did identify some inconsistencies, however, for the purpose of this regional scale study the SoN water levels were considered adequate. This is an important limitation of the study which reduces the level of confidence when assessing the results at a community level.

It should be noted that the flood modelling approach taken is suitable for economic analysis only, this is due to the number of assumptions made to allow for the large geographical scale modelled.

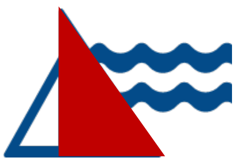
Flood risk interventions

Four types of flood risk interventions were considered: flood storage, Natural Flood Management linear, defences (NFM), and property level resilience (consisting of a generic combination of flood gates, non-return valves, and airbrick covers). Specific planned interventions were not considered. It should also be noted that this study is wholly desk based and as such deliverability testing of these interventions within the study area has not been undertaken.



Storage

Natural Flood Management



Linear Defences

Property Level Protection

3 Internal Environment Agency dataset

Approach to flood storage

In this study flood storage interventions have been modelled to restrict or reduce flow in the upper catchment resulting in a change in water flow downstream. The model interprets these changes in flow as a reduction in damage levels from a given event. Locations of possible flood storage interventions were not considered instead three storage options (small, medium, and large) were used across each catchment as shown in Table 3.

Storage option	Thames (Million m^3)	Nene (Million m^3)	Great Ouse / Cam (Million m^3)
Small *	86	8	6
Medium	265	24	21
Large	1,034,	78	78

Table 3: Storage volumes for each catchment

*still considered a considerable volume for storage

Approach to Natural Flood Management

A similar approach was applied to NFM, by translating a storage volume of water into reduced river flows downstream. However, to reflect the current lack of evidence supporting NFM effectiveness on larger catchments this was only applied at a river tributary and fully rural catchment scale. It was also assumed that NFM interventions would only show impacts during lower order events and not during extreme events.

The flood risk benefits of slowing the flow of water in the upper catchments only has been considered on the impact on flood duration or the timings of flood peaks in the lower river catchments has not been considered.

Approach to linear defences

Five linear defence scenarios were considered by the model, two reflecting the undefended and present day defence scenarios. The other three scenarios reflect increasing defence heights which were determined by calculating the height required to protect homes from certain sized flood events. Each individual defence was therefore raised by a bespoke amount, the mean of these increases are provided below for reference:

1. Undefended. To represent scenarios where defences are not replaced at their end-of-life.
2. Present day defence heights. Using the existing defence levels from the Environment Agency's Sate of the Nation Database[4].
3. Small height increase, both for existing defences and for new ones. Mean increase of + 0.2m.
4. Medium height increase, both for existing defences and for new ones. Mean increase of + 0.4m.
5. Large height increase, both for existing defences and for new ones. Mean increase of + 0.6m.

When increasing the height of a linear flood defence the model represents the reduction in water in the flood plain but does not show the resulting increase to in-channel water levels which could have an adverse impact on downstream locations.

Approach to property level resilience

Property flood resilience measures were not part of the hydrological modelling work package. Instead, they were considered within the economics work package by modifying the financial damage a flood creates by 'removing' properties from the event calculation and adding the cost of resilience interventions per house.

Property flood protection is based on a combination of flood gates, non-return valves, and airbrick covers. This makes up a typical 'resistance' installation up to a 0.6m depth of flooding. These assumptions are based on previous work under the Environment Agency's Long Term Investment Scenario[5] programme, which explored a range of different packages and found that, from an economic optimisation point of view, this combination was almost universally selected. At a local property level, different interventions might be needed in practice.

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[4] Internal Environment Agency Dataset

[5] [Flood and coastal risk management: long-term investment scenarios - GOV.UK (www.gov.uk)]

Surface water

Approach to modelling

The existing 'detailed' Risk of Flooding from Surface Water dataset (RoFSW)[6] and depth information for the three levels of flooding (3.3%, 1% and 0.1% chance of flooding per year) were used. However, it should be noted that the RoFSW dataset does not accurately reflect the depth of flooding within a property, due to finished floor levels often being higher that the surrounding land. Flood depths for each property for each level of flooding were therefore estimated using Ordinance Survey data and topographical maps.

To consider surface water flood risk at this large regional scale a simplified methodology was needed. For example, it was assumed that the amount of water stored within the surface water drainage system was negligible and therefore does not reduce the amount of water pooling on the surface.

Approach to interventions/ development

Interventions: Flood storage was the only intervention type considered for reducing surface water risk. To represent how these interventions changed surface water flood risk, the amount of water pooling on the surface during an event was calculated by reducing by the volume of water held by the 'storage' intervention. New modelling was not undertaken to reflect the reduction of water pooling on the surface, instead, the frequency that each event occurs was decreased. For example, if an event currently has a 2% probability of occurring each year, after building an intervention, that event damage would be reduced to a likelihood of a 1% chance of occurring in a year.

New development: It was assumed that there is no increase in surface water flood risk as a result of new development. This assumes that developers will fully mitigate potential increases in surface water, for example reduced permeability, directly by meeting current planning policy. However, we are aware that in practice sites under 1 hectare or domestic extensions may not be controlled by this policy.

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[6] Risk of Flooding from Surface Water - data.gov.uk

Example output

The flood modelling approach taken, as described in this note, has been designed to provide outputs that are suitable for input into economic analysis only and therefore specific flood modelling outputs are not discussed here.

Table 4 gives an example of the way climate change is expected to influence the number of properties at risk of flooding in the future. It shows characteristically high increases in properties at risk between current day and the central climate change scenario and between the central and upper end scenarios.

Intervention	No climate change	Central	Upper End	H++
No New Interventions	88,537	123,427	147,026	149,824

Table 4: Example future flood risk (number of homes)
Scenario: 1% chance flood, in year 2050, with 30,000 homes having been built each year under a hybrid development type

Document Hierarchy