Case study 42. Debenham Flood Storage Options – flood modelling and economic assessment

Author: Will Todd

Main driver: Flood risk management

Project stage: Modelling and business case development

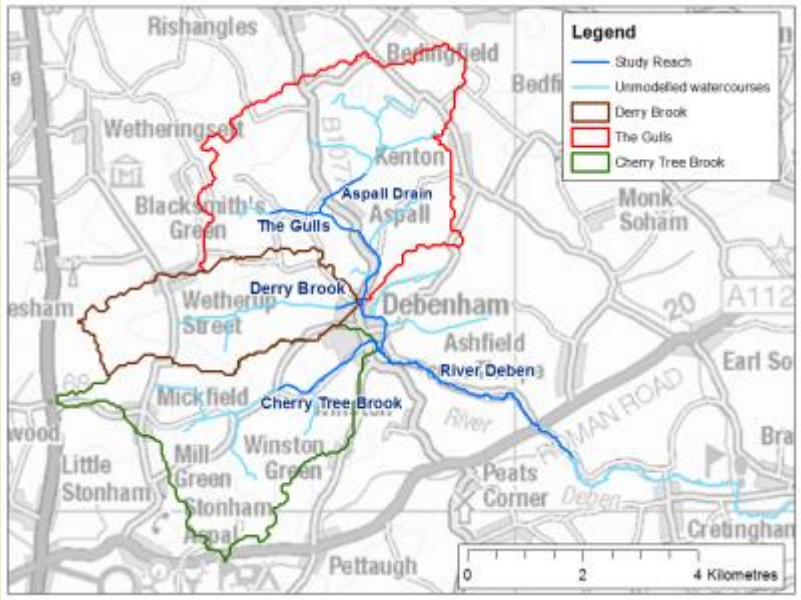
Photo 1: Flooding in Debenham in 1993 (source: local resident, Peter Carter)

Project summary:

Debenham (Map 1) has suffered from historic flooding, most notably in 1912, 1936, 1937, 1944, 1947, 1956, 1968 and 1993. Managing flood risk in the village town is complex because 3 tributaries of the River Deben meet in the village and the costs of many traditional flood management measures are prohibitive. This case study uses hydraulic modelling to assess the effect of 10 Natural Flood Management (NFM) features on flood risk in Debenham and establishes their effect on property damages for a range of return periods.

Key facts:

Modelling has shown that installing 10 NFM features providing 34,250m^3 of storage across 3 subcatchments (~34km^2) that drain in to Debenham would reduce the annual average damages to properties and farmland by 31%. The proposed NFM measures would also reduce the total numbers of properties at risk of flooding across all return periods. For the 1 in 10 and 1 in 20 year flood events, installing NFM features reduces the risk of flooding for 24 properties. Total damages to properties across all return periods would be reduced. For example, for the 1 in 75 year flood event installing NFM features would reduce total property damages by £421,400.



Map 1. Location of Debenham (source: www.greensuffolk.org/flooding/hwmp/debenham-flood-management-project/)

1. Contact details

Contact details	
Names:	Will Todd, Jane Burch, Kevin Haseldine
Lead organisations:	Environment Agency, Suffolk County Council (River Deben Holistic Water Management Project)
Partners:	Environment Agency, Essex and Suffolk Rivers trust, Suffolk County Council, JBA Consulting
e-mail address:	William.Todd@environment-agency.gov.uk jane.burch@suffolk.gov.uk Kevin.Haseldine@jbaconsulting.com

2. Location and catchment description

Catchment summary	
National Grid Reference:	TM1786463388
Town, County, Country:	Debenham, Suffolk, UK
Regional Flood and Coastal Committee (RFCC) region:	Anglian East
Catchment name(s) and size (km^2):	East Suffolk catchment, ~34km^2
River name(s) and typology:	The Gulls, Derry Brook and Cherry Tree watercourse (tributaries of the Deben). A relatively steep catchment underlain by gravel, silts and clays

Water Framework Directive water body reference:	GB105035046200
Land use, soil type, geology, mean annual rainfall:	Agricultural Deep clay and seasonally wet loam, sand and gravel Average annual rainfall: ~590mm

3. Background summary of the catchment

Socioeconomic/historic context

The name Debenham is derived from the Old English words likely to mean the village in a deep valley. There is likely to have been settlements in this area since Roman times. The main source of employment in the river catchments around Debenham has been farming and dairying.

Flood risk problem(s)

Debenham has suffered from historic flooding, most notably in 1912, 1936, 1937, 1944, 1947, 1956, 1968 and 1993 (see Photo 1). The management of flood risk to Debenham is complex due to the 3 tributaries of the River Deben meeting in the village and the costs of many traditional flood management measures are prohibitive. Thus a combination of several different ways to reduce risk are being explored, including slowing the rate at which flows enter the river network and potentially getting the water away faster beyond the confluence of the tributaries.

Working with landowners, Suffolk County Council and the Essex and Suffolk Rivers Trust, a range of measures were identified which could help reduce flooding in Debenham and also provide water quality and habitat benefits. These are known as Natural Flood Management (NFM) features (for example, as small flood storage areas and ponds). The most promising 10 NFM features were incorporated into a hydraulic model to assess their potential benefits and to ensure that they would not result in additional flooding to other properties. The model showed that together the NFM proposals could reduce flood risk in Debenham in smaller more frequent flood events, but that further measures would also be needed.

The larger flood storage reservoirs, which are modelled on The Gulls and Derry Brook, significantly reduce water levels in Debenham. However, the construction and maintenance costs of these features are much greater than the benefits they provide. Likewise, investigations into creating a 2-stage channel to help improve the flow of water away from the village have found it would cost more to construct than the benefits it would provide. The funding provided by the government is a fixed amount based on the benefits a project provides. As a result, significant funding from other sources (public and private) would be required to progress these features.

Other more conventional options for flood management such as property level resilience and improving the flood warning service in the village are also being considered.

Detailed discussions with landowners are now underway to finalise the size and characteristics of the NFM features and management principles. The next stage is to seek consents for some of the features before installing them. The next phase of work will be to consult more widely with the local community about the proposals and to develop preferred options. Funding is available for the current appraisal works and the creation of the NFM features, but additional sources of money, beyond Flood Defence Grant-in-Aid, will be required to implement any other options.

Other environmental problems

Watercourses around Debenham also suffer from water quality problems due to diffuse pollution and are at risk of low flows during periods of drought.

4. Defining the problem(s) and developing the solution

What evidence is there to define the flood risk problem(s) and solution(s)

The Environment Agency and Suffolk County Council had worked with the local community to discuss their flood risk problems and to help define potential solutions that they would find acceptable. A number of landowners agreed that, if feasible, they would be interested in allowing NFM features to be constructed on their land. They also agreed to some indicative dimensions for these features so that they could be modelled (though they remain provisional, subject to future discussions with landowners and other stakeholders).

A 1D-2D hydraulic model (ISIS-TUFLOW) was developed for the 3 main river channels flowing through the village. This model was used to inform a high level cost–benefit analysis for a range of NFM features (all storage ponds) in the upper catchments. The JFlow+ model was used to quantify the impact of the surface water NFM features on peak flows further down the catchment by modelling the catchment response to rainfall before and after the implementation of NFM features. The changes in peak flows were then incorporated into the ISIS-TUFLOW model to assess the impact of the NFM features on flood risk within Debenham.

It was found that the NFM features would reduce peak inflows to the hydraulic model, with reductions in water levels in Debenham most pronounced on the downstream reach of Cherry Tree Brook. Reductions in water levels would be seen on The Gulls upstream of the village, but these would be much less significant in the village itself around Market Square – probably a result of the un-attenuated tributary inflows (most notably from Derry Brook). In general, the NFM features have the effect of reducing flood peaks. There are also minor delays in the timing of peaks due to the attenuating function of the storage areas.

What was the design rationale?

The project has not yet reached the design stage. The study has focused on modelling the impacts of the scheme.

Project summary	
Area of catchment (km^2) or length of river benefitting from the project:	~34km
Types of measures/interventions used (Working with Natural Processes and traditional):	To be confirmed (when scheme designed)
Numbers of measures/interventions used (Working with Natural Processes and traditional):	10 NFM features which together provide 34,250m3 of storage across 3 subcatchments
Standard of protection for project as a whole:	To be confirmed once final scheme is agreed
Estimated number of properties protected:	From 2 up to 24, but varies across different return periods (see Table 1)

How effective has the project been?

To assess the economic impact of the NFM features in Debenham, damages were compared between baseline scenarios for a range of flood events with and without NFM features. Costs per flood event and average annual damages for the estimated damage incurred per year were assessed. As well as

damages to property, the potential cost of flooding to both roads and agricultural land were also assessed.

Table 1 summarises the numbers of properties that would flood for a range of return periods and how these numbers would change if NFM schemes are installed. The change in flood extents resulting from installing NFM features would lead to fewer flooded properties at all return periods, though this impact is most noticeable at shorter return periods. At longer return periods, these features are mostly at capacity, reducing their impact in reducing flood flows.

Table 1: Impacts of NFM features on cumulative flood property counts

	Number of flooded properties			
Return period (years)	Baseline	NFM	Change	Change (%)
2	5	3	-2	40
5	27	15	-12	44
10	52	28	-24	35
20	76	53	-23	30
75	112	97	-15	13
100	117	110	-7	6
1,000	177	172	-5	3

Table 2 shows how installing NFM measures would affect property damages for each modelled return period. The NFM features result in a significant reduction in property damages, especially at short and medium return periods. This reflects the design characteristics of NFM structures; capacities are small, and filled during the rising stage of larger return period flood events, reducing the impact on peak flows. The effect of NFM features on economic damages relates to reductions in spatial flood extent (number of flooded properties) and flood depths (damage within each property flooded).

Table 2: Impact of NFM features on total property damages

	Total damages			
Return period (years)	Baseline (£ thousands)	NFM (£ thousands)	Change (£ thousands)	Change (%)
2	45.9	29.7	-16.2	35
5	191.3	105.0	-86.3	45
10	385.0	219.6	-165.4	43
20	751.8	473.2	-278.6	37
75	1,763.8	1,342.4	-421.4	24
100	2,006.0	1,631.9	-374.1	19
1,000	4,977.8	4,671.5	-306.4	6

Property damages are dominant in Debenham, whereas agriculture damages are more significant at shorter return periods, accounting for a larger proportion of total damages. Property damages gradually increase in significance; at longer return periods, these costs account for almost all damages. Moreover, property damages decrease in significance as a result of NFM features in the catchment. This is important in demonstrating the potential change in flood impacts on the Debenham community

This study explored the impact of NFM features in the river catchments draining to Debenham, and on flood risk and economic damages in the village. NFM features are very effective at reducing both flood extents and depths, as well as economic damages. Using the features specified by local landowners and the Environment Agency, a 31% decrease in annual average damages could be achieved (Table 3). Most of this figure is attributable to reductions in property damages at all modelled return periods. At any given return period, this is a result of removing properties from flooding entirely or reducing the flood depth in a particular property. Damages to agricultural land are also reduced due to the reduction in flood extents when the NFM are incorporated.

Table 3: Impact of NFM features on annual average damages

	Annual average damages			
Type	Baseline (£ thousands)	NFM (£ thousands)	Change (£ thousands)	Change (%)
Property	193.1	132.5	-60.6	30.8
Agriculture	2.2	2.0	-0.2	10.2
Combined	195.3	134.5	-160.8	31.1

5. Project construction

Construction has not yet begun.

6. Funding

Not applicable as project still at the assessment stage.

7. Wider benefits

What wider benefits has the project achieved?

Once constructed, the project will have water quality benefits as the NFM features will trap diffuse pollutants. Opportunities to construct a 2-staged channel are also being explored, which will provide biodiversity, water quality and flood risk benefits. Two-staged channels are also beneficial during times of low flow, providing refuge to invertebrates and fish during droughts.

How much habitat has been created, improved or restored?

Information is not available at this stage.

8. Maintenance, monitoring and adaptive management

Not yet applicable

9. Lessons learnt

What was learnt and how could it be applied elsewhere?

Early engagement with landowners is seen as essential in this catchment, as without their buy-in NFM would not be possible.

Every effort has been made to reconcile the performance of the JFlow+ direct rainfall model and the ISIS-TUFLOW model. Obtaining gauged data using temporary flow monitoring to help refine the baseline flood risk to the community has been beneficial.

The inflow hydrographs to the ISIS-TUFLOW model were scaled based on the difference in peak flows between scenarios in the JFlow+ model. However, this does not fully account for the differences in hydrograph volume. A more detailed analysis on each subcatchment and group of NFM features could develop this approach, potentially adjusting only a portion of the hydrograph to represent the effect of the NFM features on the full flow hydrograph more closely.

In some locations, the design and extent of the proposed NFM features were modified slightly to improve performance. However, there remains scope for the design of these features to be optimised to further improve flood risk benefit. The economic damage analysis could be expanded with further information including traffic data, crop types and infrastructure. This would provide results for a greater variety of receptor types.

10. Bibliography

JBA CONSULTING, 2015. *High level assessment of flood storage options in Debenham: Phase 1 – Natural Flood Management*. Skipton, North Yorkshire.

Suffolk County Council, undated. *Debenham Flood Management Project* [online]. Available from: http://www.greensuffolk.org/flooding/hwmp/debenham-flood-management-project/ [Accessed 28 September 2016].

Project background

This case study relates to project SC150005 'Working with Natural Flood Management: Evidence Directory'. It was commissioned by Defra and the Environment Agency's Joint Flood and Coastal Erosion Risk Management Research and Development Programme.