# Defra Floods Competition

## A Dutch Approach:

### Integrated solutions…

### …Through collaborative partnership…

### …Based on advanced modelling

**Abstract**

This submission presents three elements of the Dutch approach to flood risk management, applied to the Eden Catchment to inspire the Cumbria Flood Partnership and illustrate how these approaches could help develop solutions.

Integrated solutions require a catchment approach, but also an ambition to achieve other objectives, within water management but also beyond. Dutch examples such as Lent and Zandmotor show that this can improve both flood risk management and spatial quality. For the Eden Catchment, it may be possible to turn some of Carlisle's challenges into opportunities.

An integrated approach requires true collaboration from the outset. We present the MapTable tool which enables interactive collaborative optioneering. It translates modelling to a visual presentation of the risk and opportunity metrics that matter to a range of stakeholders and enables on-the-spot option development.

Interactive optioneering requires rapid but adequate modelling. The 3Di modelling suite makes this possible because of its ultra-efficient structure, opening up new possibilities for visualisation and immediate scenario testing.

The initial solutions we developed for Willow Holme in Carlisle could be interesting, but the main aim of this submission is to illustrate an approach that could be applied to the whole Eden Catchment, and elsewhere in England.

## Preface

Water is life. Water defines the quality of our world. In The Netherlands we turned our vulnerable position into our asset. Flood risk management became a matter of existence for The Netherlands, a way of life, defining our culture. Our water-governance system is older than our Kingdom, water democracy still teaches us how important excellence, innovation and collaboration is. We invested in a robust system throughout the last 1000 years and will do so for the centuries to come. All enabled by good governance, adequate funding and innovative research. This is embedded in our collaborative approach, our 'polder model' where all stakeholders join forces to achieve the highest standards for the safety and quality of our land and across the world. The government of The Netherlands has the explicit ambition to collaborate globally and make this knowledge available world-wide, building up strong coalitions in places at risk and helping to increase resilience and reduce flood damages.

The Dutch government is therefore proud to support and endorse the Dutch Approach submission to the Defra Floods Competition, proposing the use of advanced modelling and interactive tools to help develop multi-functional solutions for the Eden Catchment in Cumbria. We see it as an excellent example of the much needed collaborative approach and the careful translation to the local context that is essential for the application of Dutch approaches worldwide. The submission also illustrates the Golden Triangle approach in which public, private and academic organisations work together for the best possible results.

The water collaboration between the United Kingdom and The Netherlands is built on a long tradition and history of partnerships. We sincerely hope that all partners can join hands in increasing this partnership for a safe and water-secure world. Because to change the world on water we need transformative and inspirational projects that can be scaled up and replicated and inspire others to step up and act on climate change and water challenges.

Simon Smits
Dutch Ambassador to the United Kingdom

Henk Ovink
Special Envoy for International Water Affairs

## How could a Dutch approach benefit the Eden Catchment?

### *Flooding in Cumbria: working toward solutions*

The floods in the UK in the winter of 2015/16 were headline news in the Netherlands, and there was a strong sense of sympathy from the Dutch public with the suffering communities.

The frequent occurrence of extreme rainfall events, the legacy of homes and infrastructure in areas at risk together with limited available funding create an extremely complex problem. Since 10 years, flood risk management in England is leading the world in aiming for a portfolio of measures, and in combining flood resistance with resilience. This is the right approach, but as the emerging Cumbria Flood Plan recognises, this will have to be ramped up further to deal with the challenges for UK catchments like the Eden and places like Carlisle.

### *Not 'Bring in the Dutch', but support local decisions*

When flooding occurs anywhere in the world, including in England, there is sometimes a call from the media to 'bring in the Dutch'. Understandable in a way, because much of the Netherlands is below sea level, and still there is hardly ever any flooding, because of a very effective flood risk management system. However, our experience world-wide, including in England, has made very clear that a simple copy – paste of Dutch solutions is nonsense.

The Dutch system is rooted in its particular geography, history and culture, which gives flood risk management an overarching priority in society. Over time this has enabled Dutch engineers, scientists and policy makers to develop a physical system to reduce the likelihood of flooding to a very low level, backed by a robust legal and institutional framework, supportive politicians, adequate funding and supported by strong research and development. Society's ongoing sense of urgency enables continued evolution of the Dutch flood risk management system, nowadays including building with nature, enhancing resilience and further integration with spatial planning. Processes are in place to enable the radical innovations needed for climate change adaptation, and policy makers appreciate that such innovation carries a financial risk.

In England flooding is important, but not an existential threat to the nation. It therefore has to compete much more with other issues such as health care, education, transport. In addition, the nature of the risk is very different: much more diverse, and with a very different balance of probability and consequence. The Eden catchment illustrates this point. As a result, Dutch approaches can't be applied directly; however, they can inspire, and if translated appropriately to the UK context, they can support the development of solutions that work locally.

*Our submission*

We welcome the opportunity provided by the Defra Floods Competition to propose exactly that: we don't pretend to have the solutions for the Eden catchment, but instead propose some innovative techniques and planning approaches that have been tried and tested in the Netherlands, translated to the context of the Eden catchment, and compatible with the principles of the Cumbria Flood Plan. Our aim for this submission is to inspire the Cumbria Flood Partnership, and also the other catchments in England, and support them in developing their catchment-specific solutions.

## Our proposed ‘Dutch approach’ consists of three elements:

*Integrated solutions…*

Flood risk management is better if integrated with other objectives. It can be more effective by combining functions, more affordable by attracting other funding streams, and more efficient by sharing resources. An integrated approach can shift the mindset from ‘preventing something bad’ to ‘creating something good’: a focus on opportunity.

In the Netherlands, for recent multi-billion € flood alleviation programmes such as Room for the Rivers and Coastal Weak Links, the flood related aspects were funded nationally. However, they all had an explicit double objective to also improve spatial quality, to be developed with and typically partly funded by local beneficiaries. This has produced world-renowned examples of integrated projects like Lent, Zandmotor, Overdiepse Polder, Katwijk, Scheveningen Boulevard. In some of these cases, the flood risk investment has enabled the realisation of existing spatial ambitions; in other cases the spatial enhancement has improved the flood risk solution.


**Car park integrated in flood defence dune & the Zandmotor (photo Joop van Houdt, Rijkswaterstaat)**

In the UK a similar ‘top-down’ process is unlikely to emerge, but partnership funding does enable a bottom-up process for combining functions and funding streams. We have made a basic assessment of the socio-economic, environmental and infrastructural context for the Eden Catchment, and have used this to identify potential opportunities to illustrate the benefits of an integrated approach.

*…Through collaborative partnership…*

Integrated flood risk management requires true collaboration from the outset: a joint problem analysis, followed by joint design. That is what our experience with programmes such as Room for the Rivers and Coastal Weak Links demonstrates: it is essential to start from a position of agreement about the issues to be addressed and the (multiple) objectives of the plans.

Various methods and tools were developed to enable collaborative planning and design processes in these recent Dutch programmes. We are presenting the MapTable approach: this brings together the results of modelling and other geographical data in such a way that partners can design and test their own measures interactively, supported by objective modelling. Impacts on risk and opportunity are calculated immediately using advanced modelling, and shown to the partners in terms that reflect each of their objectives.

We have developed a MapTable application for part of the Eden catchment, reflecting both the hydraulic and the socio-economic situation, to illustrate how this approach could work for the Cumbria Flood Partnership.

### *…Based on advanced modelling*

A fast and robust understanding of how water flows through the catchment is essential. 3Di is a revolutionary new modelling suite for hydrological and hydraulic modelling, developed and managed by a partnership of Dutch private, public and academic organisations. Its ultra-efficient computational structure enables much more detailed and faster modelling: 1000 times faster than e.g. Sobek. This opens up new possibilities for visualisation and immediate scenario testing. 3Di allows tracking the water from rainfall to discharge at catchment scale, routing it through the catchment via the drainage and river network, following its course across the land surface and finally into and through streets and buildings.

We have developed a 3Di model for part of the Eden catchment, and connected this model, as well as a flood impact model, to the MapTable application to illustrate our approach.

### *This submission*

Our submission aims to illustrate how the actions from the Cumbria Floods Plan could be assessed, developed and enhanced through advanced modelling, interactive collaborative design and an integrated planning approach.

For illustration, we have selected a particular area in Carlisle, Willow Holme, for more detailed analysis and optioneering. This is a specific case, but we are keen to stress that this is for illustration only: the proposed approach and its three elements apply to the catchment as a whole and its sub-catchments.

The essay describes our appreciation of the challenge for the Eden Catchment, and then describes the three elements of our approach: advanced modelling, collaborative partnership and integration with spatial planning. These three elements are then drawn together for the identification of potential solutions, focused on the Willow Holme area, to illustrate our Dutch approach.

## Our appreciation of the challenge for the Eden catchment

### *How to attract investment in a flood prone area*

An initial assessment based on the competition brief, our expertise and publicly available information suggests that Cumbria is facing some major challenges. Recent history clearly shows the Eden Catchment's high vulnerability to flooding. This 'flood proneness' is caused by an unprecedented sequence of heavy rainfall events in recent years, catchment hydrology, land use and the presence of vulnerable communities, businesses and infrastructure in the flood zone.

Cumbria is geographically disconnected from major National and international markets, making it difficult to attract investments. The region struggles with multiple socio-economic challenges such as an ageing population, young people migrating to larger cities, and a declining rural population. In addition, Cumbria County faces significant cuts in government spending.

We have analysed Carlisle in more detail. Its location at the confluence of three rivers and the presence of housing and infrastructure in the floodplain make the city particularly flood-prone. As Cumbria's largest city and regional economic centre, Carlisle is still attracting new residents and expects an increase in housing demand. The current housing stock needs significant improvements and there is a need for more affordable housing. The city's ambition is to keep its centre attractive for visitors and investors and to strengthen the city's position as a university town, to attract students.

Increasing community resilience against extreme weather is not only necessary for facing the changing climate but is also essential for stimulating investment.

### *Seen from a Dutch perspective*

From a Dutch perspective, the nature of the flood risk in the Eden catchment is very different: a much larger probability, but with much smaller consequences if flooding does occur. Only relatively small and fragmented parts of the area are directly at risk, although a larger area will be affected indirectly. The spatial fragmentation of the risk suggests that it is relatively more expensive to reduce risk than it is in the Netherlands: large-scale measures are unlikely to be feasible in the Eden catchment. As a result, the flooding problem can't be controlled by applying a traditional Dutch flood defence approach. Reducing the probability of flooding has to be part of the plan, but there has to be much more emphasis on living with the residual risk. This balance has of course been present in English flood risk management since Making Space for Water in 2005, and it is also recognised in the current plans for the Eden Catchment: a portfolio of solutions that aims to optimise the return on investment.

*The Cumbria Floods Plan as a starting point*

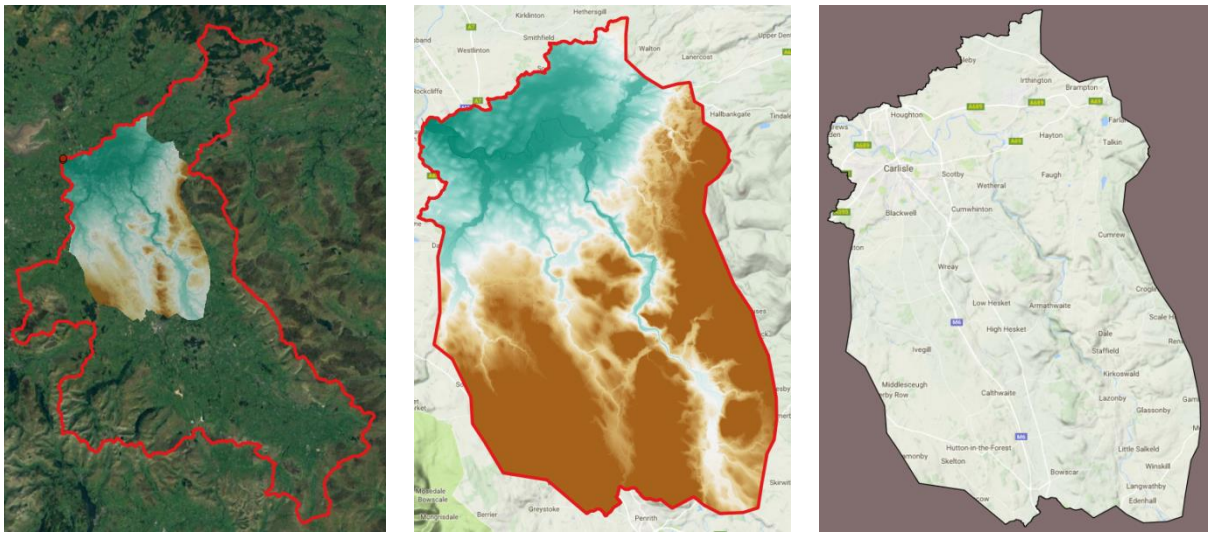
The actions for the Eden Catchment proposed in the Cumbria Floods Plan are a combination of upstream measures, reservoir management, community approaches and local flood risk reduction schemes. We are aware this is based on a long history of catchment knowledge and partnership working, so we see this as a starting point for our analysis.

The Plan clearly reflects the ambitions and current high profile of catchment-based approaches. It is right to explore this approach and optimise its use, while noting existing evidence of the difficulty to achieve significant flood level reductions, e.g. for the Rhine and Meuse catchments (NCR, 2003).

In addition, the Cumbria Floods Plan shows a clear and positive ambition to integrate issues and funding streams within Defra. The Cumbria Floods Partnership includes a much wider group of stakeholders. This presents an opportunity to look even further: to make flood risk management part of the wider socio-economic and environmental challenges of the region, and move beyond the hydrological catchment to the socio-economic ‘catchment’. Although socio-economic information suggests that the area struggles to attract investment, the local plans include ideas to address these issues, and it may be possible to connect these ideas to flood risk management.

## Element 1: Advanced modelling

We have applied the 3Di modelling software to part of the Eden catchment to illustrate 3Di's strengths and to provide baseline information to feed into the MapTable tool (see next section). For the construction of the grid, we have combined high resolution 2x2 m LIDAR data with available 30x30 m data.



a) The Eden catchment b) Elevation in focus area c) Topographic features

**Figure 1 Model area**

The aim of the modelling was to reproduce the flood extent as described in the Carlisle flood incident report (Environment Agency, 2016). To achieve this, we simulated a six hour high discharge period followed by two consecutive rain events. Due to 3Di's efficient structure this simulation was done in only 3 minutes, illustrating the possibility of interactive optioneering as proposed in the next chapter. Figure 2 shows the chosen discharge boundary locations with blue icons; Figure 3 shows the extent of one of the rainfall events. These figures show 3Di's interface, which is basically a 'google map' with water flowing on top of it.

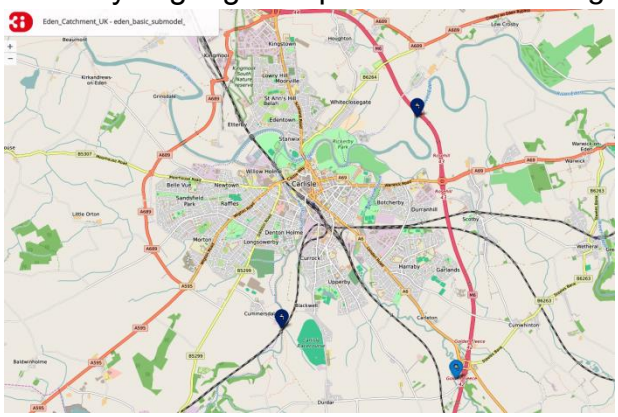


**Figure 2: Location of discharge points**

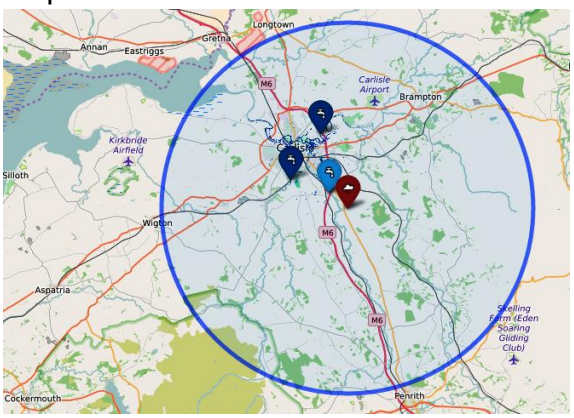


**Figure 3: Spatial coverage of the second rain event**

Although the 3Di interface is easy to use, the underlying data and computation core are very advanced, based on all relevant hydrologic processes and solved with an innovative mathematical calculation scheme called the subgrid method.

The comparison between Figures 4 and 5 shows that the maximum flood extent is adequately represented for Carlisle and the Willow Holme area, for the purpose of this exercise.

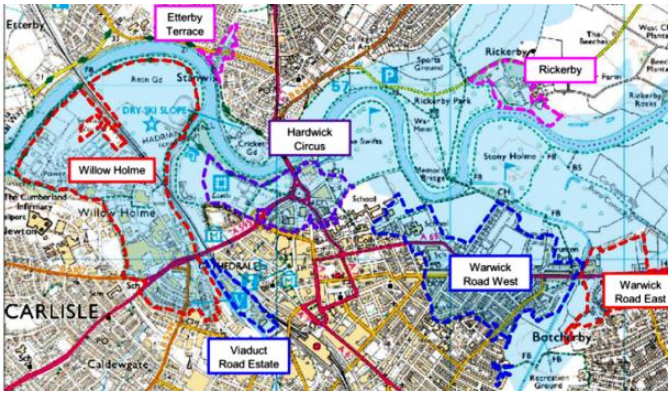



**Figure 4 Flood extent of 5-6 December 2015 floods (Environment Agency, 2016)**

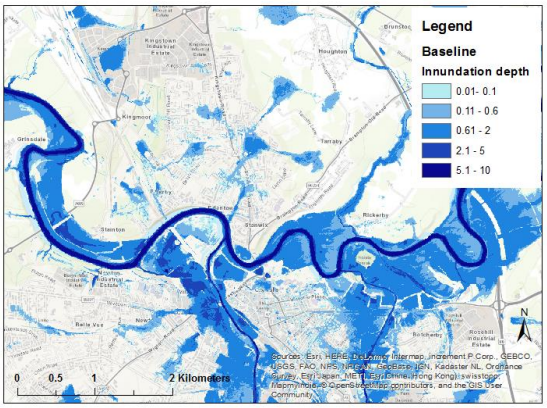



**Figure 5: Flood extent and depths as modelled in 3Di, Carlisle**

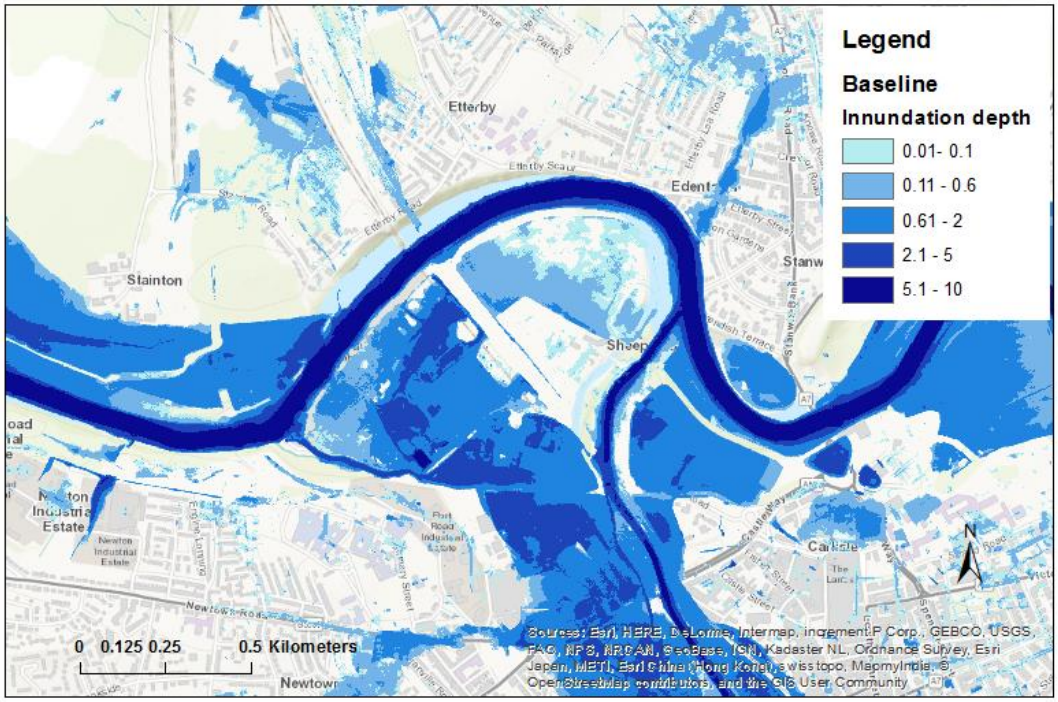



**Figure 6: Flood extent and depths as modelled in 3Di, Willow Holme**

As indicated, this exercise is not intended as a fully realistic simulation of the December 2015 event, or local flood probability, but it demonstrates the potential of rapid modelling on this scale, and provides a baseline for the option development process.

## Element 2: A tool for supporting partnership decision making

True integrated flood risk management planning requires interaction from the beginning onwards: a joint problem analysis, followed by joint design. We translated the results of the hydraulic 3Di calculations to risk and opportunity metrics, and then visualised these using the MapTable.

### *Translating hydraulics to risk and opportunity metrics*

In an integrated approach, decisions are not only based on the benefits of reducing flood risk in line with Government's Outcome Measures, but also on the benefits and impacts for other functions, relevant to other partners and funding streams. If the impact of measures can be calculated in terms of a chosen metric, the MapTable can visualise it. The obvious example is economic flood risk, but another relevant metric for Willow Holme could be the impact on the local water treatment works (for which Deltares' CIRCLE tool could be used). They could also include opportunity metrics such as the availability of the recreation ground near the river or the potential for particular habitats or landscape enhancements –to be developed with the partners. With the right algorithms in place, the cost of measures could also be visualised.

For this exercise, we used the Delft-FIAT software to calculate flood damage. This can be used with any hydro-dynamic software and other GIS environments, contains an international library of flood impact functions and is compatible with the English Multi Coloured Manual. The calculated damages could be translated into risk by assessing multiple return periods. This was not carried out within this submission.

### *Interactive option development using the MapTable*

The MapTable consists of a large touchscreen interface through which users can control a computer. When used for option development, we typically use GIS in combination with modelling software such as 3Di.

Figure 7 shows how we have visualised the 3Di results on the MapTable and used it within our team to jointly understand the dynamics and behaviour of the flood event in Willow Holme, Carlisle.

The interactive map table setting, together with an advanced modelling tool is the first phase of the joint flood risk management planning. This brings stakeholders to the 'same page', enabling a shared perspective on the problem and its causes.

**Figure 7: MapTable: interactive flood risk management planning**

## Element 3: Integrating water management with spatial planning

### *Finding opportunities for multiple benefits*

The focus of the Cumbria Flood Action Plan is on flood risk reduction. There is a strong and welcome emphasis on the whole catchment, and there is also a clear ambition to combine functions within the Defra remit. But the Plan also suggests that flood risk reduction is not perceived as an opportunity to deliver wider benefits for people, economy or nature.

Partnership funding drives the need for multi-purpose (and multi-funding) flood risk schemes. Our experience shows that incorporating flood risk reduction investments with local or regional development agendas is not only necessary to enhance support and engagement of local communities, it also speeds up the development process, reduces costs, and maximises added value.

Additionally, local and regional spatial development could create opportunities that open new ways for flood risk reduction. For example, the redevelopment of a waterfront could create opportunity for integrated flood protection at relatively low costs. On a larger scale, a change of land use along the rivers could reduce the run-off and offer new opportunities for nature and recreation. Integrated into their wider (spatial) context, flood risk reduction schemes can amplify local regeneration.

This requires an overview of all planned investments in urban development, infrastructure projects and long-term ambitions, on both local and regional scales, and a partnership approach from the outset. Secondly, it requires removal of institutional and financial barriers. Finally, it requires an integrated flood risk management strategy based on local and regional development.

### *Combining functions*

We do not have a full overview of the existing plans, and engagement with stakeholders is a next step. We have however identified some potential ideas for ‘marrying up’ flood risk management with other functions. Again, this is intended to illustrate the approach; if these turn out to be realistic, then that is a bonus.

The flood prone areas along the river Caldew and Willow Holme road could provide opportunities for redevelopment to residential and mixed land use because they are close to the city centre and castle and could make the river more visible and part of the city. In initial scan of Willow Holme suggests potential opportunities around critical infrastructure (water treatment works), heritage (the historic course of Hadrian’s wall) and amenity (recreation grounds).

*Turning challenges into opportunities*

Flooding is not the only, or even the main issue for Carlisle. We believe there is an opportunity for Carlisle (and Cumbria) to develop a completely new approach based on embracing its challenges. Carlisle could become a national *Centre of Expertise* and living lab for resilient, self-supporting, and sustainable communities by addressing three major challenges in an integrated approach:

1. Flood risk reduction and climate change adaptation
2. Energy transition (energy efficient housing, renewable energy, closed cycles of waste and resources)
3. Improving liveability (urban regeneration, strengthening Carlisle city centre, green and accessible rivers)

The river Caldew and the Willow Holme area could become a living lab for self-supporting and flood resilient urban development and provide a strategic urban regeneration site to strengthen Carlisle City Centre and its ambition to attract and retain young and highly educated people.  Doing this in collaboration with Cumbria University could improve Carlisle's position as a university town and attract new businesses and potentially national resources.

The obvious (but sectoral) concerns over the undesirability of building in the floodplain will need to be addressed, but by doing this head-on and as part of a pro-active and ambitious development, the 'living lab' could also be seen as a test case for dealing with the institutional blockers for integrated development.

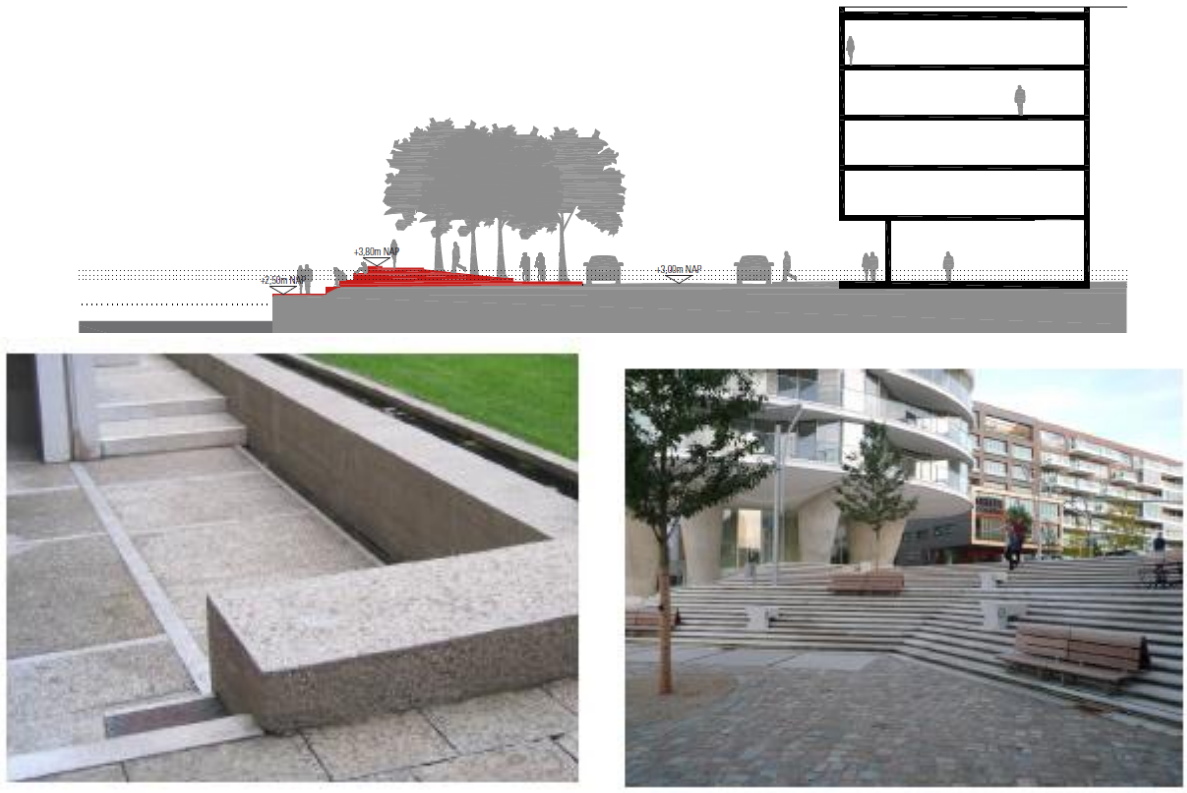


**Figure 8: Illustration of flood resilient development in Rotterdam**

## Drawing the elements together to develop solutions

We used the three elements (3Di, MapTable and integration with spatial planning) within our team to develop and assess options, in order to illustrate the proposed approach, based on the Willow Holme area (Figure 9).

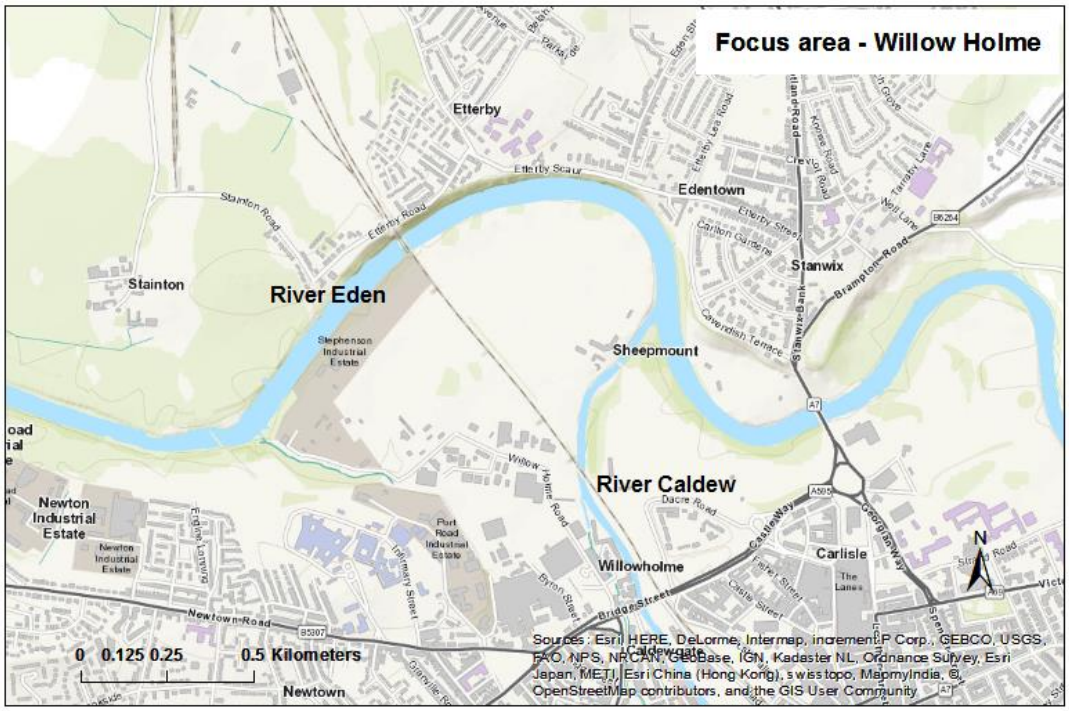



**Figure 9: Willow Holme, Carlisle**

### *Socio-economic opportunities*

The previous section identifies opportunities for combining flood risk measures with urban planning. Also, the area has potential for nature-based solutions, contributing to the revitalization of the city and a “vibrant waterfront” along the river Caldew. Clearly this is only possible if appropriately resilient to flooding. There are institutional and financial obstacles, such as the general undesirability of development in the floodzone and the fact that insurance for last winter’s floods is unlikely to pay for ‘betterment’ to improve resilience. However, these are examples of the typical obstacles for an integrated approach: they are very understandable from a sectoral perspective, but hamper developments that also aim for other objectives.

It seems inconsistent with the ambitions to strengthen the city centre that a large-scale urban extension is planned on the south side of Carlisle, to meet demand for new housing and industry. This development could detract developments from the city centre and weaken the redevelopment potential of the many underutilised industrial and residential areas within the city’s boundaries.

*Technical measures*

From a technical perspective, the Cumbria Flood Plan includes a range of measures for Carlisle. Table 1 lists these; they could all be addressed in our modelling approach, and the table indicates how.

| Theme | Measure type | How to implement in analysis |
|---|---|---|
|  | Reducing flood probability / Flood defences | Change in hydraulic model in 3Di |
| | Railway crossings | Change in hydraulic model in 3Di<br>Change in impact functions for critical infra in MapTable |
|  | Natural flood management in upper catchments | Change in hydrology in 3Di |
|  | Gravel management | Change in hydraulic model in 3Di |
|  | Managing development through long term spatial plans | Change in hydrology and flow resistance in 3Di<br>Change in impact functions in FIAT / MapTable |
| | Property level resilience | Change in impact functions in FIAT / MapTable |
| | Sustainable drainage | Change in hydrology and flow resistance in 3Di<br>Change in impact functions in FIAT / MapTable |
| | Carlisle flood plan for community resilience | Change in impact functions in FIAT / MapTable |

**Table 1: Measures considered for Carlisle, and how they could be assessed**

For illustration at this stage, the team has identified two possible measures for Willow Holme to be assessed with 3Di and visualised on the MapTable. Both are inspired by the Room for the Rivers / Making space for water principles and could support the local socio-economic opportunities:

1. A bypass between Rivers Caldew and Eden, aiming to reduce the water volume discharging on River Eden. This has three positive effects:
    a. River Caldew's discharge capacity will increase
    b. River Eden's water level will locally decrease
    c. The solution opens possibilities for recreation, culture, water and nature.
2. Lowering the embankment around the Athletics stadium to give more space to River Eden

Both measures can be developed as nature-based solutions, creating an urban river park. The Bypass (measure 1) can be developed as an open river with natural banks and a natural corridor to the city, creating room for the river, nature and recreational activities. This could be combined with urban and industrial reconstruction and revitalising the River Caldew waterfront. Lowering the embankment (measure 2) also creates a natural storage area, creating an opportunity to redesign this area into an urban wetland.

### *Working with MapTable to test options*

When working with a partnership of decision makers in practice, the optioneering stage can be prepared by developing maps indicating different types of measures together with the most promising locations. However, the interactive mode of the MapTable also supports the definition of additional measures, which can be directly drawn on the map, as shown in Figures 10 and 11.

**Figure 10 Drawing measures on the MapTable**

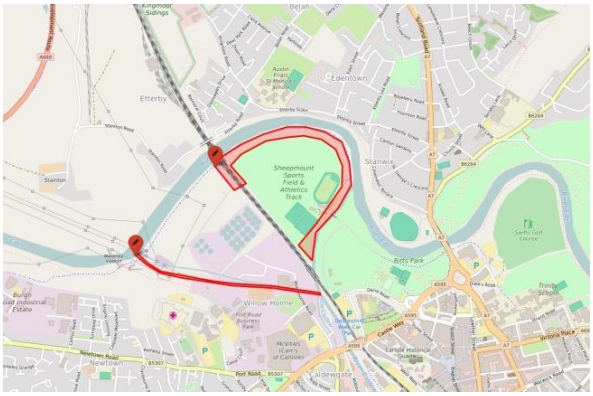



**Figure 11 Location of the measures**

The impacts of the measures can be computed on the spot. Figure 12 illustrates how the two measures influence the maximum water depth. A reduction of up to 1m is shown for the green areas, while the depths have increased for the orange areas.

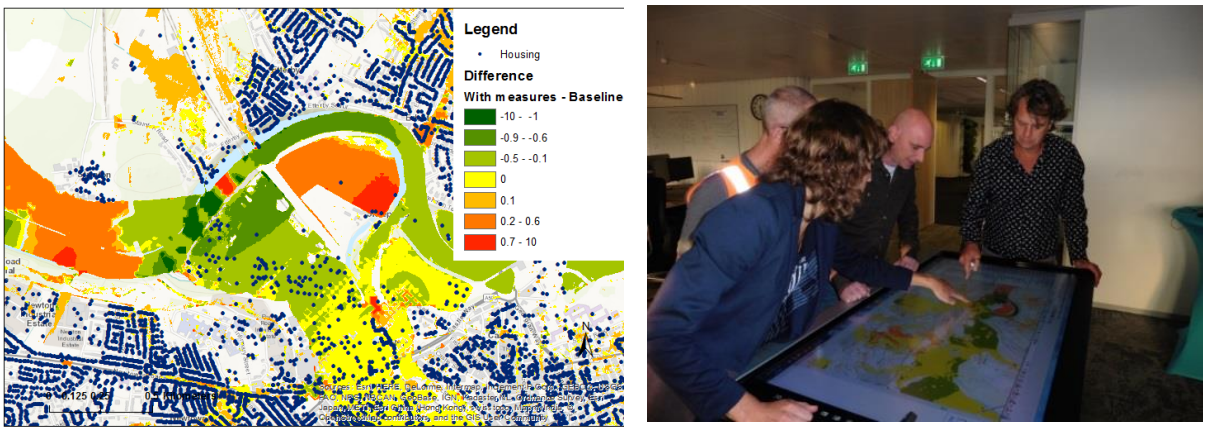



**Figure 12: Difference in maximum depth with the two measures**

We used DELFT-FIAT to calculate the number of buildings affected with and without the measures, distinguishing households and commercial/public properties, and also distinguishing three depth classes: 0-10cm, 10-60cm and more than 60cm relevant for the potential for property level resilience measures (Figure 13). This is another illustration of the type of option-related information that could be calculated on the spot, for use by the partners around the MapTable.

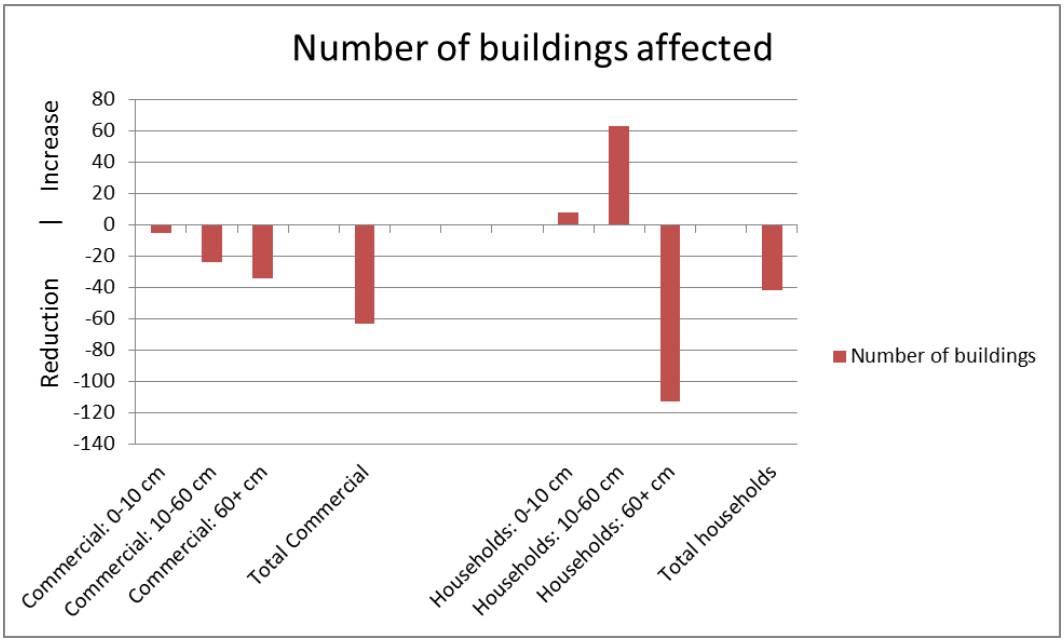



**Figure 13 Effect of the two measures on number of affected buildings.**

## So how could this work in practice?

Our analysis for this submission focused on Willow Holme, but this is only meant to illustrate the approach: proper option development requires the type of partnership working that we are proposing. Our integrated, interactive approach can be applied in selected areas or in catchments as a whole.

For a proper application we advise to model the whole (sub-)catchment, incorporate the measures from the Action Plan both in 3Di and MapTable, and organise a session around the (Map)Table with the partners of the Cumbria Flood Partnership. This could help identify opportunities for additional actions that could achieve multiple objectives. It could also support the development of a catchment wide plan, helping to balance decisions between upstream measures (land use change, adjusted reservoir management) and downstream measures (such as flood defence improvement and dredging at Carlisle).

It is our hope that this essay will trigger even more dialogue for linking knowledge and action and we are very keen to explore this approach together with the Cumbria Flood Partnership.

## Who are we?

The team behind this submission consists of global Dutch & UK based consultancy Royal HaskoningDHV, Dutch specialist modelling firm Nelen & Schuurmans, Dutch water research institute Deltares and Delft University of Technology.

**Royal HaskoningDHV** is a global independent consultancy, operating since 1881, with 6000 professionals supporting clients and enhancing society through their expertise in the built and natural environment, with a strong focus on water management. Royal HaskoningDHV has strong roots in both The Netherlands and the UK, and sees both countries as home markets, which makes us uniquely placed to identify how both countries can complement each other.

**Nelen & Schuurmans** is a consulting company offering creative (IT) solutions for water management in urban and rural areas. Innovation, knowledge development and the client's needs are our key values. Our mission is to provide state-of-the-art and cost-effective solutions, in close consultation with our clients. We believe that water management is closely related to information management. That is why we develop information products that give managers insight into the performance of their water system. Our claim is that "better information leads to better decisions".

**Deltares** is an independent institute for applied water and subsurface research. Throughout the world, we work on smart solutions, innovations and applications for people, environment and society. Our main focus is on deltas, coastal regions and catchments. Managing these densely populated and vulnerable areas is complex, which is why we work closely with governments, businesses, other research institutes and universities at home and abroad. The success of Deltares is the extent to which our expert knowledge can be used in and for society.

**Delft University of Technology** is one of the world's leading technical universities working on sustainable and innovative solutions for society. Located in the heart of an urbanized delta, the TU Delft develops high-level knowledge on integrative delta engineering, management and planning. The Delft Deltas, Infrastructures & Mobility Initiative (DIMI) is an interfaculty initiative that brings together researchers from civil engineering, urbanism and policy analysis and planning to develop integral solutions for urgent societal problems in urbanized deltas worldwide.

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*Software:*

3Di: http://www.3di.nu/en/international

CIrcle – Critical Infrastructures: Relations and Consequences for Life and Environment: https://www.deltares.nl/en/software/circle-critical-infrastructures-relations-and-consequences-for-life-and-environment-2/

Delft-FIAT - Flood Impact Assessment Tool: https://publicwiki.deltares.nl/display/DFIAT/Delft-FIAT+Home

MapTable: http://www.maptable.nl