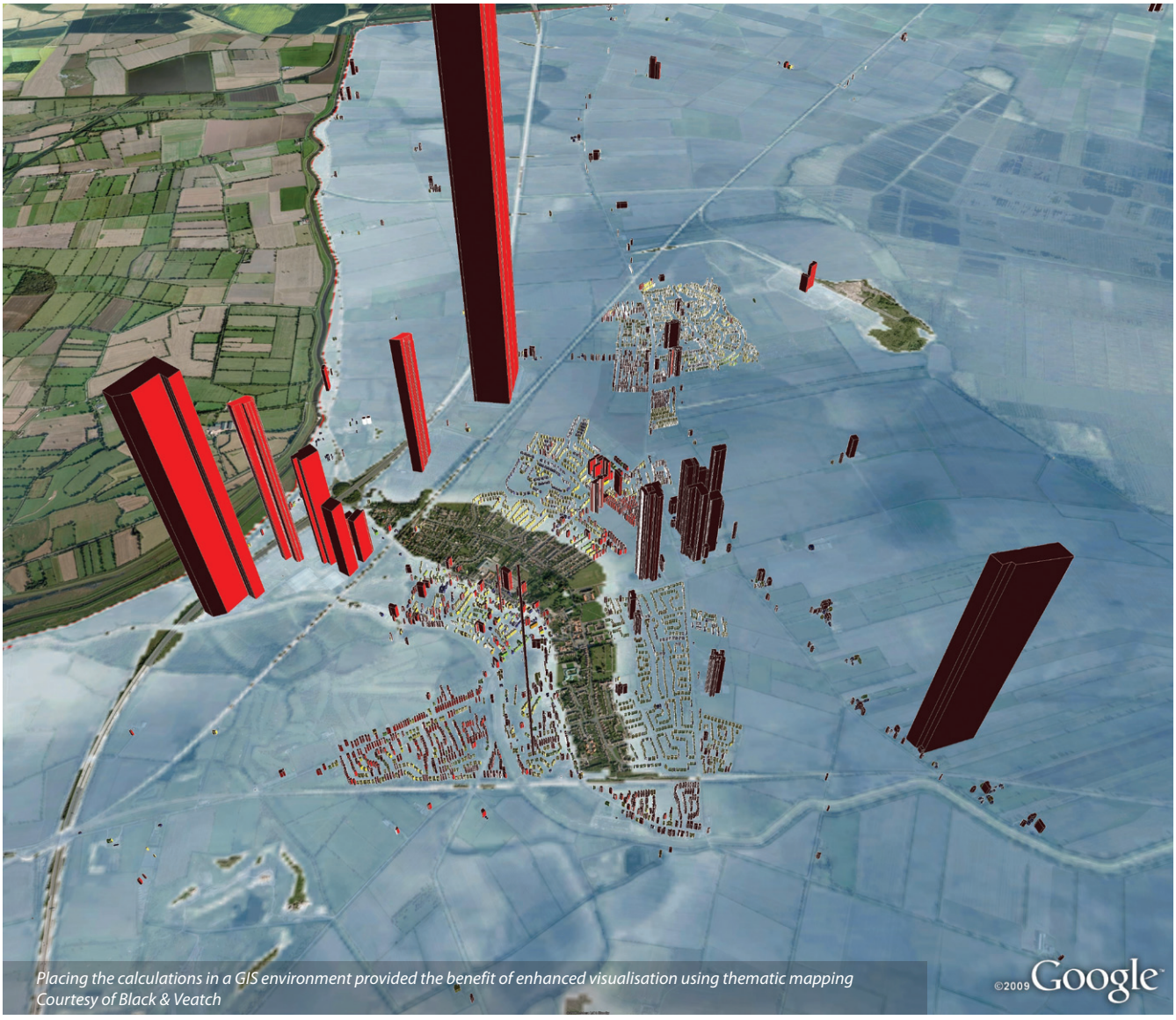
Isle of Axholme Flood Risk Management Strategy

a revolutionary approach to assessing economic risk

by Tim Palmer, Mike Dobson and Dave Barton

The Isle of Axholme is an area of north Lincolnshire between the towns of Doncaster, Scunthorpe and Gainsborough. Delivering a flood risk management strategy required developing and communicating a coherent understanding of a deeply complex catchment. More than 20,000 properties and 45,000 hectares of agricultural land are at risk of flooding in this low lying, artificially drained area. The modified rivers Torne and Idle lie at the heart of this heavily engineered and complex drainage system, served by more than 60 pumping stations and approximately 160 kilometres of flood defences.



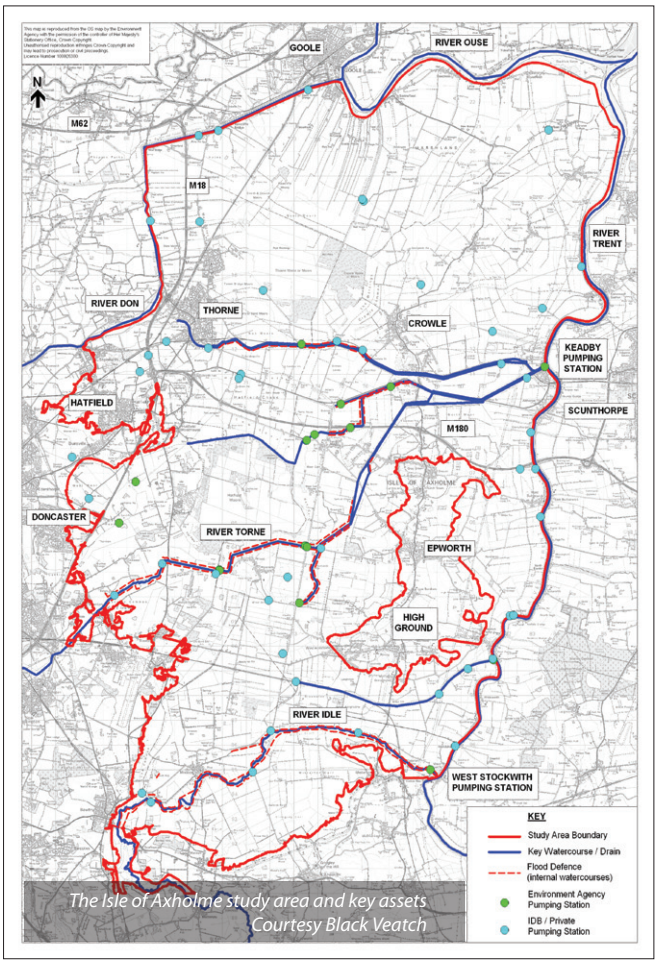
Placing the calculations in a GIS environment provided the benefit of enhanced visualisation using thematic mapping
Courtesy of Black & Veatch

The drainage and flood prevention systems cost the Environment Agency (EA) £1.1 million per annum to operate and maintain. As a consequence, Black & Veatch (B&V) was commissioned to analyse what would happen if this funding was withdrawn. If the results of this analysis were not viable, the EA wanted to know the most sustainable way of managing the flood risk in the future.

Keadby and West Stockwith Pumping Stations

The inland flood system relies primarily upon the ability of Keadby and West Stockwith Pumping Stations to discharge into the River Trent. Both stations have a gravity discharge capability. It was concluded, however, that with no ongoing maintenance, high silt loads in the rivers would result in blockage in a relatively short timescale. Hydraulic modelling showed that in this situation, fluvial flows from the Rivers Torne and Idle would back up inland of the perimeter defences, flooding large areas to a maximum elevation of 5.25m OD within about five years.

To quantify the impacts an environmental and economic baseline assessment was carried out. For comparative purposes likely costs



The Isle of Axholme study area and key assets
Courtesy Black Veatch

and residual damages associated with the sustain option were assessed. A technical review provided an indication of the residual life of each asset in order to prepare a budget implementation programme for the 100-year strategic appraisal period.

New approach to the economic appraisal

Black & Veatch developed a new approach to the economic appraisal to overcome the data processing challenges associated with study size, the dispersed nature of the population in the area, and gaps in some commonly used datasets. The new approach took advantage of the increased level of detailed digital data now available.

Existing appraisal methods rely on a variety of techniques including multi-layered spreadsheets, databases, bespoke DOS programmes and GIS. Such methods are inefficient at large scales and present challenges in terms of quality management due to their complexity and lack of transparency. In Axholme these shortcomings were overcome by an approach B&V calls its Flood Damage Economic Model (FDEM).

Flood Damage Economic Model

As the base reference, FDEM utilises MasterMap, an Ordnance Survey database that records every physical feature, plus a variety of other property classification databases. The additional databases include the National Property Database (NPD), which is used to assign information such as property type and valuation to the building features in MasterMap.

All the datasets have geospatial links, but many are also linked through references in the data; for example MasterMap contains references which link to the NPD. Datasets are stored in a spatial database. FDEM has been designed to maintain the referential integrity between all source data used and the economic information derived; for example, the FDEM database contains references to link to MasterMap, NPD and AL2. These relational linkages give FDEM its strong audit capabilities and ensure that all information created can be easily traced back through the preceding stages to the source information used.

In addition all source information is given a data quality score to allow the appraiser to incorporate data quality issues in decision making.

The decision to create a series of tools, rather than new software, reflected the process' dynamic nature. As new methods and datasets emerge, new tools can be created to encompass them within FDEM.

At Axholme FDEM was updated with geographically referenced digital data from the catchment and consolidated with data from the latest appraisal guidance - such as depth damage data - and project-specific information such as flood levels, to estimate whole life damages. The B&V team could then identify properties liable to flood, and the properties and land that could contribute significantly to total damages.

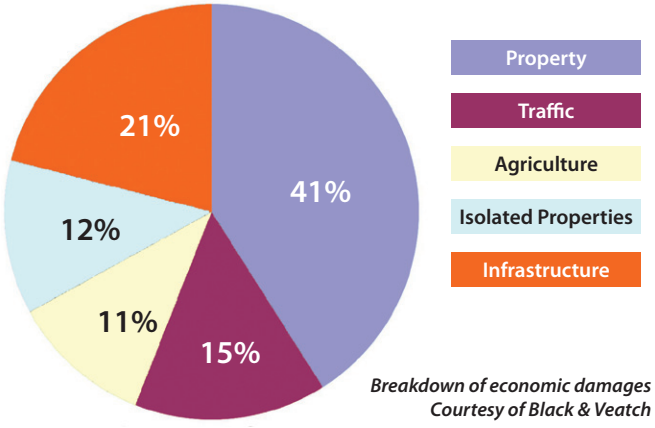
Placing the calculations within a GIS environment provides the benefit of enhanced visualisation using thematic mapping at each step in the process, making it possible to show clearly the major damage contributing properties and outliers in reports. This enabled early identification of properties that really matter, i.e. the highest damage cost contributors, while also checking for significant outliers. The visualisation also improves the reporting of results.

At Axholme FDEM helped the team understand that if a *'Do Nothing'* approach was adopted, in addition to thousands of properties flooding, several communities whilst not flooded would become cut off. The cost of writing off properties was compared to that of maintaining safe and reliable access, taking the lower of these values as damages.

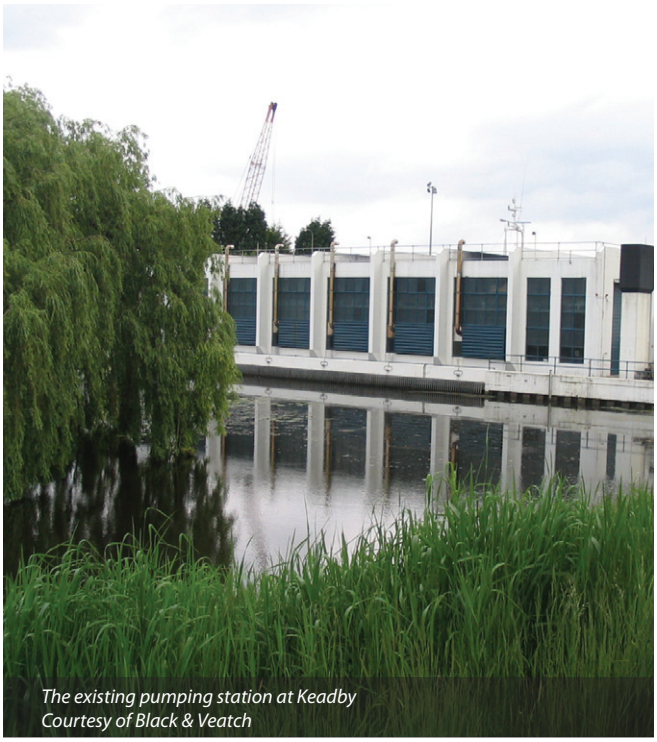
Summary of economic appraisal results:

- Present value damages under Do Nothing of £5.1 billion
- Estimated residual damages under the sustain option of £510 million, giving benefits of £4.6 billion
- Sustain option costs of £566 million over 100 years, with a present value of £299 million
- Sustain option benefit cost ratio of 15

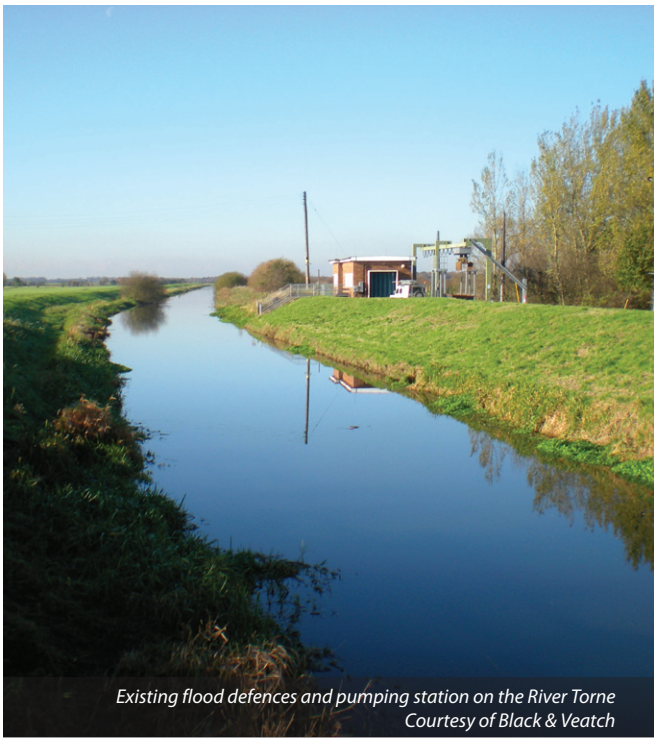
At Axholme FDEM has allowed the issues associated with such a large, predominantly rural, area to be addressed. It has also streamlined the approach to calculating economic damages, and provided clearer reporting and visualisation of the flood risks. The transparent data quality auditing process provides added confidence to appraisers and decision makers. The use of FDEM has improved the efficiency and accuracy of this economic assessment.



Breakdown of economic damages
Courtesy of Black & Veatch



The existing pumping station at Keadby
Courtesy of Black & Veatch



Existing flood defences and pumping station on the River Torne
Courtesy of Black & Veatch

An understanding of existing flood defence asset condition, residual life and the capital and operating costs was also required early in the strategy. The many and varied range of assets required a standardised methodology.

Pumping stations

For the pumping stations, existing condition data was reviewed followed by an inspection of selected assets. Because electrical, mechanical and civil components can be expected to have different life spans, a Strategy Condition Grade for the electrical, mechanical and civil components of each pumping station was determined, based on either the operator's overall grade, or the targeted inspections grade. A range of deterioration rates was developed and used to provide an estimate of residual life of individual components.

With such an extensive network of flood defences assessment costs could be significant. Building on previous studies, a desk study had the potential to reduce assessment costs. Most of the defences are earth embankments identified in the NFCDD database. By combining this information with knowledge of foundation conditions the desk study produced a programme of targeted field inspections. Approximately 25% of the assets were inspected to provide confidence in the visual condition grades assigned by the Environment Agency, to define section types for further analysis, and to identify underlying issues related to construction or geology.

Geotechnical assessment

A geotechnical assessment to define the criticality of an asset in relation to its likelihood of failure was also undertaken. This too was a desk study making use of typical sections and applying various load cases. The analyses were done quickly using commercial software programs. Geotechnical parameters needed for these analyses are assigned to the different soils. By applying routinely used factors of safety and, where necessary, sensitivity analyses, a geotechnical appraisal condition grade was reached.

Combining the visual and the geotechnical grades in a standardised approach had the advantage of allowing further subdivision of assets into categories that could be used to define residual life and thus, a programme for intervention and improvement. Residual life was used to determine when it was necessary to intervene in order to reduce the probability of asset failure to an acceptable level.

The EA's Guidance on Determining Asset Deterioration and the Use of Condition Grade Deterioration Curves was used as the basis for establishing the residual life and intervention year. The curves provide a standardised approach to assess and quantify the deterioration of flood defences. To derive the cost of maintaining the current system, pumping stations were categorised by capacity, and a cost for the replacement of components and significant maintenance overhauls or refurbishment was derived. Annual operation and maintenance costs were derived based on historical information provided by the operators. The cost of construction of replacement defences was determined using the Environment Agency's Unit Cost Database. Costs for maintenance of flood defences and channels were provided by the Environment Agency and the Internal Drainage Boards. The estimated total cost for maintaining the current system, including outfalls and the perimeter defences over the 100-year appraisal period is £566 million.

The 'Do nothing' assessment concluded that the economic case for maintaining the current system was stronger than thought originally. The complex, interdependent nature of the catchment - in which the system of drainage ditches mean areas can become hydraulically linked during floods or changes in the pumping regime - make assessing the right 'Do something' option as difficult as assessing whether to act at all.

The process of reaching a solution is ongoing and has required the development of an option appraisal methodology specific to the Isle of Axholme catchment. The FDEM approach to economic analysis that proved so effective at Axholme is, however, applicable to most flood risk management projects.

A long, medium and short list of options have been created with technically viable measures being subjected to hydraulic, economic and environmental modelling, to confirm the approaches suitable for combining within the short list. In this way it has been possible to systematically reduce the potentially very large number of options to a more manageable number.

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