Chapter 6

Quantifying flood-management responses – intra-urban

In Chapter 5 we quantified the effectiveness of responses to catchment-scale flooding. We now assess the effectiveness of responses to intra-urban flooding for each of the four future scenarios.

In particular, we consider the performance of the various responses for four contrasting exemplar catchments, and then scale the results for the country. This approach is necessary due to the absence of a nationwide intra-urban risk-modelling tool.

The limitations in the analysis highlight the need for further research in this area. Nevertheless, it is considered that the results provide a useful, if broad, appraisal of future flood-management options.

6.1 Introduction

The previous chapter explained the need to consider intra-urban responses separately from catchment-scale responses. This is because the investigation of urban flood risk requires modelling on a finer scale. This chapter therefore builds on the analysis of Chapter 5 to quantify the performance of responses to future intra-urban flooding.

As noted in Volume I, the absence of an equivalent to the RASP modelling tool (the basis for our estimates of national flood risk on the catchment scale) hinders attempts to model reductions in flood risks arising from the intra-urban responses. A different approach has therefore been used.

Our analysis of intra-urban responses initially used models of the sewer systems of four typical urban catchments to estimate the reduction in flood risks arising from the various responses – we used a comparison with published information on recorded flooding to calibrate the models. This allowed us to explore the performance of the responses in terms of volume of floodwater, the number of properties flooded and the Expected Annual Damage (EAD).

Our models estimated the effect of the responses on future EAD for each test area. This was done for the National Enterprise socio-economic scenario which was associated with the Medium-High climate-change scenario (derived from UKCIP98).

However, there is considerable uncertainty in deducing changes in precipitation over short periods in small urban areas from predictions of precipitation from models of climate change on the global and regional scale. Our analysis therefore used a sequential approach. The estimates of UK Water Industry Research (UKWIR) of UKCIP98 rainfall were used for the modelling in four test catchments – these were assumed to represent the Foresight scenario National Enterprise. We took a range of simple percentages to represent possible increases in precipitation under the other three Foresight scenarios of climate change. We then averaged the flood risks for the test catchments and scaled the results to the UK's population of 59 million (2001 census) for each scenario.

6.1.1 Estimation of future precipitation

Our models of urban flood risk require hyetographs of rainfall against time, for current and future rainfall. We based our hyetographs on two sources. We adopted the methods developed by the Centre for Ecology & Hydrology of the Natural Environment Research Council in its UK Flood Estimation Handbook which provides hyetographs for existing rainfall, with 10-, 30- and 100-year return periods. Our models also built on hyetographs provided from UK Water Industry research (UKWIR) for estimated urban rainfall for 2080 under the Medium-High emissions scenario of UKCIP98 for a number of sites in the UK.

There is considerable uncertainty in the predictions of UKCIP98 for rainfall in urban areas. The most recent publication, UKCIP02, shows different results from the UKCIP98 data and greater seasonal variability. In addition, neither prediction gives an adequate account for a number of aspects of urban rainfall, such as the local heat island effects, where, for example, urbanisation removes vegetation, and where the emissions from the buildings result in elevated local temperatures.

As noted we took a simple sensitivity approach to scale precipitation and flood risk up or down for the other three scenarios.

6.1.2 Urban catchment models

Sewerage-undertakers provided computational models for existing main-sewer systems for four urban catchments (see Table 6.2). The forecasts showed good correlation between the flooded volumes of water from the sewer systems and the increase in rainfall, although we cannot relate this directly to the numbers of flooded properties. The agreement between flood rainfall and flood volume gives some confidence in the predictions of the impacts for the other socioeconomic scenarios – these were generated by scaling flood risks in line with the predictions of UKCIP98 and the simple scaling in Table 6.1, for relative increases in rainfall.

Table 6.1 **Assumed values for increased urban rainfall for one socioeconomic scenario, providing the starting point for estimating increases in peak urban rainfall, presented as precipitation multipliers. The table illustrates the results for the 2080s relative to the present day.**

	World Markets	National Enterprise	Local Stewardship	Global sustainability
Possible precipitation multipliers	2.4	2.3	2.2	2.1

A study by UK Water Industry Research has provided some limited precipitation-change estimates. For this reason we were able to run the test models using data broadly applicable to one scenario of climate-change. This corresponded to the medium-high climate-change scenario, which the Foresight project associates with the National Enterprise socioeconomic scenario. In the absence of reliable estimates of future urban rainfall, we adopted a simple sensitivity approach in modelling the other three scenarios. For each scenario, we increased the peak rainfalls in the 2080s relative to the present day.

Table 6.2 **Modelled catchments – the project analysed the main sewer systems for four representative urban catchment areas to gauge the number of properties at risk of flooding now and in the future.**

Nature of catchment and location	Area (ha)	Impervious area (%)	Population	Population density (person/ha)	Number of properties	Property density (prop/ha)
1 Market town (northern England)	1,384	29	85,500	62	38,636	28
2 Inland city with major watercourses (Scotland)	3,934	34	263,026	67	77,413	20
3 Coastal city (Wales)	2,027	21	212,241	60	31,099	15
4 Inland town (northern England)	727	15	15,700	22	7,212	10

The results from the initial modelling were used to demonstrate the performance of the existing main-sewered catchments in terms of flooding within the urban area. Subsequently, a number of flooded areas were selected for further investigation and testing of responses. The responses considered were those that could be modelled with reasonable confidence. These included:

- Storage – either above or below ground.
- Increasing sewer size.

- Disconnecting impervious areas, assuming new infiltration or equivalent facilities.
- The potential for flood management by directed overland flood-flow pathways.

In each case, the outline dimensions for the response were determined for the specified return period of storm input, using the normal design standards currently adopted by sewerage undertakers. These were then related by unit costs to direct capital costs. The estimates of the numbers of properties originally flooded and subsequently protected for the whole of each catchment were then combined with the flooding frequency – thereby providing an estimate of the costs for response implementation and residual expected annual damage (EAD).

This analysis provided the EAD and response costs for the medium-high climate-change scenario for each response in each area. As this covered only the main drainage network, additional costs had to be estimated for the local drainage and the flooding internal to properties – i.e. the parts of the drainage system that are not the responsibility of the sewerage undertakers. These costs were based on published information and assumptions were made about the scale-up for local risk, using recent information on local drainage. Ideally, information on property flooding should have been used but this is not currently available.

The EAD and cost curves were then assumed to be applicable across the UK population of 59 million (2001 census). In this way we could scale up the results and determine the cost effectiveness of individual responses in terms of population.

6.2 Modelling the test catchments

Current techniques for modelling the hydraulics of sewers are limited in the case of extreme events and overland flow and flood pathways. This leads to high uncertainties in the prediction of flooding in general, and future flooding in particular. Because of this, it is usually good practice to use fieldwork to confirm the results of sewer hydraulic modelling by identifying the real pathways and hence those properties that are actually at risk. Economic and time constraints made this impossible in this study, so we took steps to define the uncertainty in the predictions. Firstly, as far as was practicable, outputs were based on incidents of recorded internal floodings. These were related to total flood volume predicted from the Flood Estimation Handbook (FEH) and the UKCIP98 10, 30 and 100 year rainfall. Linear scaling, based on rainfall volume, was then used to determine the number of properties flooding from the other scenarios (see Volume I).

The modelled outputs were used to determine the unit costs per property of the responses. These costs relate to the alleviation of the problem to currently accepted standards of protection. These standards are not the same as the mandatory levels of service that apply to the sewerage undertakers. It is usual for the undertakers to provide a higher standard of protection – this may, in the future, be protection against flooding for once in 30 years up to once in 100 years (as opposed to protection of once or twice in ten years). The models are known to overestimate the flooding, so it is not usual to provide solutions to deal with all of the flooding predicted by the model. Hence the response results are those required to eliminate the main flooding problems up to the 100-year level of protection in the 2080s and are based on current design approaches:

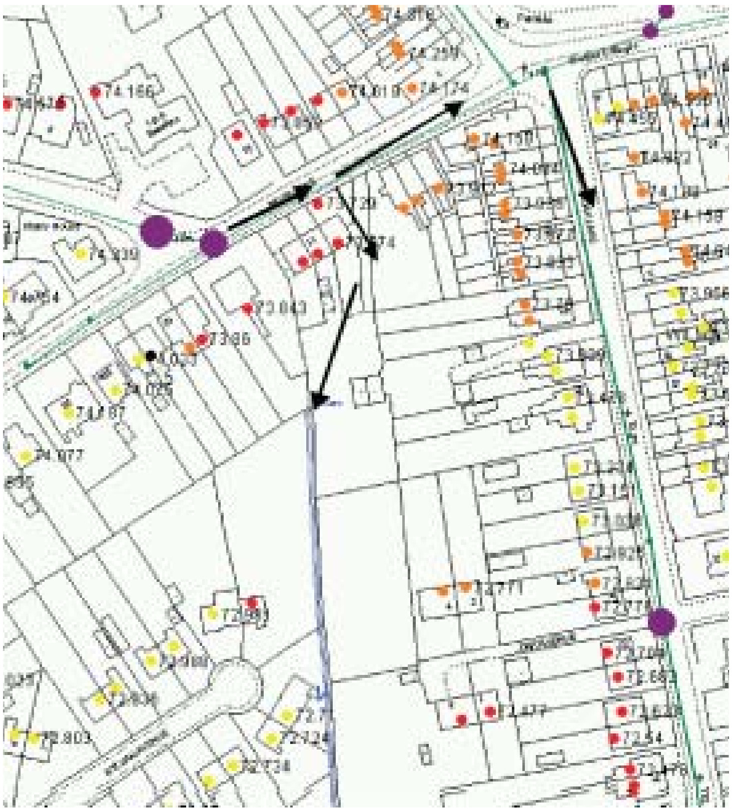
- In catchment 1, where flooding was solely pluvial, the flooding was managed to present-day standards of acceptability, based on examples of the three worst-affected areas.
- For catchments 2 and 3, the responses typically reduced the problems as predicted by the model, by some 50%. Based on whole-catchment studies, catchments 2 and 3 were considered to demonstrate the impact of coincident fluvial and coastal flooding respectively.
- We considered a fourth catchment. However, we have not included the results from this as there was a large disparity between the flooding predicted by the model and that actually recorded in the last 10 years.

6.2.1 Above-ground flow pathways

One of the sub-catchments was studied to assess the possibility of using highways and open areas to route the excess flow. The problems in one of the other sub-catchments were away from the residential area and therefore flooding would not directly affect properties. The third site included only a few properties and the gradient of the land would tend to move surface flooding into a recreation ground away from the properties.

Site 1 was, however, in a residential area. The land in the immediate vicinity was low, which caused the problem. Therefore, any flooding would initially pond in this area. Any flow from this point will take the water along the highway and the water will try to return to the sewer network further downstream. The potential for managing this flow by diverting along the highways and between property into adjacent watercourses was investigated and the pathways identified (see Figure 6.1).

Figure 6.1 **Overland flow routed to manage flooding in catchment 1**



Note: circles are major flood risk nodes

6.2.2 Model results

Table 6.3 shows the cost of below-ground storage and conveyance options per property at risk of flooding for each rainfall scenario for catchments 1, 2 and 3.

The costs in Table 6.3 may be compared with the values of the average cost per property of increasing capacity to solve sewer flooding for more than 10 properties. For example, the average cost per property predicted by the modelling was around £37,000. This cost is within the range of £5,000 – £90,000 identified by OFWAT in its consultation document 'Flooding From Sewers – A Way Forward', and a range of £17,000 – £150,000 reported by water companies in their response (OFWAT 2002a,b).

Table 6.3 **Unit cost of response per property at risk of internal flooding – main drainage only (£ thousands) present day and 2080s**

Catchment	Unit cost per at risk property For return period in years	Present day			2080s		
		10	30	100	10	30	100
1	Storage	146	194	209	68	98	77
	Conveyance	79	76	57	28	27	17
2	Storage	75	112	137	114	141	174
	Conveyance	258	238	222	191	145	149
3	Storage	896	789	696	771	702	660
	Conveyance	1,678	829	435	930	514	238

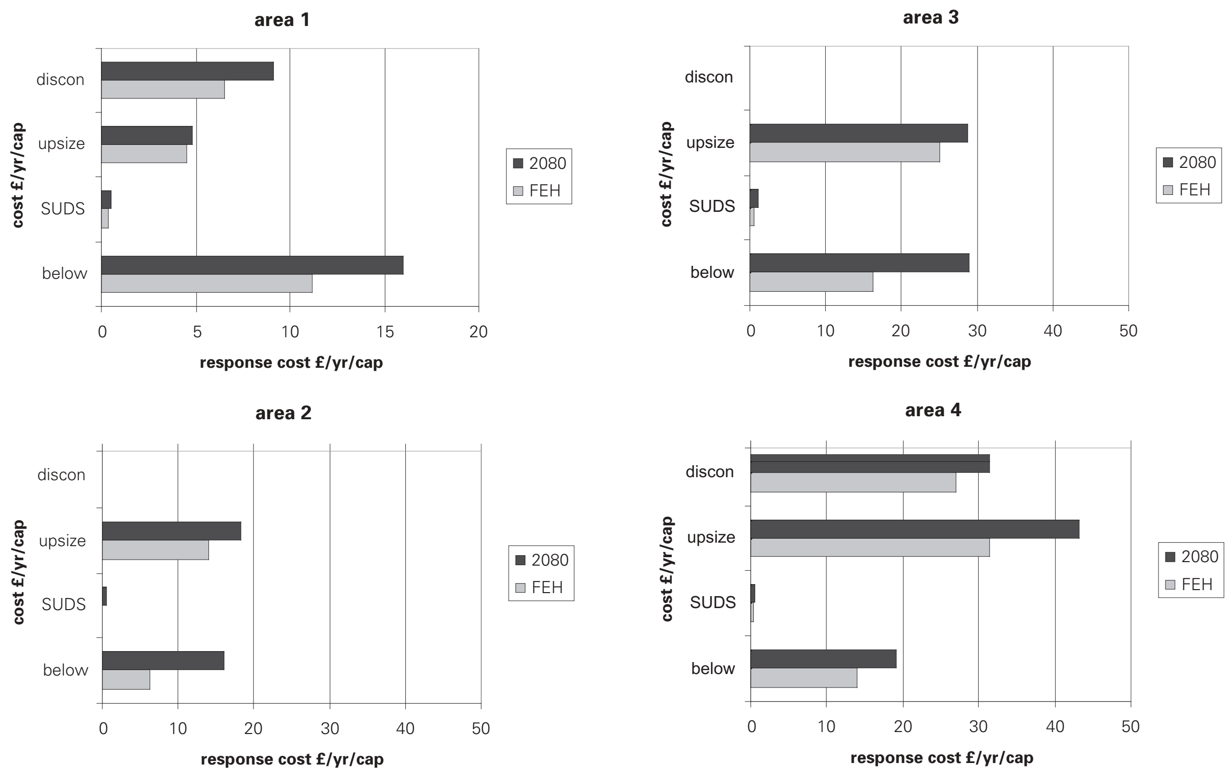
The results show that the unit cost per property of the different measures to prevent internal flooding, does not follow any defined trend, as they depend on site-specific circumstances and scale. In catchment 1, the proximity of watercourses that could accept discharges from the urban area makes the conveyance option more cost-effective. However, interaction between the urban catchment and local watercourses in catchment 2 and the tidal interactions in catchment 3 has a profound effect on costs in these areas.

The study has shown that there is a 50 to 100% increase in relative costs for responses in the catchments with these interactions. This analysis also demonstrates the potential difficulties in the selection of appropriate options and the importance of choice of levels of protection in both short-term and long-term planning.

The analysis for the catchment-wide storage solutions shows that both the inland and coastal catchments (2 and 3 above, respectively) will require large storage volumes to resolve all predicted flooding. Although the ratio between storage requirements and rainfall is significantly higher than for solutions that involve increasing pipe sizes, the cost is significantly less. Storage would therefore appear to be the most cost-effective solution. As for the 'upsizing' solution, the cost burdens are much greater in the catchments where there are interactions with watercourses or tide levels.

The alternative responses, retrofitting source controls or managing flood pathways, were also costed. However, source control depends heavily on the availability and cost of land for surface storage. Such solutions could be more cost-effective in terms of capital expenditure but, it is not possible to generalise these costs. Because of the complexity, difficulties and likely high costs of introducing these types of system into existing urban areas, it may be that they will be effective only in new developments. The comparisons between the costs for the tested responses are shown in Figure 6.2, in respect of: disconnected drainage ('discon'); upsizing of the drainage system ('upsize'); the introduction of sustainable urban drainage ('SUDS'); and below-ground storage ('below').

Figure 6.2 **Relative unit costs for solutions to main drainage flooding for test catchments**



6.3 Cost of responses in urban areas

The costs determined through modelling the three test catchments are subject to local circumstances that are catchment-specific. While they are indicative of the relative costs of the different response options and the impact of coincident flooding, it may not be appropriate to extrapolate these costs to the national level. To identify national costs requires a high-level analysis that draws on appropriate data sources – to include internal and severe external flooding caused by hydraulic inadequacies in public and private sewers and overland flow. The analysis draws on:

- The predictions of properties at risk of flooding for the different events identified in catchment 1.
- Analysis of sewer incident records.
- Relevant published information from OFWAT, Defra and the Office of the Deputy Prime Minister.

The analysis comprises four steps:

- Determine relationships between current 10-year flooding levels and other return periods for current rainfall and 2080s rainfall, using results for test-catchment 1.
- Determination of current and future unit costs of flooding based on test-catchment 1 results and published OFWAT data.
- An assessment of current national levels of flooding and extrapolation to predict future levels.
- Application of current and future unit costs to determine future national costs.

The analysis is based on figures for England and Wales and uses extrapolation to include Scotland and Northern Ireland. It should be noted that the uncertainty is exceptionally large – plus or minus a factor of three or more.

Table 6.4 provides estimates of the costs of increasing the standards of protection to the levels specified. Table 6.5 estimates the costs to achieve the same standard of protection in the 2080s for the National Enterprise scenario. The figures relate to three catagories: internal property flooding; flooding external to properties; and highway flooding. Assumptions have been made about the extent of flooding caused by sources other than main sewerage in this assessment (See Volume I).

Table 6.4 **Cost of responses to intra-urban flooding – current climate – current costs (£ millions)**

Flood type	Public sewers	Private sewers	Overland flow	Total
Flooding of property – 100-year protection	1,475	1,125	1,475	4,075
Flooding adjacent to property – 30-year protection	294	224	294	813
Flooding of highways – 10-year protection	92	70	92	256
Total cost	1,862	1,420	1,862	5,145

Table 6.5 **Cost of responses to intra-urban flooding – 2080s National Enterprise (£ millions)**

Flood type	Public sewers	Private sewers	Overland flow	Total
Flooding of property – 100-year protection	6,613	5,045	6,613	18,273
Flooding adjacent to property – 30-year protection	1,143	872	1,143	3,158
Flooding of highways – 10-year protection	367	280	367	1,016
Total cost	8,125	6,198	8,125	22,449

The costs for the responses may be compared with the Expected Annual Damages due to precipitation change and urbanisation (see Table 6.6).

Table 6.6 **Present and possible future risks of intra-urban flooding for the UK**

	Present day	World Markets	National Enterprise	Local Stewardship	Global Sustainability
Properties at risk of flooding in 1 in 10-year event	82,000	380,000	340,000	320,000	300,000
EAD £ million per year	270	7880	5055	740	1870
Uncertainty range – EAD £ million per year	100-500	3,500-15,000	2,000-10,000	250-1,400	900-3,600

6.4 Effectiveness of responses

6.4.1 Extending the analysis to all scenarios

The analyses presented above considered both present-day risk and risk in the 2080s from changing precipitation based on the scenario National Enterprise with medium-high emissions of greenhouse gases. In this section we extend these predictions to the other three socioeconomic scenarios.

The study estimated differences in rainfall between the UKCIP98, National Enterprise scenario and the other scenarios (see Table 6.1). UKWIR provided 'multipliers' for the increased rainfall in the 2080s for each test catchment. Multipliers for the other scenarios are based on the 'sensitivity' multipliers (see Table 6.1). The data from UKWIR included only the differences in the rainfall multipliers for 10-year events of 6-hour duration. In the absence of other data, our analysis applied these factors for longer return periods.

Applying the rainfall multiplier factors (see Volume I, Chapter 5), together with the multipliers derived from the scenario sensitivity (see Table 6.1) and the economic damage ratios between the scenarios, allows us to determine the changes in current flood risk for the other scenarios. The approach is to use the linear correlation with flood volume and the approximate numbers of flooded properties from the studies of the test catchments. This therefore gives an approximate way of estimating impacts under all four scenarios (see Volume I, Chapter 5).

6.4.2 Effectiveness of the responses under the scenarios

The relative costs for the different response groups determined from the modelling are given in Figure 6.2 for the precipitation driver for each modelled area. These costs do not include flood-risk reductions for private property or for local drainage remediation. Nor do they deal with flooding external to property, or road and highway flooding, intra-urban inundation or coastal flooding. The SUDS is above-ground storage and costs do not include land purchase. The paved-area disconnection costs reflect only solutions for one-third of the flood risks. The 2080s results are believed to relate roughly to the National Enterprise scenario.

Table 6.5 gives the cost of dealing with public-sewer property flooding corresponding to a return period of 100 years, based on projected rainfall from UKCIP98, for England and Wales as £6.6 billion, and, as detailed in Table 6.4, as £1.5 billion for present day rainfall. The proposed investment in sewerage systems by the Water Companies in England and Wales over the next AMP period 2005-2010 is approximately £1.6 billion and this broadly matches the latter projection. Assuming that this level of investment is maintained up to 2080, this is equivalent to some £368 million per annum for the whole UK.

These costs contrast with the cost of different remedial options to reduce flood risk. Comparison with the costs of the below-ground storage option, as detailed in Figure 6.2, show that investment of £1,317 million/2 = £658 million is required. Hence, considering this option alone, there would be a shortfall of some £658 million – £368 million = £290 million per annum, based on existing projections. This leads to a projected shortfall in planned investment costs of some (658-290)/658 = 56%. Hence, for the precipitation driver alone under the National Enterprise scenario, the relative future reduction in flood risk for main drainage within the urban area is estimated at approximately one-half of that required. However should investment of £368 million per annum occur under the National Enterprise scenario, for the below ground storage option, the residual flood risk would be some 72%. This figure would be reduced to 58% for the sewer upsizing option. Under National Enterprise, there could be more investment in the conventional solutions than today, and this figure may be reduced further.

A similar approach can be taken to consider the other scenarios and the differences in the level of protection that need to be taken into account:

- Under World Markets there would be less investment in managing flood risk in poorer areas, although the total investment may be as high or higher than today. It is therefore probable that the relative reduction in flood risk due to the precipitation driver would be similar to that estimated for National Enterprise, but less equitably delivered. The same relative response effectiveness will be assumed. However, it is likely that more surface storage and disconnections will be used in the poorest areas.
- Under Local Stewardship, there would be more focus on local solutions, with movable flood barriers and so on. Because of this it is expected that there would be less use of the below-ground options, although there may be some, with SUDS storage and disconnections favoured. As these are cheaper, the lower GDP under this scenario would not be a barrier.
- Under Global Sustainability, the above-ground options would also be favoured, without using any additional below-ground options.

The model responses that were tested presume current standards of protection and that undertakers conform with the OFWAT Levels of Service (LoS) specified under DG5. However, most undertakers provide a higher LoS than the mandatory standards and hence 'design standards' or Levels of Protection (LoP) are usually higher. The LoS and LoP differ between scenarios, and hence so do the damage costs. In this analysis it has been assumed that the specified LoS/LoP generally relates to the National Enterprise scenario, which is equivalent to current LoP. Table 6.7 provides an estimate of the differences for the other scenarios.

Table 6.7 **Estimated level of protection for types of urban flooding in the 2080s**

Scenario	Level of Protection (return period in years)		
	Flooding of property	Flooding external to property	Flooding of highways
World Markets	100	30	10
National Enterprise	100	30	10
Local Stewardship	30	5	2
Global Sustainability	50	10	5

Although Table 6.7 suggests that the trajectory for current levels of service will be maintained under the World Market scenario, this will apply only to urban areas of prosperity and there will be large parts of urban areas for which these LoP will not apply. However, it is presumed that overall, the LoP in the wealthiest areas will 'average' to that projected for the National Enterprise scenario. Under the scenario Global Sustainability, there could be a greater acceptance by stakeholders that flooding can occur. Under Local Stewardship, individual properties may either be allowed to flood or there will be much greater local management of floodwaters with preparatory and mitigating measures.

The results for the 2080s relate to the National Enterprise scenario. The assumptions concerning the scaling between the different relative proportion of flooding events is as given in Table 6.8. In the absence of any other information, the unit cost of preventing the other occurrences has been factored from that for main-drainage flood management.

Table 6.8 **Relative distribution of urban floods and unit costs to deal with types of property flooding**

Flooding from:	% disbribution of flood causes from recorded information	Relative prevention unit cost (National Enterprise)
Public sewers	23	1
Private sewers	17	0.5
Overland flow*	23	0.25
Private rainwater goods	37	0.25
Total	100	2

*Barriers, surface detention and re-routing etc.

Overall, this gives a total cost multiplier of two times the estimates for the main-drainage responses. Table 6.9 gives the capital investment costs for the National Enterprise scenario for the whole of the UK. The costs of SUDS have been increased by some two times to allow for land-acquisition. All capital costs are based on current prices.

Table 6.9 **Relative costs for types of response for the UK under the National Enterprise scenario – precipitation driver only – current cost base**

Response – alternative options	2080s			Present day	Relative cost increase 2080s: present
	Relative unit cost	Cost £/cap/yr	UK £M/yr	UK £M/yr	
Below-ground storage	**28**	**20.3**	**2,387**	**1,317**	1.8
SUDS (above-ground storage)	**1**	**0.7**	**164**	**94**	1.8
Upsizing of sewers	**24**	**17.3**	**2,034**	**1,705**	1.2
Disconnection of paved areas	**13**	**9.1**	**3,210**	**2,293**	1.4

In terms of the effectiveness of the responses under the different scenarios, Table 6.10 shows the likely component residual flood-risk multipliers, based on expert-group judgement, and taking into account the likely implementation of the response group under the different scenarios.

Table 6.10 **Potential residual multipliers for the precipitation driver under the different scenarios**

Response	Multiplier on increased flood risk up to 2080			
	Scenario			
	WM	NE	LS	GS
Below-ground storage	0.7	0.5	0.9	1
SUDS (above-ground storage)	0.5	1	0	0
Upsizing of sewers	0.6	0.6	1	1
Disconnections	0.5	0.8	0.2	0.2
Likely	**0.6**	**0.7**	**0.4**	**0.5**
Range	0.5 – 0.7	0.5 – 1	0 – 1	0 – 1

The costs for the response measures using the four response groups may be scaled in terms of the increase in risk for precipitation and urbanisation to estimate the overall costs of providing solutions to internal flooding of property from all causes such that expected levels of protection are met (Table 6.7). The results of this analysis are shown in Table 6.11.

Table 6.11 **Annual cost for response measures to reduce flood risk to standards of protection as specified for each scenario in Table 6.7 (£ million)**

Response measure	World Markets	National Enterprise	Local Stewardship	Global Sustainability
Below-ground storage	2,617	2,387	664	1,044
SUDS (above-ground storage)	90	82	23	36
Upsizing of main sewers	2,230	2,034	566	890
Disconnections	1,173	1,070	298	468

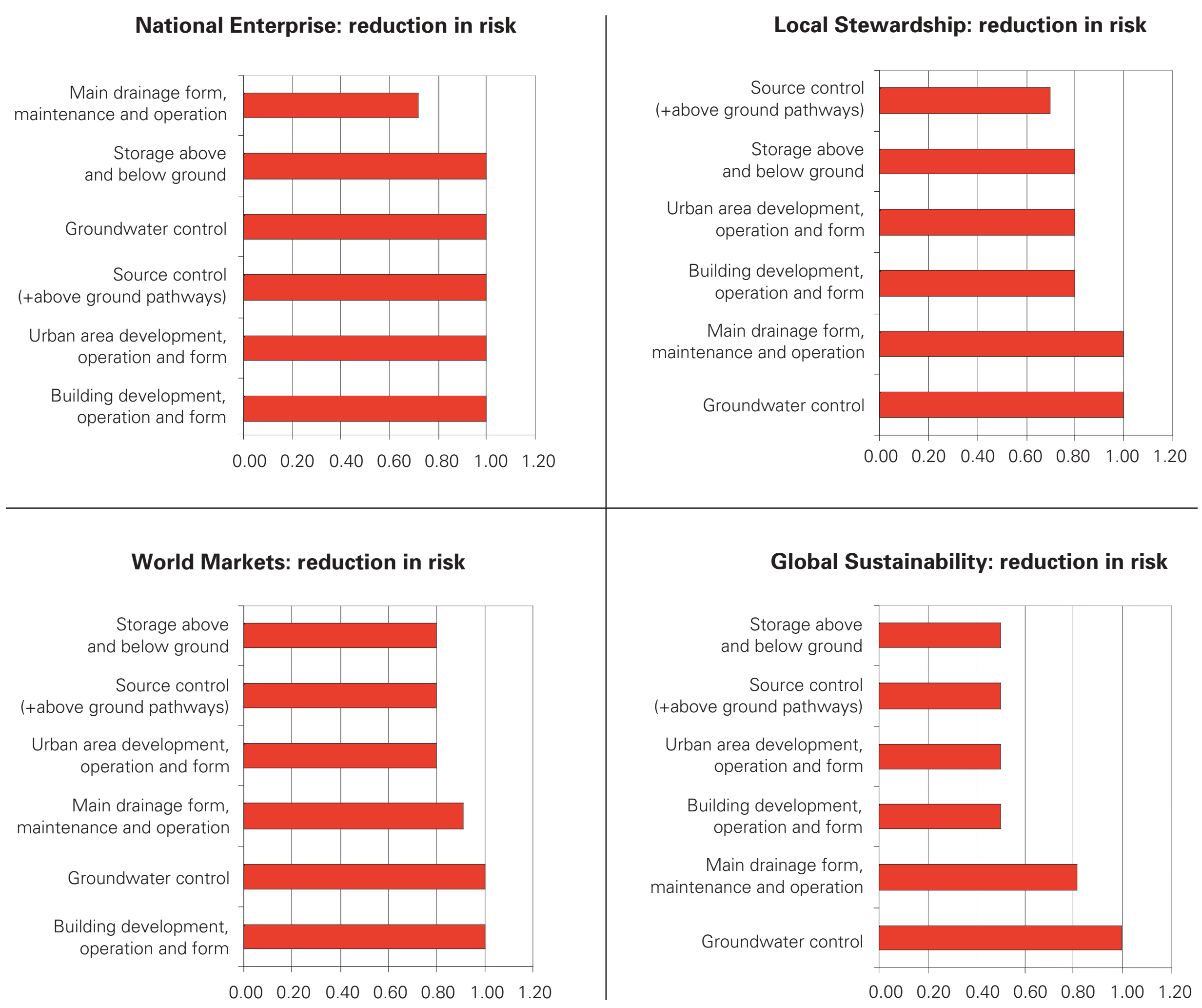
Although the solutions involving SUDS and disconnection look attractive, these have been determined by simple multiplier assumptions about land costs (Table 6.9). There has been no consideration of the feasibility of this option, as the wholesale introduction of SUDS or disconnections alone will not be practicable. Because of this, Table 6.12 shows the most likely costs of the responses within each scenario aggregated across the four different types of measure, weighted in terms of the residual flood risk, given in Table 6.10.

Table 6.12 shows that with even the most likely implemented engineered solutions, there will be an increase in EAD from present-day £270 million per annum to up to £4,200 million per annum under the World Markets scenario and up to £490 million per annum under Local Stewardship.

Table 6.12 **Annual cost of most likely responses and residual flood risk**

	WM	NE	LS	GS
Cost of responses likely to be used under this scenario (£ million per year)	540	260	400	110
Residual flood risk multiplier	0.6	0.5	0.7	0.4
Residual EAD (£ million per year)	4200	2400	490	720
Uncertainty in residual EAD	2000-8000	1000-5000	200-1500	300-2000

Figure 6.3 **Reductions in flood risk for intra-urban area from main response groups**



Overall, the effectiveness of the individual responses in the intra-urban area have been determined by combining quantitative analysis and expert review (see Figure 6.3). From these, we can revise the original overall flood-risk multipliers (Volume I, Table 3.2), as shown in Table 6.13.

Table 6.13 **Effectiveness of responses in urban area form and operation group**

	World Markets	National Enterprise	Local Stewardship	Global Sustainability
Original overall risk multiplier for intra-urban area 2080	29	7	19	3
Response group risk multiplier for response groups	0.6	0.5	0.7	0.4
Overall future risk multiplier as a result of potential responses in intra-urban area	17	4	13	1

6.5 Summary

The following key points arose from the analysis:

- The main challenge for the above analysis was the lack of a suitable model to assess: changes in intra-urban risks; and costs of responses at a national level. As the estimated national figures had to be scaled up from the exemplars, there is a high degree of uncertainty in the results. The figures are therefore best used for broad comparisons.
- The Expected Annual Damages (EAD) for intra-urban flooding could be reduced to levels similar to today in the Global Sustainability and Local Stewardship scenarios, with investments in responses of around £110m/year and £400m/year respectively.
- Though substantial reductions in EAD could be achieved using responses in the World Markets and National Enterprise scenarios, EAD would remain in the order of ten to fifteen times higher than present day levels.
- A combination of different responses would be most effective at reducing risks and cheapest under all scenarios, as it would allow optimisation of the approach used to reduce risks.
- The development of a national intra-urban model would help reduce this uncertainty and facilitate the development of a cost-effective approach to reduce risks in advance of need.