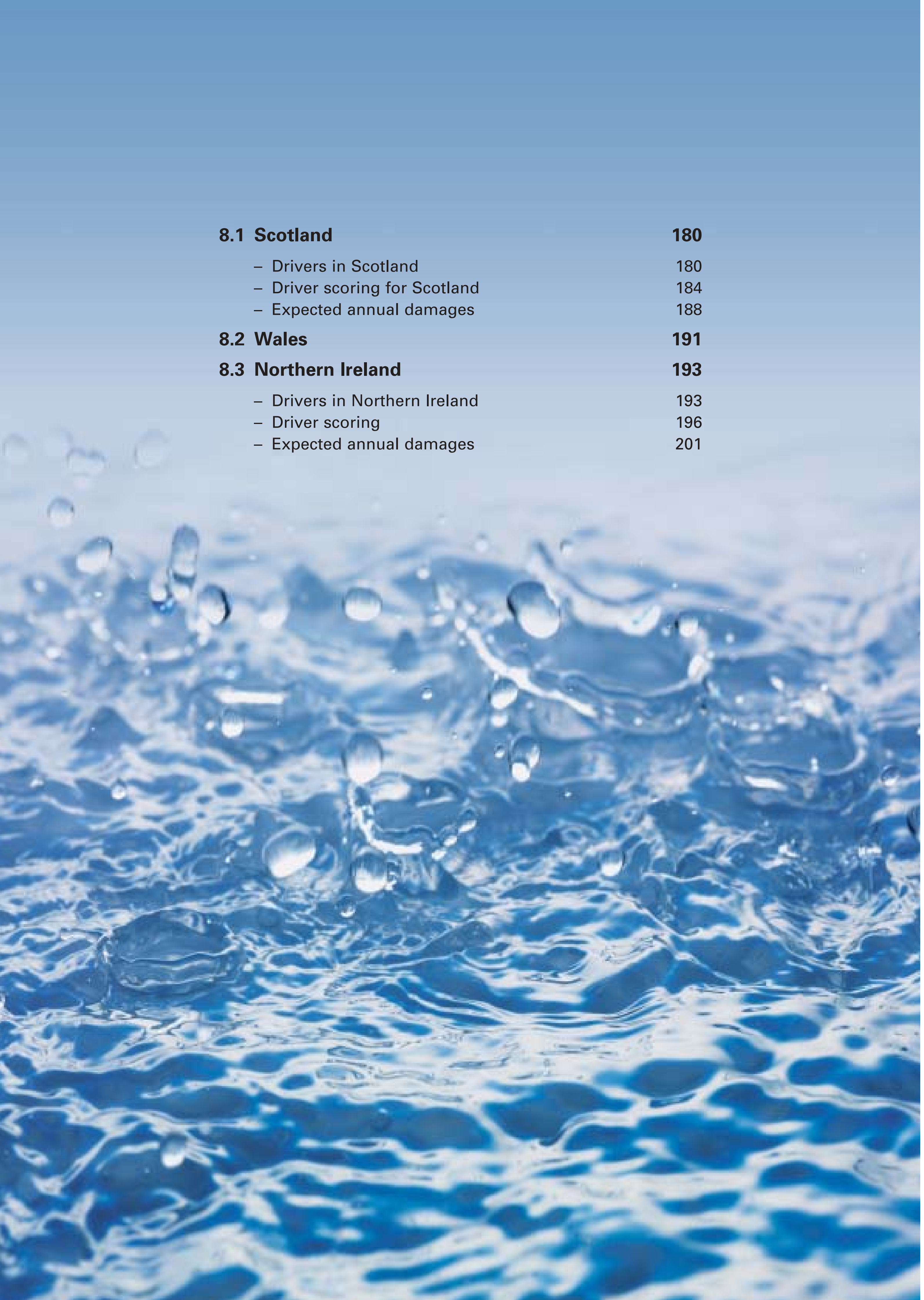

Chapter 8

Scotland, Wales and Northern Ireland

Most of the forgoing analysis of the operation of drivers of future flood-risk is equally applicable to all parts of the UK. In this chapter we look at local factors that may influence their operation and relative importance in Scotland, Wales and Northern Ireland.

Estimates of future catchment-scale flood risk are also presented for Scotland and Northern Ireland, since these were not covered by the RASP modelling analysis in Chapter 4.

8.1 Scotland

The scale and nature of flood risk in Scotland differs from that in England and Wales. With a population of about 5 million, but proportionately a much larger land area, the number of inland properties at risk is only 77,191. This is some 12% of the number in England and Wales. The two most damaging recent floods – in the Perth region as the Tay and Earn overflowed their banks in 1993 and the Strathclyde flood in December 1994 – led to losses of around £130 million. This is proportionately much lower than the losses for floods in England in 1998 and 2000. The average annual flood damage in Scotland is estimated at around £50 million for inland and coastal properties protected against the 1 in 50-year event.

8.1.1 Drivers in Scotland

Climate change

The most damaging floods in Scotland occur when slow-moving frontal storms come in off the Atlantic. These can last for up to 72 hours and sometimes increase flood flows as they melt lying snow. Less frequent storms of an easterly or northerly origin can generate floods along the east coast. Floods associated with persistent high groundwater levels are virtually unknown in Scotland.

The climate scenarios in UKCIP02 predict increases in winter rainfall of up to 10-15% for eastern Scotland by the 2080s but less than 10% in western Scotland. Other work suggests increases of up to 25% in winter precipitation across parts of Scotland by the 2080s (Hulme *et al.* 2002). UKCIP02 predicted a stronger westerly circulation for Scotland by the 2080s, which is likely to generate more storms, higher rainfall and flooding, especially in the winter. Given the higher rainfalls in the west of Scotland – 3,000mm against 700mm in the east – floods in western Scotland are likely to continue, especially if there is a higher incidence of Atlantic storms. When combined with models of rainfall runoff, it seems likely that within 50 years the current 1 in 50-year inland flood will become the 1 in 25-30 year flood across parts of Scotland.

Daily and short duration rainfall is also set to increase in northern Scotland at rates up to twice those anticipated for south east England. In urban areas the two-year daily rainfall could increase by more than 20% in eastern Scotland, but much less in western Scotland. A consequence of this could be that by the 2050s there will be more frequent pluvial floods that overwhelm urban drainage systems.

Average temperatures in the UK are predicted to rise by 1 to 5°C by the 2080s. In Scotland, temperature rises could be in the middle of this range, increasing by about 3.5°C by the 2080s. As a result, there will be significantly fewer days with snow on the ground at elevations above 800m, decreasing the likelihood of snowmelt floods. However, higher levels of atmospheric water vapour will offset any benefits from reduced snowmelt by increasing the frequency of high-intensity rainfall events and the threat of pluvial floods.

Catchment runoff

There is less pressure in Scotland to build on inland floodplains than in England, although projections for household growth will continue to generate demand for new housing development. Scotland is a highly urbanised society, with a higher percentage of the population living in urban areas. Scotland also has many 19th-century sewerage systems. It will be very expensive to upgrade these as the flood risk increases.

While much of lowland Scotland has underground drainage to improve agricultural production, this has been on a smaller scale than across much of England. It would therefore require less drainage engineering to increase runoff in Scotland. This reflects the fact that there is less arable land in Scotland (11%) and more moorland and rough grazing (38%).

Agricultural land use and rural land management in Scotland may also change as a result of reforms to the Common Agricultural Policy. The result could be lower stocking densities and more extensive upland woodlands. There could also be restoration of wetlands and floodplains for controlled inundation. However, many of these changes in land use will be in uplands rather than lowlands. As Scotland has a higher proportion of upland than the rest of the UK, the drivers related to agriculture and land management could exercise a lesser role in Scotland by the 2080s.

Fluvial processes

The EU's Water Framework Directive will apply across the whole of the UK by 2015. As a consequence, the operation of the driver Environmental Regulation and Habitats is unlikely to differ markedly in Scotland vis-à-vis the rest of the UK. However, Scottish rivers generally have higher flows, steeper gradients and less drainage and river engineering. As a result they typically migrate across valley floors more rapidly than their counterparts in the English lowlands. Morphological channel changes and migration may therefore pose a greater threat to flood defences than in England.

Few Scottish rivers are highly eutrophic. Because of this lack of excess nutrients, they support less in-channel vegetation to impede flood flows. However, extensive floodplain afforestation could inadvertently increase flood risk unless it is implemented with careful consideration of the effects on flood flows.

Human behaviour

The institutional framework for flood management in Scotland has evolved in a different way from that in England and Wales. Duties and responsibilities are distributed between riparian owners, the Environment and Rural Affairs Department of the Scottish Executive, 32 local authorities and the Scottish Environment Protection Agency (SEPA). Scotland is also unique in how it represents the interests of diverse stakeholders. This has attracted positive comments from the insurance sector. Planning policy is set out in Scottish Planning Policy (SPP)7 – Planning and Flooding (Scottish Executive, 2004). SEPA is a statutory consultee where a flood risk is identified, and if they object, the case has to be notified to Scottish Ministers.

Current Indicative Floodplain Maps for Scotland – depicting notional depths for floods with an annual probability of occurrence of 1 in 100 – compare unfavourably with the Environment Agency's section 105 maps for England and Wales. However, more accurate second-generation maps are currently under development for Scotland.

Following the publication of the first national planning policy in 1995, most local authorities have set up informal advisory groups which bring together a diverse range of private and public sector stakeholders. These Flood Liaison and Advice Groups are forums to share knowledge and offer advice on flooding issues.

In some aspects, we can expect the responses of Scottish stakeholders to increased flood risk to continue to converge with those in England and Wales. This has already manifested itself with the extension, in November 2001, of Floodline, the national flood warning service to Scotland, and other developments such as the second-generation indicative floodplain mapping. However, for other issues Scotland could proceed independently, for example, in matters of planning policy (SPP7) and the use of Flood Liaison and Advice Groups to constrain further development on floodplains.

Socioeconomics

Scotland is a highly urbanised society. As a consequence, a marked increase in urban flooding by the 2080s could result in more rapid increases in the social and economic impacts of floods than in the UK as a whole. As noted above, this could be offset in certain scenarios, such as Local Stewardship, by action at a local level.

Coastal processes

The threats posed by coastal flooding in Scotland are relatively modest compared with those in England and Wales. Only the Clyde estuary is currently served by a flood-warning service. Sea level rise for mainland Scotland is predicted to be 310 to 570 mm by the 2080s, against 500 to 710 mm for London. Excluding storm surge and wave behaviour, this implies that the current 1 in 100-year sea levels around Scotland could become 1 in 10- to 20-year levels by the 2050s. We can thus expect a significant increase in the frequency of coastal flooding along the shorelines of the estuaries of the Clyde, Tay and Forth. These are also the locations of major investments in strategic infrastructure, so there could be higher flood risk along these shorelines.

In the case of storm surges, for the 50-year storm, water levels in Scotland could be elevated by less than 1.25m compared with 2.5m along the East Anglian shoreline. Projected sea-level rises are also much lower, especially when compared with those for south-east and south-west England. This difference is due to the continued uplift of Scotland following the last ice age.

The hard, rocky nature of much of Scotland's coastline means that the driver Coastal Morphology and Sediment Supply is less significant than in southern and eastern England, where readily eroded cliffs and major river estuaries deliver large volumes of sediment to the near-shore zone.

Wave heights are set to increase around the UK by the 2080s. The increase could be more severe for the Western and Northern Isles of Scotland, given increased storminess and an increased westerly circulation.

8.1.2 Driver scoring for Scotland

We repeated the scoring exercise performed for the UK for the drivers in each driver group as they operate in Scotland. We did this taking account of differences in the behaviour of the drivers outlined above. Table 8.1 lists the resulting scores.

Table 8.1 **Summary results for driver impacts on local flood risk in Scotland. The table lists multipliers of flood risk for Scotland for each driver set (see Chapter 2) compared with current flood risk. The equivalent values for the UK as a whole appear in brackets for comparison. The accompanying text explains briefly where there are differences between values for Scotland and the UK as a whole (note: drivers that grey-toned affect flood risk indirectly via other drivers)**

Driver	Driver type	World Markets		National Enterprise		Local Stewardship		Global Responsibility	
		2050s	2080s	2050s	2080s	2050s	2080s	2050s	2080s
Climate change									
Precipitation	Source	5.7 (4)	8 (5.7)	4 (2.8)	5.7 (4)	2.8	4	2	2.8
Temperature	Source	1	1	1	1	1	1	1	1

- The Precipitation driver is slightly increased for Scotland under the National Enterprise scenario and further increased under the World Markets scenario. This reflects the more severe impacts anticipated under these scenarios, especially during the winter flood season.
- Scottish Temperature drivers are the same as those for the UK as a whole.

Driver	Driver type	World Markets 2050s	World Markets 2080s	National Enterprise 2050s	National Enterprise 2080s	Local Stewardship 2050s	Local Stewardship 2080s	Global Responsibility 2050s	Global Responsibility 2080s
Catchment runoff									
Urbanisation	Pathway	2.8	5.7 (4)	2.8	5.7 (4)	0.7	0.5	0.7	0.5
Rural Land Management	Pathway	1.4	1.4 (2)	1.4	1.4 (2)	0.7	0.5	0.7	0.7
Agricultural Impacts	Receptor	0.7	0.7	1.2	1.7	1	0.85	0.7	0.5

- Catchment drivers, especially Urbanisation, are very sensitive to the higher incidence of short periods of more intense rainfall that are predicted for Scotland by the 2080s. The risk of flooding downstream of urban areas is thus likely to increase at a higher rate than in England and Wales where such rainfall is set to increase at a lower rate.
- By contrast, the driver Rural Land Management has a lower ranking in Scotland than for the UK as a whole. This is due to the impacts of the Common Agricultural Policy and the greater proportion of upland versus lowland farming in Scotland.
- The impacts of agricultural losses on flood risk, mainly in the lowlands, should prove similar to those in the rest of the UK, leaving this driver unchanged.

Table 8.1 **Summary results for driver impacts on local flood risk in Scotland. The table lists multipliers of flood risk for Scotland for each driver set (see Chapter 2) compared with current flood risk. The equivalent values for the UK as a whole appear in brackets for comparison. The accompanying text explains briefly where there are differences between values for Scotland and the UK as a whole (note: drivers that are grey-toned affect flood risk indirectly via other drivers)** *(continued)*

Driver	Driver type	World Markets		National Enterprise		Local Stewardship		Global Responsibility	
		2050s	2080s	2050s	2080s	2050s	2080s	2050s	2080s
Fluvial processes									
Environmental Regulation	Pathway	1	1	1	1	1.4	2.8	2	4
River Morphology and Sediment Supply	Pathway	1	2	1	1	2.8 (2)	4	2 (1.4)	2.8
Vegetation and Conveyance	Pathway	1	1.4	1	1.4	1	1.4 (2)	1.4 (2)	4 (5.7)

- The Environmental Regulation driver is unchanged.
- Under the scenarios Global Sustainability and Local Stewardship, higher winter flows could shift some rivers beyond their current indicative floodplains by the 2050s, increasing the relative importance of the river morphology driver. This in turn would generate greater flood risk for agricultural land and small rural settlements, as existing defences would be damaged or circumvented.
- Reduced use of fertilisers under the Global Sustainability and Local Stewardship scenarios will decrease in-channel vegetation and hence produce better conveyance of flood flow. Given the much lower levels of eutrophication in Scotland than across much of southern and eastern England, this effect is unlikely to be triggered by the 2050s, especially under the Global Sustainability scenario. However, increases in the extent of floodplain woodlands (currently being promoted in Scotland) could offset the effects of these improvements on conveyance, especially under the Local Stewardship scenario.

Driver	Driver type	World Markets 2050s	World Markets 2080s	National Enterprise 2050s	National Enterprise 2080s	Local Stewardship 2050s	Local Stewardship 2080s	Global Responsibility 2050s	Global Responsibility 2080s
Human behaviour									
Stakeholder Behaviour	Pathway	2	2.8	0.5	0.33	0.25	0.2	0.25	0.2
Public Attitudes and Expectations	Receptor	Known to be important but not quantified							

- The Stakeholder Behaviour driver is unchanged.
- Public Attitudes and Expectations may evolve differently in Scotland than in the UK as a whole, especially under the Local Stewardship scenario, reflecting lower expectations of investment in conventional flood defence, triggering greater community awareness and mutual self-help.

Table 8.1 **Summary results for driver impacts on local flood risk in Scotland. The table lists multipliers of flood risk for Scotland for each driver set (see Chapter 2). compared with current flood risk. The equivalent values for the UK as a whole appear in brackets for comparison. The accompanying text explains briefly where there are differences between values for Scotland and the UK as a whole (note: drivers that are grey-toned affect flood risk indirectly via other drivers)** *(continued)*

Driver	Driver type	World Markets		National Enterprise		Local Stewardship		Global Responsibility	
		2050s	2080s	2050s	2080s	2050s	2080s	2050s	2080s
Socioeconomic									
Buildings and Contents	Receptor	6.0	17.0	2.2	3.1	2.47 (3.0)	4.0 (4.8)	2.5	4.8
Urban Impacts	Receptor	7.0 (5.0)	28.3 (19.8)	2.52 (1.8)	5.14 (3.6)	3.0	4.8	2.2	3.9
Infrastructure Impacts	Receptor	7.1	24.0	2.2	3.6	3.0	4.8	2.5	3.9
Social Impacts	Receptor	6.0	19.8	2.2	3.6	2.47 (3.0)	6.1	2.2	3.2
Science and Technology	Receptor	Known to be important but not quantified							

- The higher rankings for Scotland for the Urban Impacts driver under the scenarios World Markets and National Enterprise reflect the more highly urbanised society, increase in urban flooding by the 2080s and difficulty of retro-fitting improvements to existing urban drainage systems.
- Given low growth and low consumption, the pressure to develop floodplains and the coastal zone (already lower in Scotland than for much of the UK) will be reduced under the Local Stewardship scenario.
- The higher degree of social cohesion in Scotland could, however, somewhat offset the adverse social impacts of floods.

Driver	Driver type	World Markets 2050s	World Markets 2080s	National Enterprise 2050s	National Enterprise 2080s	Local Stewardship 2050s	Local Stewardship 2080s	Global Responsibility 2050s	Global Responsibility 2080s
Coastal processes									
Waves	Source	2 (3)	5 (10)	1 (2)	3 (5)	1	3	1	2
Surges	Source	3 (5)	8 (20)	2 (3)	5 (9)	1 (2)	3 (5)	1	2
Relative Sea Level Rise	Source	3 (5)	14 (20)	3 (4)	10 (13)	2 (3)	7 (10)	2 (3)	5 (7)
Coastal Morphology and Sediment Supply	Pathway	3 (5)	5 (10)	3 (4)	5 (7)	2 (3)	3 (4)	1 (2)	1 (2)

- Despite the possibility of severe increases in wave height in the Western and Northern Isles, the effect is localised and it would be inappropriate to increase the ranking value above UK levels for the whole of Scotland.
- Scores for the other three of the drivers for coastal process in Scotland are below comparable values for the UK as a whole across most scenarios, reflecting the generally less adverse impacts of coastal process drivers in Scotland.

Summary

The scores for Scottish drivers (Table 8.1) differ only slightly from those for the UK as a whole. Most adjustments are downwards by relatively small amounts. Exceptions are Precipitation and Urbanisation, which are both higher in Scotland, and drivers associated with coastal processes, Surges, Relative Sea Level Rise and Sediment Supply, all of which we score significantly lower. Scotland's higher levels of social cohesion and lower development pressures on floodplains and coastal lowlands mean that the Building and Contents and Social Impacts of future flooding are likely to score lower than for more densely populated areas in the rest of the UK.

8.1.3 Expected Annual Damages

Given the driver scoring's prediction of increased flood risks, we expect annual damages due to inland and coastal flooding in Scotland to increase under all four future socioeconomic scenarios. To investigate the economic impacts of increased flood risk, we used existing data (Werritty *et al.* 2002) to predict future Expected Annual Damages (EADs). Because of the limited data available, we restricted our predictions to the scenario World Markets. For each residential and non-residential unit within the indicative floodplain in Scotland, we calculated an expected average annual damage. Lack of data prevented us accounting for the effects of existing flood defences. Hence, we calculated our figures first on the basis that all floodplains were unprotected. For comparison, we then recalculated EADs assuming that all floodplains were defended to a 1 in 50-year Standard of Protection.

Working from standard depth-damage relationships, we generated cumulative values for the EADs caused by more frequent floods. However, blanket application of such analysis assumes that a flood will inundate all properties within the indicative floodplain to the specified depth for the return period. In practice, the five-year flood would inundate only a small proportion of the unprotected floodplain, whereas the 100- or 200-year flood would extend to the suggested limits. To account for this, we scaled the damages calculated for 5- 10- and 20-year floods to reflect the proportion of the indicative floodplain that would actually be inundated.

We scaled the data on the basis of known inundation patterns for eight sites with flood protection schemes, provided by J B Chatterton Associates. These scaling factors for the flooded area are first approximations and, given the sensitivity of losses to the area inundated, alternative weightings credible for Scottish floodplains would produce different results for the 5- 10 and 20-year events. As the proportion of the floodplain inundated by a given event has a significant impact on average annual damages, especially in terms of the extent of the 5- and 10-year floods, we need further research to improve the calibration of this relationship. We report only the results for unprotected sites or those protected up to the 1 in 50-year flood (see Table 8.2).

Table 8.2 **Expected average annual damages due to inland flooding in Scotland for residential and non-residential units (£ million) under the World Markets scenario**

Assumed standard of protection	Expected Annual Damage (£ million)		
	2003	2050s	2080s
Unprotected	185	311	398
1 in 50-years	32	53	68

The estimated average annual damage for inland flood risk at unprotected sites in 2003 is £185 million. This falls to £32 million with all sites defended to a 1 in 50-year standard of protection. This value allows us to compare the forecasts with an earlier estimate (£20 million) based on a much smaller sample (Werritty *et al.* 2002). The broad agreement between these two calculations established a basis for predicting expected annual damages.

Our analysis also predicted increases in expected annual average damages due to river floods in the 2050s and 2080s. We based these calculations on the estimated reduction in the return period for the present 50-year flood for selected Scottish rivers (Werritty *et al.* 2002). In our analysis we scaled the percentage increases predicted for the 50-year event to represent changes in the 5-, 10-, 25- and 100-year events to produce predictions for expected annual damages in the 2050s and 2080s (see Table 8.2).

We conducted a similar analysis for coastal flooding, with areal scaling represented by assuming inundation of 50% of properties within the coastal floodplain, that is, coastal sites with elevations below 5m above Ordnance Datum (Table 8.3). It proved impractical to predict future expected annual damages for the 2050s and 2080s on the basis of baseline data for coastal flooding. There are no credible methods for incorporating the impacts of rise in relative sea level, increased surge activity, higher waves and morphological changes in increasing the probability of flooding and reducing the standard of protection that existing coastal defences provide.

Table 8.3 **Expected average annual damages due to coastal flooding in Scotland for residential and non-residential units (£ million) under the World Markets scenario**

Assumed standard of protection	Expected Annual Damage (£ million)
Unprotected	58
1 in 50-years	19

Summary

The results imply an overall increase in annual average damage by about 68% in the 2050s and 115% in the 2080s (see Table 8.2).

With respect to coastal flooding, based on comparison of the figures for the 2003 baseline, annual average damages in Scotland are much lower than those for inland properties, a situation that is likely to persist into the future.

8.2 Wales

The work described in earlier chapters applies closely to Wales in view of its geographical nearness to England. Nevertheless, there are some important differences.

Catchment runoff

Arterial drainage for agriculture is still predominant in rural areas of Wales. It is likely to remain so unless there are major changes in land use.

Fluvial processes

The Environment Agency, Welsh Assembly Government and Dwr Cymru (Welsh Water) are committed to implementing the Water Framework Directive to improve water quality and biodiversity in rivers. This could increase the impacts on flood risk in Wales of the drivers Environmental Regulation and River Vegetation and Conveyance.

Coastal processes

The Welsh coast is a huge environmental legacy: 70% has designated status and must be protected from potential adverse impacts of climate change. The coastal strip is proportionately more important in Wales than for the rest of the UK.

Public attitudes and stakeholder behaviour

The physical and demographic characteristics of Welsh floodplains differ significantly from those in England. For example, many Welsh floodplains are characterised by short, urbanised watercourses with short times to peak, in depressed, post-industrial settlements. These conditions produce higher flood risks than in sparsely populated floodplains of languid, lowland watercourses in England. Also, some small Unitary Authorities in Wales remain reluctant to use their limited budgets to reduce flood risks that are poorly perceived. Rationalisation of funding, with increased grant aid, is raising the profile of flood defence with local authorities.

The constitution of the Welsh Assembly Government created a statutory obligation towards sustainable management of flood risk. The National Assembly of Wales has a committed duty, working closely with the Countryside Council for Wales, to maintain and enhance Special Protection Areas, Special Areas of Conservation and so on. The make-up of stakeholders differs in Wales from the rest of the UK. For example, Network Rail has a disproportionately large responsibility for coastal flood embankments in Wales.

Conclusions

In future, river and coastal flood risks in Wales may well diverge from those in England for three main reasons:

- Interest in planning flood and coastal defence in Wales is according to political rather than catchment boundaries. Control of funding policies in Wales resides within Wales rather than stemming from Defra and England.
- The different structures of the economies in England and Wales make the environmental value of the countryside – rivers, mountains and coasts – relatively more important in Wales.
- The decline of heavy industry and traditional agriculture has shifted economic activity to the coastal strip, where about 10% of the population works.

8.3 Northern Ireland

8.3.1 Drivers in Northern Ireland

Climate change

There is already an apparent change in the balance between summer and winter rainfalls in Northern Ireland. If this trend continues under the scenarios for climate change, summers could be drier and winters wetter (15-20%), with marginally wetter autumns, increased soil moisture in winter (4%), and higher incidence of intense rainfall events (75%). Greater run-off, arising from higher rainfall and wetter catchment conditions during winter months, could, in the long term, increase peak flood flows in the order of 15-18% in Northern Ireland. This could have a major impact on flooding thresholds and hence on flood risk. These trends and changes are similar to those in the UK as a whole.

Catchment runoff

Urbanisation will be intense in Northern Ireland. Development is likely to include 250,000 new dwellings by 2025 (see 'Shaping our future,' DOE 2002), equivalent to one-third of current housing stock. The cultural and historical pattern for dispersed domiciles is a distinguishing feature of Northern Ireland. This dictates that, with the possible exception of Greater Belfast, widespread urbanisation is unlikely in floodplains and areas prone to coastal flooding. Development is more likely through expansion of spatially isolated, rural communities.

Highly impermeable soils are prevalent in Northern Ireland. As a consequence, the impacts of urbanisation on flood risk in Northern Ireland under the socioeconomic scenarios World Markets and National Enterprise are likely to be less than in the UK more generally. Under the Global Sustainability and Local Stewardship scenarios the fact that permeability is inherently low negates the reductions in flood risk predicted for the UK as a whole, even with the introduction of Sustainable Urban Drainage Systems.

Agriculture is currently a key determinant of rural land management in Northern Ireland. This is likely to continue. Unlike extensive areas of lowland England, Northern Ireland's Department of Agriculture and Rural Development (DARD) sees effective land drainage for agriculture and high levels of watercourse maintenance continuing into the future. This should minimise rural flooding. However, if the policy changes in line with reductions in grants for agricultural drainage, collapsed drainage systems and reduced watercourse maintenance would exacerbate rural flooding.

Upland farming will decline under the World Markets scenario, following reduction of subsidy and reversion to semi-natural habitat. Land drainage for agricultural stability is an important role of the Rivers Agency, the statutory drainage and flood-defence authority for Northern Ireland. Reductions in the maintenance of arterial drainage and field drainage will increase the risk of waterlogging and groundwater flooding in rural areas, resulting in reduced river flows. The plethora of lakes in Northern Ireland provides significant surface storage which also attenuates river flows.

Under the Global Sustainability scenario we can expect further conversion to local stewardship schemes. Under this scenario, farming will not be sustainable into the future as landowners become local land custodians and flood risk decreases. Decreases in agricultural losses will reflect the fact that few high-value crops will be grown in Northern Ireland. Arable farming will be limited to grade 1 and 2 land in line with reductions in subsidy, changes to stewardship schemes and restricted opportunities for 'niche market' agriculture.

Fluvial processes

Current standards of protection against river flooding are designed to cope with events that occur 1 in 50-years to 1 in 100-years or more for urban communities and 1 in 3-years to 1 in 5-years for the more important agricultural areas given over to beef, milk and horticulture.

Increases in peak flows of 15 to 18%, driven by climate change, could result in a significant reduction in these standards over the next 50 to 80 years, reducing to 1 in 15 to 1 in 20-years for urban areas, and 1 in 1 to 1 in 2-years for agricultural areas. Increase in average annual temperatures under future climate change scenarios, accentuated by strong seasonal differences of up to +1.5 to 4.0°C in summer and autumn, could lead both to increased growth and extended growing periods for riparian vegetation.

Maintenance currently covers 6,792 km of designated watercourses in Northern Ireland. Standards of flood protection could be significantly degraded unless maintenance activities increase as necessary to deal with future vegetation growth. Withdrawal of subsidies through the Common Agricultural Policy would affect the large rural farming community and would probably create widespread changes in rural land. This could lead to the development of managed wetlands on previously farmed floodplains or, if managed, the further development and extension of stewardship schemes in sensitive rural areas. In either case, there would be marked changes in the Environment driver.

Watercourses in Northern Ireland suffer from massive eutrophication. This contrasts with Scottish gravel-bed rivers and English lowland fluvial systems. In futures with reduced channel maintenance, increased vegetation will make conveyance less efficient. However, as high nutrient loadings are associated with current farming practices, current levels of eutrophication are unlikely to persist in future. Agriculture is marginal in Northern Ireland. All scenarios are likely to feature reductions in the agents that cause eutrophication, although for different reasons.

Socioeconomic impacts – public attitudes and stakeholder behaviour

The public has little perception of the importance of flood risk. Without greater public awareness of flood risk, there will be poor preparedness and response to flood warnings. Were floods to become more extensive and more frequent, without better public awareness, there would be greater flood damage and risk to life.

As peak flows increase, progressive reduction in flooding thresholds within existing communities, especially in Belfast and Lisburn, will create the potential for more frequent flooding. The commercial sector will be hardest hit during extreme events, accounting for over 75% of flood damage in the indicative floodplain. Under the National Enterprise scenario, with medium-high emission of carbon dioxide, average annual damages are likely to increase by 60% in the long term, irrespective of the baseline valuation of average annual damage, and excluding potential encroachment of the floodplain.

Coastal processes

The probability of coastal flooding and erosion may increase, particularly along the more vulnerable east coast. Rises in relative sea level (20-69 cm) and greater storm surge intensities in the Irish Sea are predicted for this area. Stakeholders living in coastal fringes are unaware of the threats of erosion and flooding. This could lead to increased damages. It might be possible to mitigate these effects by replacing informal coastal forum initiatives with formal Shoreline Management Plans and Coastal Zone Management Plans backed by legislation and supported by PPS18 guidance, as in other parts of the UK.

8.3.2 Driver scoring

We repeated the scoring exercise performed for the UK as a whole for the drivers as they operate in Northern Ireland (see Table 8.4). Our analysis for Northern Ireland takes account of the social factors that we have already described in this chapter.

Table 8.4 **Summary results for driver impacts on local flood risk in Northern Ireland, with results presented separately for each driver set (see Chapter 2): the figures in the table are multiples of current flood risk, with the equivalent values for the UK as a whole shown in brackets. Where there are differences between these values, we explain them in the accompanying text (Note: drivers that are grey-toned affect flood risk indirectly via other drivers)**

Driver	Driver type	World Markets		National Enterprise		Local Stewardship		Global Sustainability	
		2050s	2080s	2050s	2080s	2050s	2080s	2050s	2080s
Climate change									
Precipitation	Source	4	5.7	2.8	4	2.8	4	2	2.8
Temperature	Source	1	1	1	1	1	1	1	1
• Scores for Precipitation reflect the predicted increases in mean winter precipitation and intense precipitation events, especially in the west. They are unchanged from those for the UK as a whole. • Risk multipliers for temperature are unchanged from UK-wide values.									
Catchment runoff									
Urbanisation	Pathway	2 (2.8)	2.8 (4)	2 (2.8)	2.8 (4)	1 (0.7)	1 (0.5)	1 (0.7)	1 (0.5)
Rural Land Management	Pathway	1 (1.4)	0.7 (2)	1 (1.4)	0.7 (2)	0.7	0.5	0.5 (0.7)	0.5 (0.7)
Agricultural Impacts	Receptor	0.5 (0.7)	0.5 (0.7)	1 (1.2)	1 (1.7)	1	1 (0.85)	0.7	0.5
• Flood-risk impacts of Rrbanisation in Northern Ireland under World Markets and National Enterprise scenarios are likely to be lower than in the UK generally due to the prevalence of highly impermeable soil. Under the Global Sustainability and Local Stewardship scenarios this inherent 'impermeablity factor' negates the reductions in flood risk predicted for the UK as a whole, even with the introduction of SUDS. • Farming will decline in intensity and extent more markedly in Northern Ireland than in the UK as a whole under World Markets and National Enterprise scenarios, following reductions in subsidies and increased domestic competition, respectively. Widespread conversion to land-stewardship schemes is expected under the Global Sustainability scenario. Under three scenarios, flood risk reductions due to changes in Rural Land Management are more marked in Northern Ireland as a result. • Generally lower values for the Agricultural Impacts driver reflect that in future few high-value crops will be grown in NI, with arable farming limited to limited grade 1 and 2 land in line with reductions in subsidy, a sea change to stewardship schemes and restricted opportunities for 'niche market' agriculture.									

Table 8.4 **Summary results for driver impacts on local flood risk in Northern Ireland, with results presented separately for each driver set (see Chapter 2): the figures in the table are multiples of current flood risk, with the equivalent values for the UK as a whole shown in brackets. Where there are differences between these values, we explain them in the accompanying text (note: drivers that are grey-toned affect flood risk indirectly via other drivers)** *(continued)*

Driver	Driver type	World Markets		National Enterprise		Local Stewardship		Global Sustainability	
		2050s	2080s	2050s	2080s	2050s	2080s	2050s	2080s
Fluvial processes									
Environmental Regulation	Pathway	1	1	1	1	1.4	2.8	2	4
River Morphology and Sediment Supply	Pathway	1	2	1	1	1.4 (2)	2 (4)	1 (1.4)	1 (2.8)
Vegetation and Conveyance	Pathway	1	1.4	1	1.4	1	2	2	5.7

- The relatively high impacts of the driver River Morphology and Sediment Supply predicted for the UK under the Global Sustainability and Local Stewardship scenarios are not expected in Northern Ireland. Flood-risk increases are eliminated under the scenario Global Sustainability in Northern Ireland, as flood defences exhibit large degrees of freeboard. However, under the Local Stewardship future, channel deterioration following the breakdown of central control is predicted to drive some increase in flood risk.
- Flood-risk multiplier scores for Vegetation and Conveyance are the same for Northern Ireland as for the UK as a whole as differences between Northern Ireland and the rest of the UK that affect this driver cancel each other out. Watercourses in Northern Ireland currently suffer from massive eutrofication and in futures with reduced channel maintenance, increased vegetation could make conveyance less efficient. However, current levels of eutrophication are unlikely to persist, as all scenarios are likely to feature reductions in application of those agents causing eutrophication, although for different reasons.

Driver	Driver type	World Markets		National Enterprise		Local Stewardship		Global Sustainability	
Human behaviour									
Stakeholder Behaviour	Pathway	2.8 (2)	4 (2.8)	0.5	0.33	0.25	0.2	0.25	0.2
Public Attitudes and Expectations	Receptor	Known to be important but not quantified							

- Large scale flooding is rare in Northern Ireland and the behaviours and attitudes of stakeholder organisations and the wider public are based on limited experience. While Ulster is a highly dependent society (very dependent on the rest of the UK for economic support), the strong community ethic will counteract the type of dispersal of society predicted for the UK more widely. However, the closed society would make it much more vulnerable to pressures imposed under the World Markets scenario, with potentially serious consequences for the driver Stakeholder Behaviour. The increase in flood-risk multiplier score for Northern Ireland reflects this.

Table 8.4 **Summary results for driver impacts on local flood risk in Northern Ireland, with results presented separately for each driver set (see Chapter 2): the figures in the table are multiples of current flood risk, with the equivalent values for the UK as a whole shown in brackets. Where there are differences between these values, we explain them in the accompanying text (note: drivers grey-toned affect flood risk indirectly via other drivers)** *(continued)*

Driver	Driver type	World Markets		National Enterprise		Local Stewardship		Global Sustainability	
		2050s	2080s	2050s	2080s	2050s	2080s	2050s	2080s
Socioeconomics									
Buildings and Contents	Receptor	6.0	17.0	2.2	3.1	3.0	4.8	2.5	4.8
Urban impacts	Receptor	5.0	19.8	1.8	3.6	3.0	4.8	2.59 (2.2)	4.59 (3.9)
Infrastructure Impacts	Receptor	7.1	24.0	2.2	3.6	3.0	4.8	2.5	3.9
Social Impacts	Receptor	6.0	19.8	2.2	3.6	3.0	6.1	2.2	3.2
Science and Technology	Receptor	Known to be important but not quantified							

- The only difference in driver scores relates to the urban impacts of floods in Northern Ireland under the socioeconomic scenario Global Sustainability. Lack of flood awareness might limit willingness to adopt mitigating actions such as flood proofing and retro-fitting that are taken up in the UK more generally.

Driver	Driver type	World Markets		National Enterprise		Local Stewardship		Global Sustainability	
Coastal processes									
Waves	Source	1 (3)	2.5 (10)	1 (2)	2 (5)	1	3	1	2
Surges	Source	1.8 (5)	5 (20)	1.1 (3)	3.2 (9)	1 (2)	2.5 (5)	1	1.4 (2)
Relative Sea Level Rise	Source	2.5 (5)	14 (20)	3 (4)	10 (13)	2 (3)	7 (10)	2 (3)	5 (7)
Coastal Morphology and Sediment Supply	Pathway	1.3 (5)	3.5 (10)	2 (4)	3.4 (7)	2.1 (3)	3 (4)	1 (2)	1 (2)

- The north and east coasts of Northern Ireland are such that North Atlantic storms do not materially affect the region. This reduces the impacts of waves as a driver of increased flood risk.
- Flood risks associated with increased surge activity are also less severe than is generally the case for the UK, although forecasted increases in south-easterlies, associated with high pressure blocking during North Atlantic Oscillation conditions, will significantly increase surge risk on the east coast.
- Relative sea-level impacts in Northern Ireland are reduced due to uplift of the north east part of the island of Ireland that is continuing in response to isostatic rebound.
- Impacts due to the driver Coastal Morphology and Sediment Supply are generally lower in Northern Ireland as the coastline is in all cases dominated by strong rock control and limited supply of sediment.

Summary

In summary, driver scores for Northern Ireland tend to be closer to those for Scotland than for England and Wales. The strongest contrasts are related to Urbanisation, Rural Land Management and the Coastal processes driver set.

We have modified the multiplier scores for flood risk for the Urbanisation driver of inland flooding to take account of the limited urban development of river corridors. Floodplains in Northern Ireland are narrow and wet. Historically, developers have avoided these adverse conditions in favour of building dispersed settlements in upland areas. This situation is unlikely to change, limiting the impacts of future urbanisation.

Farming is relatively more important and vulnerable to change in Northern Ireland than in the UK as a whole. The general decline in intensity and extent will have disproportional impact on the region. Reductions in flood risk due to changes in agriculture and Rural Land Management are more marked as a result.

Significant reductions in the driver scores for the Coastal processes driver group reflect the geology and geographical location of Northern Ireland and the orientation of its coastlines. These tend to reduce the degree to which coastal flood risk will rise in comparison to the UK as a whole. A notable exception to this general prediction may be Greater Belfast, which is exposed to flooding by storm surges under appropriate conditions. Increasing flood frequency here could lead to heavy urban and economic impacts.

8.3.3 Expected Annual Damages

Given the increased flood risks predicted in the driver scoring exercise, we should expect annual damages due to inland and coastal flooding in Northern Ireland to increase under all four future socioeconomic scenarios. To investigate the future economic impacts of flooding, we calculated expected annual damages for the present day and then estimated values for the 2080s. Our predictions for the 2080s applied the baseline assumption, that flood defence policy, levels of investment and maintenance practices will continue as today.

The basis for the calculation of present-day expected annual damages is the estimate that there are over 40,000 properties within the indicative floodplain (IFP) in Northern Ireland. These are properties potentially at risk of events with a probability of more than 1 in 100 in a given year. This estimate derives from work carried out by the Rivers Agency in conjunction with CEH under a project titled Evaluation of Watercourse Maintenance.

To estimate properties that would be flooded by more frequent events, we assumed that 90% (or 38,837) of properties in the IFP would be inundated by the 50-year event and that 10% (4,315) would be flooded during the 1 in 20-year event. We took as the threshold for property damage the 5-year event. We then estimated damages associated with 10-, 20-, 50- and 100-year floods and aggregated these to estimate the current expected annual damages for Northern Ireland's built-up floodplains (see Table 8.5). We should note that because of a lack of data we do not account for the effects of existing flood-defence infrastructure. For comparison, the equivalent figure would be only £16 million if we assume that all floodplains were defended to a 1 in 50-year standard of protection.

We adjusted estimates for event loss for current conditions to reflect the increased probability and consequences of flooding predicted in the driver scoring. Owing to limited data availability, we restricted predictions to the World Markets scenario. The resulting estimated expected annual damages for the 2080s indicate an increase of 65-100% under World Markets in comparison to present-day conditions (see Table 8.5). Although current estimates of expected annual damages may seem high in comparison to other available estimates for Northern Ireland, the accuracy of the current estimates does not affect the relative change predicted under World Markets.

Table 8.5 **Expected Annual Damage due to inland flooding in Northern Ireland (£million) under the World Markets scenario**

Assumed standard of protection	Expected Annual Damages (£million)	
	2003	2080s
Unprotected	101	165
1 in 50-years	16	32

The tidal flood-risk inventory for Northern Ireland lists 12,715 properties within the coastal zone and with elevations below 5m. However, we cannot calculate a realistic estimate of expected annual damages as there are no estimates of flood frequency. Based on the fact that the number of properties at risk from coastal flooding is only about a third of those in inland IFPs, we anticipate that the expected annual damages for coastal flooding are much smaller than for inland flooding. There is an overlap between the areas at risk of tidal and coastal flooding in Newry, Strabane and Greater Belfast, with the latter accounting for over half the overlap.

Summary

The flood risk to people, private homes and commercial properties in Northern Ireland is significantly below that elsewhere in the UK, particularly within the coastal zone. The predicted increase in expected annual damage for the World Markets scenario is similar to that predicted for Scotland, but is much lower than for the UK as a whole. Despite this, the consequences of frequent, widespread and unchecked flooding in the province would be socially and economically severe at the regional scale.