

FLOOD RISK AND DEVELOPMENT A SUSTAINABLE AND APPROPRIATE APPROACH

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1. INTRODUCTION

Significant damage has been caused in Ireland by recent floods, such as January 2000 along the River Shannon, in the South and East in November 2000, along the East Coast following exceptional sea levels in February 2002, and most recently in Dublin and other areas in November of the same year. Such flooding results in severe economic losses and personal hardship, and its severity and frequency appear to be increasing with time, which could cause increased damages and suffering, and exacerbate consequential problems such as difficulty in procuring affordable insurance and a rising demand for aid and expensive flood relief schemes.

Development is an essential component of national and regional growth and prosperity. It is however also a human activity that can have a significant influence on the processes that can lead to flood damages; either directly where the development itself is at risk, or indirectly where the development can increase the risks of flooding at other locations. With ongoing rapid development, and the predicted increases in flood flows arising from climate change, the extent of flood risk in Ireland could rise significantly in the future.

Existing problems of flood risk can be reduced or damages mitigated through flood relief schemes based on engineered or non-structural solutions. These can however be costly and impose a significant demand on central or local government finances, and will not eliminate the risk entirely. The continued reliance on such engineering solutions as the primary means of managing flood risk in the future, with limited efforts to manage the risk at source, is not sustainable.

A more cost-effective approach is to manage risk at source, by preventing or minimising future increases in risk, rather than to attempt to treat the symptoms and protect against it in the future. Avoiding future risks through risk-based planning and appropriate development control must therefore be considered as a potentially more sustainable approach to managing flood risk in the long term and to avoid an ever-increasing spiral of rising flood damages and demands for expenditure on flood relief. This approach has been widely accepted and adopted around the world.

This paper discusses some of the issues and approaches that might be considered in developing and implementing a sustainable and appropriate approach in relation to managing flood risk with particular reference to planning and development control.

2. CAUSES OF FLOODING

2.1. The Chain of Processes

The mechanisms of flood risk have often been described by the ‘source-pathway-receptor’ model (ICE, 2001), where the source may be heavy rain or high sea levels, and the pathway may be the watercourses or overland routes by which the floodwater makes its way to the receptor, i.e., people and property. While the source or root causes of flooding (rainfall and sea levels) are natural phenomena and essentially uncontrollable (with the exception of the man-made drivers of climate change), the pathways by which these phenomena may be transformed into flooding and flood damage are subject to influence by local or regional human activity. These activities, and the influence they can have, are controllable and can significantly increase or decrease the risk of flooding to property and infrastructure.

In assessing the causes of flooding and man’s impact, the middle step of the above model (i.e., the ‘pathway’) may be broken down into a chain of discrete processes or relationships to facilitate analysis of how human activities influence the overall flooding process (Adamson, 2003). These activities are

manifold, and include channel restriction arising from undersized culverts or bridges, a lack of river maintenance, agricultural and forestry land-use and drainage practices and a lack or failure of flood defences.

One activity that can potentially have a more significant impact than any other however, is development. Inappropriate development can place itself at risk, and can also increase flood risk at other locations within a river catchment; many times over in the case of small catchments. The primary mechanisms by which development can impact on flood risk, or vice versa, are outlined below.

2.2. THE RELATIONSHIP BETWEEN DEVELOPMENT AND FLOOD RISK

2.2.1. Impact of Flood Risk on Development

Locating development in an area at risk from flooding (a floodplain) can lead to property damage, human stress, hardship and ill-health, problems obtaining property insurance and consequential demands for the expenditure of local authority or central government resources on flood protection works. The construction of protection works at the time of the development, or at a later date, will incur significant additional costs and will not provide absolute immunity from the risk of flooding. Development located in an area prone to flooding can therefore increase flood risk and / or necessitate heavy expenditure on flood protection works.

2.2.2. Impact of Development on Flood Risk Upstream

In times of flood, a river can flow not only through its normal channel but also along its floodplains. Any constriction of the natural flow path can restrict flow, 'back-up' the river and lead to increased flood levels upstream. The construction of buildings or houses, and particularly embankments for infrastructure or protection, in or across a floodplain can therefore not only put the development itself at risk of flooding as described above, but can also increase the flood risk for land and properties upstream.

The same is obviously true of any form of construction or encroachment in the normal river channel. Undersized culverts, or narrow openings between bridge piers, can restrict flow and also carry the additional risk of causing a blockage of floating debris during high flows, potentially further exacerbating the problem and degree of flood risk.

2.2.3. Impact of Development on Flood Risk Downstream

Natural or agricultural land, such as forests, woodland, pastures or crop fields, is normally able to absorb and temporarily store a considerable proportion of any rain that falls onto it. Covering such land with buildings, tarmac (such as for parking areas or roads), or other impermeable materials significantly reduces this ability to absorb rainfall, and will lead to increased storm water runoff. Large developments, or a series of small developments, including those away from major rivers, can therefore increase river flows and the risk of flooding to land and property downstream.

Development that prevents floodwaters from accessing natural storage areas, such as can occur by constructing embankments around sections of a floodplain, reduces the attenuation of the river system. This in turn will increase flood flows and risk downstream.

2.2.4. Development Behind Flood Defences

Flood defences are built to a specific design standard, i.e., an average frequency, or annual probability, of flood event against which the defences are designed to protect. Should a flood occur that exceeds this standard then the defences will fail and the defended area will flood, i.e., the presence of a flood defence does not provide immunity from flooding, but rather reduces the frequency, and so development behind the defences will still be at risk from flooding, despite the defences.

The design standard of flood defences can be reduced by changes in the river's flow regime. This might occur due to factors such as climate change or increased runoff from upstream development.

3. EXISTING PLANNING POLICY AND LEGISLATION

3.1. Introduction

The material below is not intended to be a comprehensive review, or legal interpretation of, the planning system as it operates in entirety. Rather, the parts of the planning system that have most day to day relevance to the issue of flood risk have been focused on, such as the preparation of development plans and the operation of the development control system.

There are other areas of human activity that may have implications in relation to flood risk that the planning system does not have a direct influence over, primarily in relation to exempted development or development activity that does not normally require a formal grant of planning permission.

3.2. Structure of Planning System

The Planning and Development Act 2000, as amended, provides the legislative structure for the Irish planning system. The planning system primarily functions through the preparation of Development Plans by planning authorities and the assessment of development proposals that require planning permission under the act in accordance with the provisions of the development plan and other relevant policy documents such as the National Spatial Strategy, any regional planning guidelines that may be in place and any other relevant policy documents such as Ministerial Guidelines or Directives issued under the provisions of the Act. An Bord Pleanala provides an appeal mechanism in relation to development control related decisions made by planning authorities.

Key elements of the planning system that ensures it takes flood risk into proper account are:

- (1) The requirements of the Act in relation to what development plans must and / or can take into account.
- (2) The policies of the local authority Development Plan.
- (3) Other relevant policy documents such as Ministerial Guidelines and Directives
- (4) The operation of the development control system.

3.3. Planning and Development Act 2000

Under section 9 of the Act, every planning authority is required to make a development plan every six years. Under section 10, the Act requires the development plan to be:

“an overall strategy for the proper planning and sustainable development of the area of the development plan and shall consist of a written statement and a plan or plans indicating the development objectives for the area in question”

A development plan is required to include objectives in relation to a number of mandatory areas under section 10(2) and under section 10(3), a development plan may indicate objectives for any of the purposes referred to in the First Schedule to the Act.

Under this schedule, in relation to the location and pattern of development, planning authorities may include objectives aimed at:

“Regulating, restricting or controlling development in areas at risk of flooding (whether inland or coastal) erosion or other natural hazards”

Other optional objectives cover additional matters relating to flood risk.

In making a decision on a planning application, a planning authority is obliged under section 34(2)(a) to restrict its considerations to the proper planning and sustainable development of the area with

regard being had to the provisions of the development plan and a number of other specified requirements.

Therefore, the development plan is a key influence upon a planning authority in deciding on the merits or otherwise of development proposals for which planning permission has been sought.

3.4. Ministerial Guidelines and Development Plans

Under Section 28 of the 2000 Planning and Development Act, the Minister for the Environment, Heritage and Local Government, may, at any time, issue guidelines to planning authorities regarding any of their functions under the Act and planning authorities are obliged to have regard to such guidelines in the performance of their functions. Furthermore under section 28(2), An Bord Pleanála is obliged to have regard to any guidelines issued under Section 28 that are applicable to its jurisdiction.

Guidelines within the meaning of Section 28 of the 2000 Act, on the preparation of Development Plans are in the process of being finalised with a view to publishing them as a consultation draft. These guidelines will address the issue of flooding in a general manner along with a wide variety of other best practice and practical issues.

In England, Scotland and Wales, guidelines have been prepared to inform local authorities on best practice in relation to development plan policies and development control considerations. These are addressed in more detail later in this paper. While there is currently no equivalent to such guidelines in the Republic, the issuing of such guidelines under Section 28 of the 2000 Planning and Development Act would, in the longer run, make a valuable contribution to the proper consideration of flooding issues in the planning process.

Turning to the development plan process, in identifying lands for various categories of development, it is good practice that flood risk is be considered at all relevant stages such as:

- Considering an overall settlement strategy in strategic terms by reference to deciding on the areas that are most suited to development in terms of achieving coincidence in peoples' places of work and residence, the availability of physical and social infrastructure and avoiding risks of natural hazards such as flooding.
- Considering the use of specific areas of land for particular land uses such as in cities and towns, where areas being considered for development or redevelopment and that might be within an area at risk from flooding.

It is consistent with the proper planning and sustainable development of an area that the development plan aims to ensure that existing flood risks are either reduced or addressed and that new development does not individually or cumulatively give rise to new flood risks.

In dealing with the issue of flooding, it is also good practice that development plans should identify in a broad manner, any main river catchments and or coastal areas that experience or are at risk from flooding. Policies could then outline the considerations that will arise in relation to development proposals within river catchments from the point of view of seeking a balance between accommodating development requirements and managing existing flood issues or avoiding the generation of new flood risks. Such policies will normally be derived from, and should include references to, any mapping of flood patterns, such as that carried out for certain areas by the Office of Public Works. Such maps could indicate areas affected by historical flood events, or predicted floods based on the approximate extent of flooded areas with a 1% annual probability of occurrence for rivers and a 0.5% annual probability for coastal areas. More precise information may be needed for development plan policies relating to particular sites in areas at risk of flooding where development is proposed or is likely to occur.

Other possible development plan policies might set out requirements for individual planning applications to effectively address surface water drainage and the cumulative impact of altered drainage patterns where substantial areas of "greenfield" development are envisaged.

Development plans, in suitable locations, might also encourage forms of development that reduce or better manage the rate of surface water discharge. For example, the above might be achieved by indicating a preference for more permeable surfaced areas rather than hard surfaced areas in car parks, as well as use of storage ponds and mechanisms to control the release of surface waters. The approaches described above are often described as Sustainable Urban Drainage Systems (SUDS), and are discussed briefly later in this paper.

It would also be good practice that development plan policies dealing with flooding recognise the uncertainties inherent in the prediction of flooding and the fact that flood risk is expected to increase as a result of climate change. In this regard, a precautionary approach is desirable. It might also be appropriate that development plans include policies indicating that developers will be required to support the funding of flood defences needed for particular developments, either partially or fully, depending on the circumstances involved.

3.5. Relationships with other Policy Frameworks

Given the nature of flooding issues, development plan policies need to be set within a broader context that is linked to and supportive of other policy frameworks. Other policy frameworks that are particularly relevant relate to the areas of forthcoming river basin management plans and policies relating to Coastal Zone Management, which are beyond the scope of the discussion above on the physical planning system.

4. PLANNING APPROACHES

A range of approaches or policies might be adopted in relation to applying the existing legislation to the consideration of flood risk as part of the planning and development control decision-making process.

4.1. Uncontrolled Development

As noted above, development is essential for economic growth, and it may be argued that the pursuit of growth should be the primary consideration in planning decisions to the exclusion of other considerations. Such an approach would however be likely to lead to ever-increasing levels of flood risk and damages, and demands for expensive relief schemes, and may therefore be economically counter-productive. It is further internationally accepted that due consideration must be given to sustainability and environmental issues (see section 5), which would not be the case under this approach. Uncontrolled development is therefore not desirable, sustainable or publicly acceptable, as reflected in current legislation which requires public consultation and consideration of issues such as environmental impacts, and is therefore not considered further as a viable policy.

4.2. No Development

A diametric opposite to the approach described above would be a blanket ban on all development in potential flood risk areas, and on development that could increase flood risk elsewhere. However, not all development is subject to damage when flooded, and the economic and / or social demand for certain types of development may justify a moderate level of risk. While potentially the optimum policy in terms of minimising increases in future flood risk, this cautious approach may be considered excessive by unnecessarily restricting development and placing a severe constraint on local, regional and national economic development, and is therefore not considered further as a viable policy.

4.3. Appropriate Development

Certain types of development in a flood risk area is sometimes necessary for economic or social reasons, but the type of development permitted should be compatible with the existence and degree of the risk.

The damage caused to a development during a flood event is a variable in itself. Development where the property or contents have a high potential for flood damage must be considered inappropriate for location in a flood risk area, and might include;

- High-density residential property (economic, social and personal welfare risk), or any residential property in areas subject to flash or deep flooding (risk to life),
- Manufacturing or storage property where the cost of flood damage to the contents, such as machinery or products, would be high (economic risk),
- Property or infrastructure with particular structural vulnerability to flooding (economic risk and risk to life),
- Key infrastructure for which disruption by flooding would cause significant delays to large numbers of people (indirect economic risk),
- Industry or services where flooding could cause leakage of pollutants, such as chemical or sewerage plants (risk to personal health and environment).

Other types of development may however have a low-susceptibility to flood damage, and might include;

- Minor infrastructure (such as roads) where temporary closure will not cause significant inconvenience,
- Warehouses storing flood-resistant materials (e.g., plastic products),
- Playing fields, parks or other green amenity areas,
- Elevated structures where flow may pass under the property which is built above the predicted design (or highest historic) flood level,
- Flood-resistant structures.

Such developments may be temporarily unusable or inaccessible when flooded, but cause only minor inconvenience, and sustain limited, if any, permanent damage. Development of this type will not be susceptible to significant damage and, if appropriately designed, can have negligible impacts, or even reduce the risk, elsewhere. In assessing the appropriateness of development within a flood plain however, the issues of loss of storage and conveyance must be considered to avoid risk impacts at other locations. Similarly, the nature and degree of risk is also an important consideration and should be assessed, as high velocities or depths, which may not cause damage to property or infrastructure, may cause a risk to life to the users of a property.

Given the economic need for development, and the limited space available, an approach that permits appropriate development may therefore be considered to be not only sustainable in terms of minimising future flood risks, but also appropriate in terms of maintaining national or regional economic growth. This has been recognised in other countries, such as in England where the relevant policy document states that '*Local circumstances may require the identification of areas, such as functional floodplains, ... where new built development should be avoided and only development that is appropriate to the risk can proceed, subject to suitable design and conditions to secure the necessary management of that risk.*' (DTLR, 2001).

Issues for the implementation of appropriate development are considered further in Section 6.

5. INTERNATIONAL APPROACHES

It is useful for the purposes of comparison and support to examine policies and guidelines adopted in other countries. Outlined below are policies recommended by international bodies and individual nations.

5.1. United Nations

In 2000, a range of bodies within the United Nations, lead by the Economic Commission for Europe, produced a document on 'Guidelines on Sustainable Flood Prevention' (UNECE, 2000), which were developed to provide recommendations for measures and best practice to prevent, control and reduce the adverse impact of flood events. The document is holistic and makes recommendations in a wide range of areas from public awareness to structural measures. The document does however specifically recommend that '*Land uses should be adapted to the hazards in the immediate and in the potential flood plains*', and that '*Restrictions and prohibitions (on land use) should be based on risk assessments*'. These recommendations support the adoption of development appropriate to the degree of risk, as discussed above.

5.2. European Union

The Water Directors of the European Union agreed to take the initiative on flood prevention, protection and mitigation following the catastrophic flooding in central Europe in August 2002. An expert group was subsequently established which produced a document on best practices in flood risk management (EU, 2003), which at the time of writing remains in draft form but has been submitted for the consideration of the Water Directors. Many of the issues raised are in line with the UN document referred to above. The proposed approach to development control is relatively strict, with exclusion preferred over the compromise solution, although recommendations are also made for '*adapting (land) uses to the hazards in the potential floodplains ... in order to minimise the damage potential*'.

5.3. United Kingdom

In the U.K., slightly different approaches are taken in the different jurisdictional areas of England, Scotland and Wales.

In England, the Office of the Deputy Prime Minister has issued Planning Policy Guidance 25 (DTLR, 2001), which is a comprehensive guidance note for local authorities for the consideration of flood risk in relation to planning and development control. The document supports the application of the Precautionary Principle to assessing flood risk, and recommends the avoidance of risk where possible and management of the risk elsewhere. Due to population density in many parts of England, where 1.3 million properties are already considered to be at risk, a strict policy to place severe restrictions on development has not been considered appropriate, but the principles of strategic and sustainable risk management are still recommended '*... (plans) should set out the strategic approach to flood risk and the control of surface-water drainage*'. The Guidance also specifically supports the principle of appropriate development through the application of what is termed the sequential approach, '*A flexible approach is needed to take due account of flood risk through the sequential approach ... This should ensure that further development normally avoids the areas of highest risk and that appropriate measures are taken to make development safe where other considerations in favour of the development proceeding may outweigh the flooding issues*'.

In Scotland and Wales, the relevant documents ('National Planning Policy Guidance 7 – Planning and Flooding' and 'Technical Advice Note (Wales) 15' respectively) take a similar approach, stating that '*... (the development plan) should set out policies to avoid or manage the threat of flooding*.' (Scottish Executive) and '*(flood risk information) should be taken into account by local planning authorities in development plan preparation*.' (NAW, 1998).

5.4. Germany

In Germany, the Environment Ministers of the Länder prepared Guidelines for Forward-Looking Flood Protection (LAWA, 1995), in which flood protection and prevention measures are discussed. The document emphasises in particular the management of land-use within floodplains, and makes a range of recommendations, including the needs to '*designate floodplains and work towards keeping these areas empty*' and '*review land use and construction plans in the light of flood risk*'. The first of these might be considered somewhat strict in relation to limiting development, but the overall approach would support the general principle of appropriate development.

5.5. France

In 1987, France passed a law (modified in 1995) requiring the preparation of Natural Risk Prevention Plans (*Plans de Prévention des Risques Naturels - PPR*), which identify and map zones of natural risk (including flood risk) and set out controls that are to be applied in relation to each risk zone, including those applicable to existing and future development (MATE). The Plans are appended to the development plans for each Commune, and impose strict regulation on new construction in zones of high risk. This approach encompasses the concepts of flood risk assessment, strategic planning and appropriate development.

5.6. Summary

The range of statements highlighted above indicate the international acceptance and promotion of the need for strategic planning in relation to flood risk and development. While there are slight variations in the relative degree of prohibition or control proposed, which reflect differences in regional or national conditions or policies, it is generally accepted that development in flood prone areas must be controlled, but may also be permitted where appropriate to the degree of risk.

6. PLANNING AND DEVELOPMENT CONSIDERATIONS

Flood risk management is a concept that can encompass a wide range of policies and strategies, information analysis and works aimed at reducing the exposure, both current and future, of human interests to flood damage. Its application to planning and development control may steer the 'middle-road' in terms of policy options; maximising the opportunities for increased, but sustainable, development while minimising increases in flood risk and its consequential economic losses and human suffering. Outlined below are some of the approaches and strategies of current flood risk management practice that have particular application in planning and development considerations.

6.1. Flood Risk Assessment

Information on, and understanding of, a risk is essential to enable effective management of that risk. Conversely, it is not possible to tackle a problem if the location, cause and degree of that problem are unknown. Relevant information for the management of flood risk includes a range of flood hazards, such as possible extents, depths, velocities, frequency of flooding, flood mechanisms, possible impacts (damages), potential pollution sources, etc. In the context of this paper, a knowledge and understanding of such hazards can be used to plan and control development to avoid or minimise additional risk. For example, knowledge of flood extents will enable effective control of development within flood prone areas, while knowledge of likely maximum flood levels at a location will enable minimum development levels to be specified so that new buildings or infrastructure are not at risk.

Information on the nature and degree of flood hazards is currently collated and analysed in Ireland for a specific location as part of a flood relief study, or for the design of infrastructure or property development. The latter is not however always the case, and if undertaken, will generally be for the purposes of determining minimum floor levels or embankment levels, rather than as part of the decision-making process on the location of the development. The use of flood risk information as part of the planning process permits informed decisions, such as the allocation of land not at risk to flood-

sensitive development, and conversely reserving flood-prone land for appropriate development, as discussed above, or for flood attenuation.

Flood hazard is assessed systematically in many countries on a national basis as part of a flood risk or hazard mapping programme, but is not currently available in Ireland (although steps are being taken to remedy this situation). There is therefore a need to undertake a flood risk assessment as part of the preparation of the development plans for locations where flood risk may be an issue. This can be undertaken in a number of ways and to varying degrees of detail, from visual inspection and examination of historic data, through assessment of the hydro-morphological conditions to a detailed analysis involving hydrologic and hydraulic modelling.

6.2. Whole Catchment Approach

Locations within a catchment are not independent points, but rather constitute a web of inter-connected sites, linked by groundwater, surface and channel flow. Changes at one location therefore necessarily have impacts at others within the catchment. A whole catchment approach, whereby the catchment is considered in its entirety as part of a flood risk or impact assessment, rather than considering only the immediate vicinity of the proposed development, is therefore necessary to fully assess the impacts of development on flood risk. This is true not only in relation to the impact of paving areas of previously green land, but also in relation to increasing the conveyance of a short reach to reduce flood levels, or development in a floodplain that can lead to a loss of storage.

An individual development may have a minor or undetectable impact on flood risk up or downstream. A series of small developments built at the same time around a catchment or flood risk location, or incrementally over time, can however have a major impact and significantly increase flood risk at other locations, such as towns downstream. This effect will be particularly dramatic in small catchments where the proportion of the total impermeable area may rise quickly as a result of only small areas of development, but also due to the potential for development to compound the flashiness of the catchment.

Hydrological catchment boundaries and the borders of jurisdictional areas rarely coincide. The whole catchment approach will therefore, in many cases, require interaction and co-operation between planning authorities to form agreements on trans-boundary flows and planning policies, which may require the establishment of a formal forum for discussion of flood risk management issues.

6.3. Strategic Planning

As has previously been stated, the management of existing flood risk through, for example, the construction of a structural flood relief scheme or the relocation of properties, can be expensive, and catering for an ever-increasing risk in this way is not sustainable. Managing potential future risk, while more complex, can be significantly less expensive and is an essential component of sustainable development.

Managing potential future flood risks can be put into effect through the consideration of flood risk during the preparation of development plans. Planning for floods through the designation of zones of no development (where flood risk is high) or appropriate development (where flood risk is medium to low), the specification of individual or communal runoff management systems, or the inclusion of areas for flood storage in the development plan may negate the need for expenditure on structural defences or interference with the natural channel, as well as avoiding increasing flood risk at other locations.

As noted above, incremental development comprising a series of small individual developments built over time can have a major impact on runoff and / or flood risk. It is not reasonable or efficient to require a catchment-based assessment of the potential future impacts of all future development to be undertaken by each developer. This impact is most effectively evaluated and managed at the strategic planning stage, i.e., during the preparation of development plans.

6.4. Sustainable Urban Drainage Systems

Sustainable Urban Drainage Systems (SUDS) is a commonly used name for engineered works designed to manage, or attenuate, storm water runoff in urban areas. The suite of measures are generally designed to increase infiltration and hence reduce the runoff that would otherwise occur from tarmac, concrete or other impermeable surfaces, or to store and attenuate stormwater runoff peaks. Commonly used measures include;

- permeable surface materials (e.g., porous pavements, cellular blocks, geotextiles, etc.) that are designed to increase infiltration from otherwise impermeable surfaces and hence reduce runoff,
- storage systems for individual properties or developments (e.g., roof runoff containers, underground storage units, tanks, ponds, etc.), that temporarily store storm water runoff,
- communal storage areas and attenuation ponds, which attenuate flows in channels or runoff peaks from storm water drainage systems,
- swales, french drains and natural channels that provide storage and increase infiltration.

Again, a detailed discussion of these measures is beyond the scope of this paper, but the reader might refer to other papers for further information (DCC, 1999). One issue that does deserve particular attention in the context of this paper however is that of system maintenance, cost-effectiveness and the relative merits of individual and communal systems.

Drainage and storage systems generally require maintenance to avoid a reduction in capacity or effectiveness due to sedimentation, excessive growth of vegetation or blockage by debris. It may not be prudent to assume that individuals or organisations with no maintenance technology or capacity will regularly undertake or pay for the maintenance of systems that are implemented for the common good, rather than specifically for their own. The net cost of maintaining a series of small systems will also generally be higher than that for fewer, larger systems. The maintenance and management of a small number of large communal systems is therefore likely to be both more cost-effective and reliable than a large number of individual systems. A similar economy of scale can be achieved in the initial construction of the systems.

On the basis of the above conclusion, the incorporation and design of stormwater runoff management systems into development plans can generate cost-efficiencies and increase the likelihood of performance of design. Such strategic planning can also take account of the full potential implications of future development (as allowed for in development plan for specific location and the catchment as a whole) and the possible effects of climate change.

An example of how such an approach might be incorporated with minimum impact, would be the inclusion of a linear park at the downstream end of a town. Such a park would be available as an amenity under normal circumstances, but would provide the necessary storage to prevent increases in downstream flood flows during storm events. The full range of storm durations would need to be considered as part of the design, as well as other issues such as safety (e.g., evacuation procedures) and potential pollution issues, but the required area set aside for this purpose would generally not need to exceed 5% of the development area (assuming a storage depth of 1m, and a requirement to store 50% of the total rainfall from a storm with a rainfall depth of 100mm. The 50% storage requirement might comprise, for example, storage of 70% of the runoff volume from a catchment with a 70% percentage runoff rate).

6.5. Climate Change

Research indicates that climate change is likely to occur under a number of scenarios of future gas emissions, and may already be occurring. The impacts of climate change on winter rainfall in Ireland are estimated to be an average increase in the order of 11% by mid-century, with an increase of up to 20% in some parts of the country, while sea levels may rise by approximately 5mm per year (Sweeney et al, 2003). The results of such changes may include an increase in fluvial peak flood flows of up to approximately 20% (Bruen, 2003). However, it is recognised that the occurrence and degree of change are subject to significant uncertainty.

Accounting for climate change in the assessment of future flood risk is therefore complex, with a balance required between applying precautionary allowances and the cost that this approach might incur (potentially for an eventuality that may not arise).

The Office of Public Works have assessed this issue and have adopted a site-specific policy in relation to the design of flood relief schemes whereby the design approach adopted must be appropriate to the specific conditions. For example, where the impacts of climate change, if realised, would be extreme (e.g., at restrictive culverts or bridges), or where the implications of defence failure (e.g., over-topping of walls or embankments) are unacceptable, or where the cost of upgrading a defence or conveyance capacity of a cross-channel structure is high (e.g., a major road bridge), a precautionary approach should be taken, and an allowance for the impacts of climate change be made in the design process. In another situation, where the consequences of defence failure or the cost of upgrading defences are low (e.g., topping up an embankment), the design should be based on estimated existing conditions, but with account taken of the potential need for upgrading in the future.

A similar site-specific policy may be appropriate when considering the potential impact of climate change in the preparation of development plans, and the measures incorporated to manage possible future flood risks.

7. SUMMARY

Development is the primary human influence in terms of its potential impact on flood risk, and, if uncontrolled, has the potential for significantly increasing flood risk in the future, and hence the exposure to flood damage and human suffering, and the resultant demand for expenditure on defence measures. However, the application of the principles of flood risk management can avert this scenario.

Sustainable development can be achieved by the consideration of flood risk as part of the strategic planning process, and particularly during the preparation of development plans. The plans need to comprehensively address the issue given recent trends and events in relation to flooding, and considering the scope afforded to them under the Planning and Development Act, 2000. Guidelines to planning authorities in relation to flood risk would need to be developed and issued under Section 28 of the Act to have the relevant statutory significance.

Determining the flood risk, either from a national dataset (once available) or through a specific assessment, is essential to determine the existing and potential future locations and degrees of flood hazard, taking into account the potential impacts of climate change. Based on this information, zones for controlled, and importantly, appropriate development may be set to avoid placing flood-sensitive development in flood-prone areas. Similarly, if considered strategically, and with due consideration to the whole catchment, cost-effective and reliable runoff management systems can be designed on the basis of long-term development proposals that will provide sustainable solutions while permitting the development required to sustain regional and national economic growth.

A sustainable and appropriate approach to flood risk and development can therefore be applied to minimise potential increases in flood risk, without unduly restricting development.

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