Safe routes for urban flooding - encouraging the uptake of designing for exceedance: sharing the learning

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Abstract
It is unsustainable and unaffordable to continue to increase the size of piped drainage infrastructure indefinitely. When flow exceeds the capacity of the drainage, water is seen on the surface, which may or may not cause flooding depending on how it is managed. We can choose to manage and design for this as 'exceedance' by providing better ways to convey or store the water. A recent CIRIA project has identified the key components to manage exceedance and encourage its uptake and use.

Introduction
Flooding from drainage systems often create local impacts. In the past, they did not attract the sort of attention of some of the major flooding incidents similar to that seen in the media in the winter of 2013/14. However, since 2007 there has been far greater recognition and acceptance that surface water and pluvial flooding can and does cause major impacts on individuals and communities (Pitt 2008).

Many drainage systems that carry surface water (including highway drainage, surface and combined sewers) are designed to a 'design standard'. This considers everyday rainfall (primarily for public health reasons) and design rainfall to reduce the likelihood of flooding. By default, exceedance from such drainage systems will occur when the event exceeds the capacity, with highways designed to 'flood' more frequently than sewers with a lower 'return period' of rainfall used. Often when exceedance occurs it forms minor puddles on surfaces that cause a minimum of impact initially. But such events can cause more wider spread problems and it has typically been left to the emergency services and local authorities through civil contingency and emergency planning to manage the impacts, as well as the local communities helping and supporting themselves.

In 2006, CIRIA released guidance C635 "Designing for exceedance in urban drainage systems" (Balmforth et al), however, this had limited uptake and application. In 2013, CIRIA managed and MWH technically led, a project funded by the joint Defra and Environment Agency flood and coastal erosion risk management research and development programme and Wessex Water to investigate and encourage the uptake of designing for exceedance. The project confirmed in a survey that one third of respondents had used C635, a further third were aware of it, and the final third were not aware of it at all. The project evaluated and presented 12 exceedance case studies (Digman et al, 2014a), mostly from the UK, identifying the primary lessons from these and other examples in a Success Factors Report (Digman et al, 2014b). This paper reports an overview of the findings.

What is designing for exceedance?
In the context of an urban environment, Ashley et al (2014) define exceedance as:

"flow that is conveyed or stored on the surface because the capacity of a drainage system carrying storm water (including as a result of a blockage to an inlet) has been exceeded".

Designing for exceedance helps to manage excess flow that may occasionally occur on the surface within the existing urban environment. This takes place typically on the surface to make the most of available space creating or utilising multi-functional infrastructure to reduce the impact of exceedance on homes and vulnerable assets. Designing and accommodating exceedance events provide the opportunity to manage such rainfall, often overlooked in the past. To explain different types of rainfall to various stakeholders to help understand how to manage the events, Fratini et al (2012) developed a simple graph.

Digman et al (2014b) developed this further into the four domains approach, including the exceedance event. By designing to manage all the domains and considering them as a continuum, it is possible to create a more resilient approach to manage rainfall and reduce impacts. Figure 1 summarises the rainfall events and the impacts, and how considering exceedance events can reduce the impacts of such events.

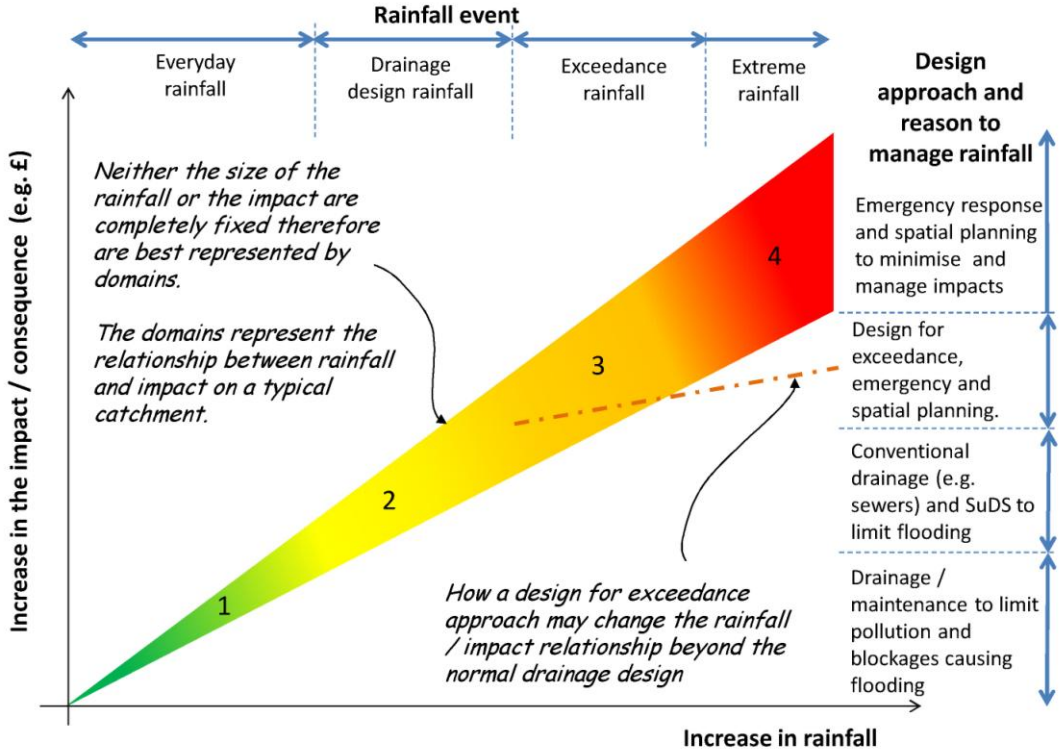

Figure 1. The four-domains approach to help illustrate how to manage different types of rainfall and how an intervention to manage exceedance can reduce the impact

Managing exceedance typically falls into two types. Type 1 is generally for retrofitting when there are relatively minor adjustments to the local landscape to deal with existing and often simple localised problems. Type 2 focuses on structured and strategic exceedance management for new build or complex existing problems. The Lead Local Flood Authorities may lead on this through their Local Flood Risk Management Strategy (LFRMS), local SuDS guidance, and /or development specific design codes. Both types require multi-stakeholder involvement, however, the type 2 approach due to its scale, needs documents like these to set the tone within local government identifying that designing for exceedance is a pre-requisite of the planning and design process and not a bolt-on optional extra. Making this part of policy and guidance at a local level will help create the opportunities to manage exceedance successfully.

The benefits of designing for exceedance

Designing for exceedance provides a cost effective way to manage local flood risk by managing water on the surface by occasionally making use of multi-functional infrastructure such as diverting and storing water on a playing field. As this is occasional, there may be a short-term inconvenience; however, the more devastating impacts on assets and property can be constrained. Designing for exceedance also enables a phased approach to manage flooding that can be implemented often far quicker than traditional solutions.

What makes a success?

The technical approaches to manage exceedance are well established, although at times this requires some imagination to identify and work out where such measures fit in, especially to create them as part of

the urban environment. Figure 2 indicates the types of measures to manage exceedance. Using the highway to convey and store exceedance is a vital component due to it being a likely location where exceedance will occur, and is a primary open space to make use of. Open green space and hard standing such as car parks enable exceedance flows to be temporarily stored. Property level protection may be required, but often minor changes in topography, for example to kerbs, are necessary to direct flow away from properties or to specific storage areas (for example, bunded areas, detention basins).

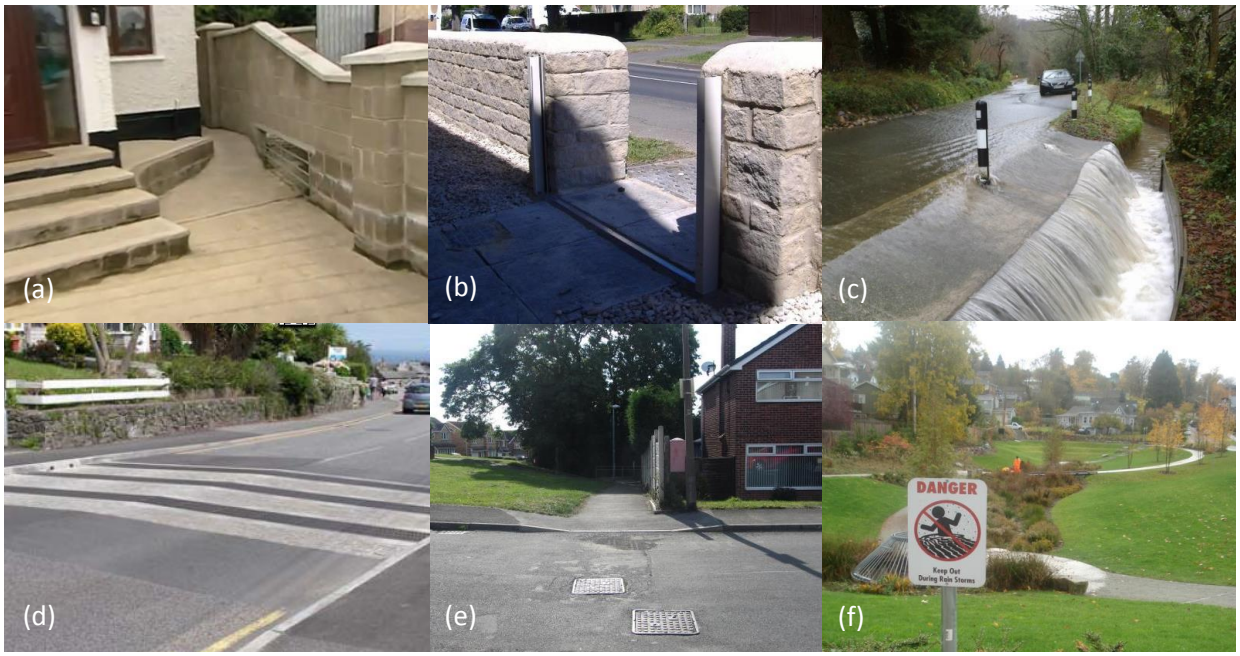

Figure 2 (a) Creating pathways around properties in Dublin *(Courtesy of Dublin City Council)*. (b) Property level protection to slot in a gate in a wall in Witney *(Courtesy of Oxfordshire County Council)*. (c) Conveying flow on the highway in St Blazey *(Courtesy of Simon Jeffrey).* (d) Conveying flow on the highway and intercepting at key points *(Courtesy of Halcrow).* (e) Amending a drop kerb to direct flow to a watercourse and stop property flooding on the right in Aston. (f) Detention basin in Seattle, USA to store flows when the drainage system is exceeded.

Despite the numerous technical options, in reviewing a number of growing examples of designing for exceedance in the UK and overseas, it has demonstrated that a range of barriers to use have to be overcome. In the past, resistance to using the highway to manage exceedance has come from highway engineers due to concerns about pavement performance and health and safety. Examples such as at Witney, St Blazey and Torquay (figure 2) demonstrate that disciplines are in fact working together to consider the risks and design highways to manage exceedance. When it is known where exceedance may occur, then the highway can be constructed and maintained to cope with exceedance by design, rather than by default, which is current practice.

The approach taken to implement successfully designing for exceedance is critical. Engaging with communities can help them to understand problems, and to develop and accept solutions often viewed more radical than below ground pipes. Collaborative working within and between organisations helps to develop joint solutions, as to manage exceedance may often require more than one stakeholder. Inter-disciplinary working helps to break down barriers and share knowledge to create the awareness of the need, conditions and opportunities to manage exceedance.

In new developments, disciplines working together, often in an architect led design approach, are vital to manage exceedance to ensure it is accounted for. This CIRIA project identified good and poor approaches to manage exceedance. In Upton near Northampton and Glebe Farm near Cambridge, flood pathways and

storage areas were designed and built to manage exceedance. Poor examples from other sites only proposed to contain flow pathways shown on a drawing with no account of volumes. Such an approach does not match the aspirations of the National Planning Policy Framework (DCLG 2012).

Designing for exceedance offers the opportunity to create more resilient areas, and not manage all flows below ground. This in turn can create greater cost beneficial solutions (at a lower cost, whilst providing a higher level of protection). A great example of different organisations working together was at Witney, near Oxford. Oxfordshire County Council (OCC) worked with West Oxfordshire District Council, Environment Agency and Thames Water to manage exceedance of a drainage culvert and implemented a joint solution. This resulted in physical alterations to the urban environment to channel the exceedance flow to an open watercourse downstream. The community played a key role in helping to develop the solution and to manage actively the exceedance when it occurs. For example, OCC agreed procedures with local residents to close the road using road signs when exceedance occurs. Community involvement in developing and accepting solutions such as at St Blazey and Torquay demonstrate the importance of local community engagement.

Designing for exceedance is ultimately about assessing and managing risks, when managing flood water on the surface by design. In Torquay, Torbay Council assessed the depth of water and the risk, discussing it with shoppers and business owners. In Dudley, Dudley Metropolitan Borough Council provided signs to warn motorists that the road was liable to flooding. To help manage risks, ISO 31000:2009 provides a framework to enable risks across a range of disciplines to be assessed and mitigated. This approach needs to be more commonly incorporated into a strategic and integrated approach to managing all risks in urban environments.

Conclusions

Designing for exceedance provides a more affordable way to manage flooding from drainage systems. The technical approaches are well known, however, implementing schemes is critically about working together better. This is between disciplines and organisations, as well as communities becoming more integral to developing and accepting solutions. Designing for exceedance provides us with the opportunity to manage flooding, rather than it managing us, affecting assets and communities.

Acknowledgements

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