The challenge of delivering integrated urban drainage

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ABSTRACT

In the UK, Defra's strategy 'Making Space for Water' advocates a holistic approach to managing urban flood risk. This is necessary, as urban flooding can be extremely complex. Delivering effective integrated urban drainage solutions can be very difficult because flooding can arise from a variety of different sources, there are a wide number of bodies responsible for flood control, and climate change threatens to increase the frequency and severity of flooding.

This paper outlines some of the key challenges and potential solution strategies developed during the scoping project for the Defra integrated Urban Drainage pilots (Balmforth et al 2006a). The key focus of the project and this paper is flooding. The scoping study report provides an overview of the existing barriers to integrated urban drainage, recommends an integrated approach to flood risk management, and gives examples where an integrated approach has proved successful. It sets out a potential framework for integrated drainage and an agenda for future change.

THE NEED FOR INTEGRATED URBAN DRAINAGE

Flooding solutions are more readily delivered by the water industry when the source, and hence responsibility is clear. Although the mechanism of flooding may be difficult to understand, the single source and single ownership of the problem substantially facilitates the effective solution.

The challenge occurs when there is more than one source of flooding and/or where the responsibility lies with more than one responsible body, e.g. Water Company and Local Authority. This is compounded when the mechanisms behind the flooding are difficult to understand and interaction takes place between the different sources. This is commonly observed in both small and large scale flooding, but it is the general public which suffers when responsible bodies are unable or unwilling to act collectively to develop solutions. Often this is not resolved, and 'part' schemes may be undertaken which may resolve one stakeholder's responsibility to the flooding, but not prevent flooding occurring from another source.

There are numerous large scale examples of multiple sources of flooding which have been recorded. In Glasgow, flooding in 2002 was attributed to three different sources: overland flow, sewer surcharging and watercourse overloading (Figure 1). Here, extreme flooding was observed across a wide drainage area and Scottish Water invested in building extensive sewer network models to replicate the flooding and identify its source. Spiers (2004) reported how an integrated catchment model had been developed which enabled the different sources of flooding to be distinguished and the responsible bodies to collaborate in delivering an integrated solution. Other examples which demonstrate the challenge of multiple stakeholder responsibility and complex flooding mechanisms are discussed by Balmforth et al (2006a and b), including those in Bradford (Keighley) area and Titford.

Any increase in extreme events as identified in recent studies from climate change (UKWIR 2004, Evans et al 2004) is likely to place significantly more pressure on the performance of the sewer systems. Recent CIRIA guidance on managing extreme events advocates an integrated solution where the below ground and on surface drainage systems work in concert. Such innovative approaches can only be delivered through an integrated approach where stakeholders work together.

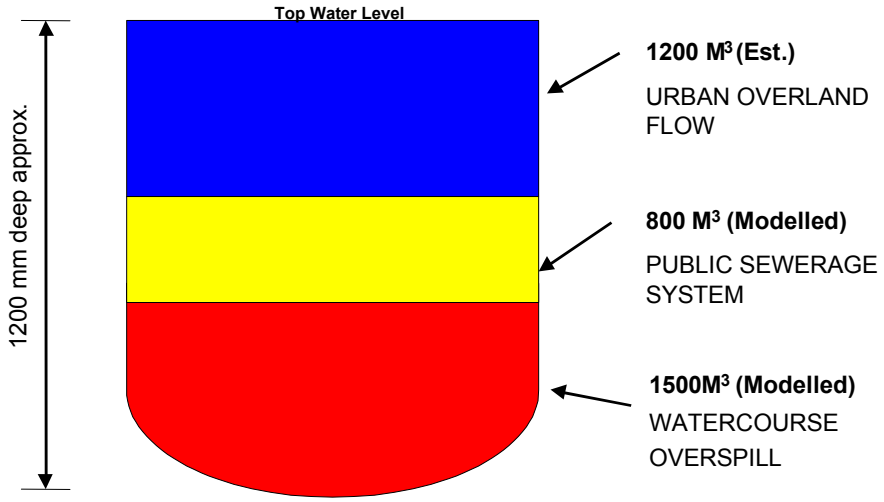

Figure 1 Discrete catchment flood volumes attributable to different sources for 30th July 2002 Glasgow floods (Courtesy of Scottish Water)

MAKING SPACE FOR WATER AND INTEGRATED URBAN DRAINAGE

The Government's strategy Making Space for Water (Defra 2004) proposed a more joined up, holistic approach to drainage management. This approach is particularly valid in high-risk urban areas where the consequences of integrated urban drainage flooding problems can be severe if no way forward to resolve the flooding can be found. The concept of Making Space for Water is demonstrated in Figure 2. It covers a wide number of flooding mechanisms which can be complex on their own, let alone if they are combined.

A key to the success of integrated urban drainage is bringing together stakeholders (Figure 3) to overcome legislative and institutional barriers, so they work together to take a long term strategic approach. The benefits of this approach can be well defined and include:

- A holistic approach to integrated urban drainage planning and management
- Sustainable development with higher efficiency and lower whole life costs
- Stakeholder involvement and ownership of the problem and subsequent solutions
- Adaptability to climate change

THE SCOPING STUDY

The scoping study identified some key challenges to integrated urban drainage as well as existing and recent success stories. These along with a potential framework for working together are summarised below.

Barriers to integrated urban drainage

Barriers to integrated urban drainage were highlighted in a number of key areas, however at times, some barriers are used as excuses to prevent moving forward, rather than barriers which cannot be truly overcome. A number of these barriers are discussed in more detail below below.

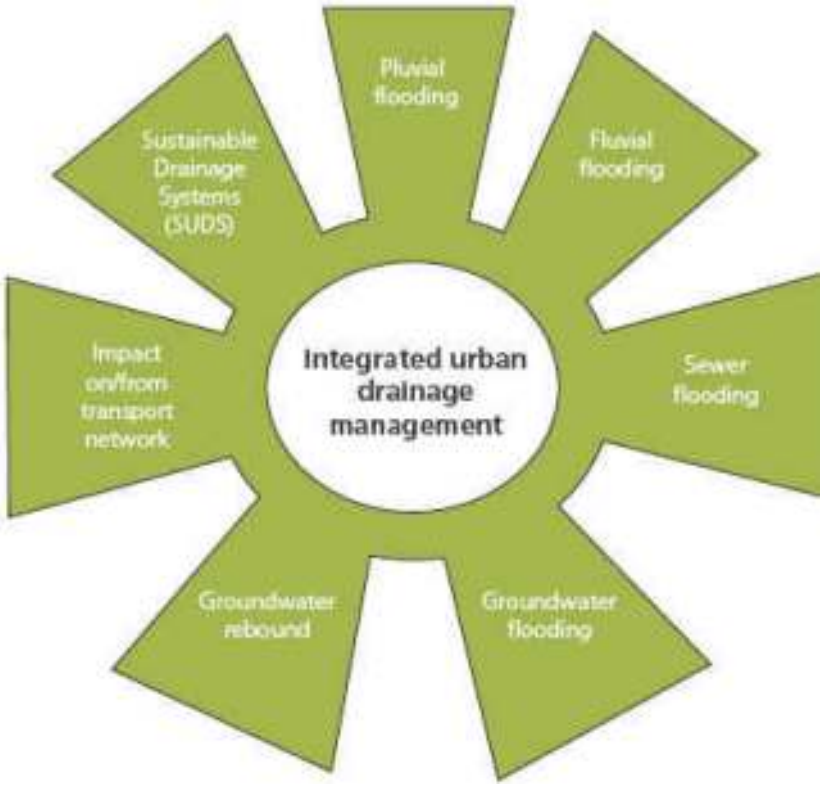

Figure 2 – Integrated urban drainage management (Defra 2005)

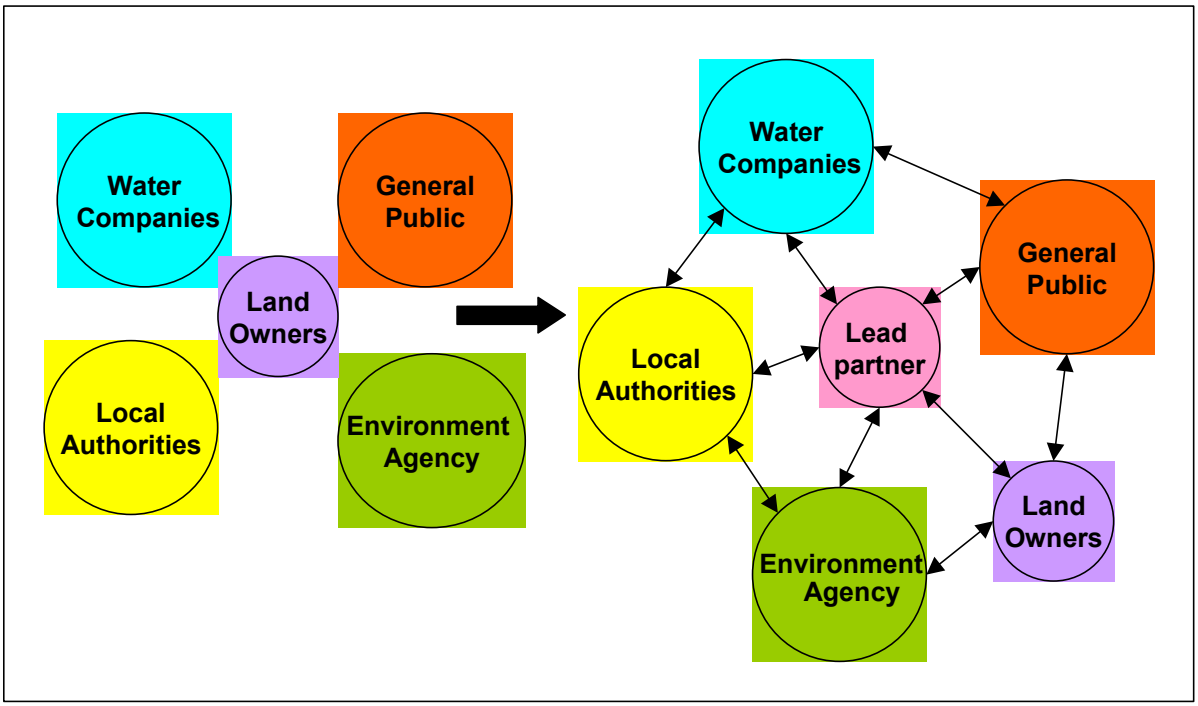

Figure 3 Shifting from the conventional to the integrated approach (Balmforth et al 2006a)
(Note: Not all stakeholders identified, figure for illustrative purposes only).

Responsibility for Flooding

The legislation governing English law has been developed over hundreds of years, established by statute and case law. Various different stakeholders have different permissive and statutory responsibilities (Table 1). No one stakeholder has overall responsibility for flooding and this can severely inhibit an integrated approach. Such a situation often leads to only partial solutions being delivered, delays solution development, and increases costs. Occasionally a lack of agreement over who is responsible leads to no solution being developed at all.

The general public, as landowners have a responsibility for drainage within their boundary. They are often not engaged during the resolution of flooding problems, and can feel particularly disengaged when flooding is the responsibility of more than one stakeholder.

Other key stakeholders exist on the periphery, having no legal status but a significant interest in effective flood risk management. Insurers do not have direct responsibilities over flood control or drainage, however have a significant impact on setting insurance premiums and paying out for flood repair. As an industry they are becoming more involved with these issues. In particular, the insurance industry can play a strong role for new developments, which may have a high flood risk.

Table 1 - Major stakeholders responsible for drainage and flood management in England (after National SUDS Working Group, 2004)

NAME	FUNCTION	AUTHORITY
Local authority drainage departments	Drainage, flood alleviation and regulation of watercourses, apart from designated main rivers.	Broad powers bestowed by the Public Health Act 1961 and particular responsibilities in drainage districts. Set out in the Land Drainage Act 1991.
Highway authorities	Responsibility to keep the roads (except trunk roads) free from flooding and to make provision for runoff from highways in a proper manner.	Relevant legislation includes the Highways Act 1980 and the Land Drainage Acts 1991 and 1994.
Internal drainage boards	Supervisory duty over flood defence and drainage for low-lying land in England and Wales. Regulation of ordinary watercourses apart from designated main rivers within specified areas.	Set out in the Land Drainage Acts 1991 and 1994, covering maintenance, improvement and operation of drainage systems, conservation and revenue-raising.
Water Companies (Sewerage undertakers)	Responsibility for providing and maintaining a public sewerage system, which includes sewers carrying surface water away from impermeable areas belonging to buildings.	Set out in the Water Industry Act 1991 (as amended) and 1999, which obliges sewerage undertakers to provide and maintain a drainage and sewerage system to ensure effectual drainage of its area, and to authorise and charge for the discharge of trade effluent to sewers. Highly regulated by Ofwat.
Environment Agency	The Agency aims to protect and enhance the environment and to make a positive contribution towards sustainable development in England. Responsible for maintaining, operating and improving flood defences. Provides 24-hour Flood Warning service. Provides emergency response. Has a supervisory duty by consent over Local Authorities and Internal Drainage Boards. Report on Government High Level Targets to Defra.	Powers and duties set out under the Environment Act 1995 and related legislation. Regulation and executive action on water resources, land, water and air quality, flood and coastal defence, flood warning, waste management, navigation, conservation, fisheries and recreation.
Defra	Defra sets policy and provides strategic government.	Formed by Government. Reports directly to Ministers.

Legislation, regulation and funding streams

There are various elements within the current legislative and regulatory framework that inhibit integrated flood risk management. Sustainable Drainage Systems (SUDs) are seen by many as important in the future management of flood risk. However their adoption is inhibited by current legislation (right to connect and the definition of a sewer) and the limited horizons embedded in the 5year regulatory cycle of Water companies in England and Wales. Identifying and maintaining surface flood pathways to manage extreme events is also seen as important yet the legal means to protect such pathways is not clear.

Recent amendments to the Planning system for flood risk with the publication of PPS25 are likely to improve how flooding is considered for new development, however, there has been a perceived conflict between PPG3 and PPG25 related to flood control and housing density. Within the UK, housing densities are often lower than in other parts of Europe and examples from abroad could be adopted to improve integrated urban drainage with high housing density. How flood risk is considered is also improved in PPS25 with wider requirements for flood risk or drainage impact assessments.

Often, funding can only be secured by one stakeholder resulting in a half delivered solution for the general public. The cycle of funding within the water industry can act as an inhibitor for integrated solutions which require more than one stakeholder to work together. To address this, a common source of funding for the water companies through OFWAT and that to the Environment Agency and Local Authorities might prove beneficial.

Technical Considerations and Tools

In recent years, the development of tools to predict urban flooding from numerous sources has substantially improved, in particular for above ground flood routing. However the computation of flood waters through the urban fabric remains complex and data intensive. This is made more challenging by the need in some cases to understand the interactions between different sources of flooding. Minor topographical detail can in particular cause a change in flow paths, therefore requiring accurate data for detailed analysis.

Effective flood risk management requires an understanding of both the probability and *consequence* of flooding. Consequence requires an ability to define the location, depth and extent of flooding. Flood inundation modelling is well advanced for river and coastal flooding, but its development for urban flooding is less well advanced and has been inhibited by the complexity of urban areas and the level and detail of data required. Significant advances are at last being made, however, and recent research results (AUDACIOUS and FRMRC) provide useful pointers towards future capability.

There is a real opportunity to use SUDS in new development, however in some areas there is still resistance for their implementation due to a perceived lack of knowledge of their design and long term performance. This information however does exist (Wilson et al 2004) with numerous examples in the UK and globally, and further learning should be gained from these schemes.

Public perception

The process of flood risk management is in general not understood by the general public. This is the case for flooding from both pluvial and fluvial sources. In addition to the lack of understanding, society is generally averse to flood risk, and expectations can be unrealistic. Confusion reigns over the understanding of probability, consequence and risk. Clear, simple explanations are required.

The general public are often poorly engaged, particularly where pluvial flooding occurs in urban areas. Improvement can be made if the public is considered to be a primary stakeholder, and indeed when treated as such, expectations can be managed and positions understood by all. In addition, they can feel empowered and involved particularly when formed into a focus or liaison group.

Data

The quality, quantity and format of data held by different stakeholders varies substantially for both assets and flood recording. A further challenge is the sharing of such information between different stakeholders with concerns over data protection, formats, confidentiality and sensitivity.

Integrated urban drainage management requires good data, particularly above ground data, in order to understand the underlying cause of flooding and the effectiveness of potential solutions. Until recently the quality of this data has been poor or required substantial time investment. Although data is now more readily available (e.g. LiDAR), computationally using this data over wide areas is still limited due to the size of data sets.

Examples of best practice

Critical Success factors

Although many barriers exist, there are also numerous examples throughout the UK and globally that demonstrate how integrated urban drainage can be successfully implemented through voluntary partnerships. A common theme is that there is often a lead stakeholder, one who decides to drive change, with other stakeholders joining the common cause. In addition, there is 'high level buy in' by all parties. Such examples have been observed for new development, and as a response to existing problems.

Liasing and working with other stakeholders has been identified as being key to the process of integrated urban drainage. However, stakeholder engagement should be considered to be more than consultation with others but resemble a conversation, where listening and learning is important (Green 2005). Five key principles to stakeholder engagement are inclusivity, transparency, appropriateness, clarity, and comprehensiveness (Defra 2003). This type of approach has been shown to produce positive results.

New Development and catchment wide approaches

Recently implemented planning guidance requires the development of Regional Spatial Strategies and Local Development Frameworks with accompanying area plans. These provide the opportunity to develop dialogue with different stakeholders through spatial planning. These can also promote an integrated drainage approach (e.g. in Bradford, Ashley et al 2005a) and as promoted in PPS25 that includes catchment wide and specific flood risk assessments. Master planning also provides the opportunity for a holistic approach achieving synergies with flood risk management, amenity and green space planning. Consultation is key within this approach, and this was adopted at Upton, where English Partnerships introduced the Enquiry by Design process, which brought interested stakeholders together (Balmforth et al 2006b). The process resulted in the development of a design framework which focused on providing sustainable solutions for the infrastructure including the drainage for above and below ground flows. Other approaches include the setting up of Flood Liaison Advisory Groups, as in Scotland, which offer a forum for knowledge and advice to be shared about flood risk management with all major stakeholders represented.

There are well documented examples of catchment wide approaches to flood risk in areas with existing problems. In Glasgow, Scottish Water developed a regional master plan which included 27 combined drainage area plans and looked at interaction between above and below ground assets. In Bradford, the Bradford Water Management Advisory Steering Group was set up which also considers how land management can be best applied as well looking to manage the flood risk holistically. The FLOWS project in Cambridge (Finch 2006) and the SMURF project in Birmingham (Scott et al 2005) have both demonstrated how successful effective engagement can be achieved using different mechanisms with stakeholders across the community. In Augustenborg, Malmö, Sweden, integrated urban drainage has been accommodated within the urban environment, without detriment to network performance or the built environment. It demonstrates the advantages of implementing innovative and imaginative solutions through sustainable drainage and green roofs. This takes a proactive approach to flood risk and manages flows above ground, rather than buried in under utilised structures. In Australia, Water Sensitive Urban Design techniques have produced more sustainable solutions to control not only exceedance flows above ground but also pollutant load (Patterson 2006).

A framework for integrated urban drainage

The scoping study identified and used a number of proposed methodologies (Ashley et al 2005b, AUDACIOUS Handbook 2006) to help develop a framework to facilitate the delivery of integrated urban drainage management. The intention was to provide a flexible framework which was adaptable to individual needs, rather than develop a high detail prescriptive approach. The framework is summarised in Table 2 with a brief description of each step (Balmforth et al 2006a).

Table 2 – Summary of proposed framework for delivering an integrated urban drainage project (adapted from Balmforth et al 2006a).

STEP		SUMMARY
1	**Identify the issues and categorise spatially**	• Identify if this is an integrated urban drainage project. Confirm that flooding or risk of flooding is likely to be from more than one cause (if this can be identified at this stage). • Identify across the catchment the impact of the flooding. Identify driver for project (e.g. regional for strategic planning, existing flooding from numerous sources). • May be completed by one or more of the interested stakeholders.
2	**Identify and engage stakeholders**	• For new developments this will be driven through the planning process. • For existing flooding problems, this will initially be driven by the responsible stakeholders for the flooding. Some stakeholders may be reluctant to become involved • Other stakeholders who may have an interest should be identified and engaged (potentially on a less frequent basis). • Identify who may take the lead in the first instance. • Engage with all stakeholders. Target objectives maybe agreed at this point, or later during the process once a greater understanding is achieved (step 8).
3	**Identify sources of flooding**	• For new developments funding may be readily available (driven through the planning system). • Large scale commitment at this stage is unlikely by all stakeholders and an initial commitment to investigate (possibly in stages) may be required • Some stakeholders maybe very restricted in funding and consideration may need to be given by others to support at this stage.
4	**Identify data/information requirements**	• The level of data required will depend upon the identified issues previously. Extensive data collection should be avoided at this stage. • Level of detail should be appropriate to the spatial extent of the study. • Data collection focus should be on providing information for step 5. Improving the level of understanding is key, with photos and interviews if required. • Avoid being too narrow in the problem being addressed (likely to be influenced by stakeholders involved).
5	**Identify and undertake appropriate diagnostic study**	• Modelling approach is likely to be necessary, however this will be very dependent upon the spatial extent and complexity of the study (as well as funding). • Study should identify the causes, scale, frequency, extent, risk and ownership of flooding. • Stakeholders should agree to and 'buy in' to the selected study methodology.
6	**Confirm/amend understanding: Assess risk**	• Review the diagnostic study with stakeholders. • Identify if further work is required. An iterative approach to determine agreed understanding of the link between cause and effect may be required. • Assess the flood risk with objective rating. • Further data collection may be required.
7	**Identify stakeholder responsibilities**	• For new developments this is likely to be driven through the planning process. Stakeholders should be identified at this stage who may be responsible for future adoption and maintenance for solutions. • Existing sources of flooding should be assigned to the responsible stakeholder. • Agreement should be made to move forward to agree a solution. If one

STEP		SUMMARY
		party cannot agree (or will not have the funding) the other stakeholders should consider to pursue their solution separately.
8	**Agree target objectives and develop integrated solution**	• Clear target objectives should be agreed if not already and signed up to by the responsible stakeholders. • Use modelling tools to develop integrated solutions. Identify a flood risk management strategy. Assess cost for solution to be completed jointly and separate if funding is not available for all parties. • Appropriateness of solutions should be considered for all stakeholders. Solutions should be assessed for risk if a staged approach to delivery is deemed the way forward.
9	**Identify individual stakeholder contribution to solution**	• Stakeholders should agree to who is responsible for the delivery and funding of the schemes and signed up formally.
10	**Confirm agreements for solution delivery**	• Ideally solutions will be delivered as single contracts, however each individual stakeholder may wish to deliver their respective work separately. If agreement cannot be reached, stakeholders may go their own way for resolution of their responsibility. It may be necessary to assess the impact of their solution and communicate this to all parties involved.
11	**Monitor performance and provide feedback**	• Monitoring should be completed to demonstrate that the agreed objectives have been delivered as well as providing feedback into the system to enable improvement.

The framework and Table 2 relies heavily on good stakeholder engagement and interaction. Many of the examples identified that have successfully developed some form of integrated urban drainage have had strong communication strategies in place. This may be similar in form to FLAGS (Flood Liaison Advisory Groups) in Scotland or the Water Management and Advisory Group in Bradford (Ashley et al 2005a). Alternatively an extension of groups which already exist can be utilised such as local Flood Warning Groups with a change to their remit.

High level buy in from all stakeholders will be required for an effective engagement process. The group may have a core group and a wider membership which forms more of a consultation rather than delivery mode. The core group must agree core objectives and make a commitment to fund the investigation stage. Clear two way communication and interaction is necessary between the core group and the wider stakeholders likely to include community groups and the general public. This communication should include the aims and objectives of the group as well as their responsibilities.

A lead stakeholder should be agreed in the group who will facilitate and drive the group to completion of their objectives, and this should be based on their skills, not necessarily those with the greatest responsibility. Agreement must be given to share data and knowledge with clear guidelines on the data's usage. A signed agreement to share data should be completed at the start of the project.

Possible changes to help integrated urban drainage

Although there is clear evidence that the delivery of integrated urban drainage schemes is achievable, there are a number of potential improvements which could facilitate this. Some of these are briefly summarised below:

- Broaden the current definition of a sewer, as this restricts potential adoption by sewerage undertakers

- Identify who should be the responsible stakeholder for adoption, ownership and maintenance of SUDS. Introduce legislation to deliver this.

- Review the existing 'right to connect' (Water Industry Act 1991) and amend to encourage/improve the uptake of SUDS. This review is currently underway.

- Enable water related stakeholders to become more involved with the planning process regionally and locally (although recent planning legislation should improve this).

- Enable a form of control over uncontrolled development such as the expansion of paved areas increasing runoff.
- Protect existing and future designated flood pathways to enable the management of exceedance flow. Produce surface water plans to support this.
- Prevent developers sub-dividing plots of land into small packages to avoid the requirement of a flood risk assessment.
- Consider further the cost/benefit of sewerage separation with a view to managing flow above ground.
- Identify methods to provide equitable funding to all stakeholders.
- Develop a SUDS for Adoption guide, similar to Sewers for Adoption (WRc and Water UK 2006)
- Develop a common currency of risk so a consistent approach across the industry is achieved (between different disciplines and sectors).
- Develop a GIS based information system holding all infrastructure details, including in particular all related water assets.

FUTURE IMPACTS

The most likely potential impact on delivering integrated urban drainage comes from climate change. Our ability to adapt to this will become critical in the future. Although there is still uncertainty over the accuracy of future climate predictions, a general consensus is that it will occur, with the query over when and by how much.

Key impacts will be through the changes in rainfall patterns, with the potential for more extreme events. This impacts on the above and below ground networks. Another impact will be rising sea levels, which increase flood risk, and reduces the capability to freely discharge at times. Changes to these may impose other development pressures, urbanisation and population shifts which will need to be considered in the future.

Another major impact will result through EU legislation, in particular the Water Framework Directive and the proposed Flooding Directive.

Defra are currently supporting a programme of integrated urban drainage pilots with a wide range of stakeholders leading the pilots and tackling diverse issues. Good practice guidance should be available in the Summer of 2008.

CONCLUSIONS

Making Space for Water advocates a holistic approach to managing urban flood risk. There are numerous examples where stakeholders have worked together to achieve this, despite there being numerous barriers which currently exist and prevent successful working in other cases. Stakeholders engaging with each other and the wider community can overcome the existing barriers, as long as there is high level buy in and agreement. The engagement process is a critical component as outlined in the framework that can facilitate the successful delivery of integrated urban drainage. Although, integrated urban drainage is achievable now, there are a number of barriers, which if addressed, would substantially improve its delivery. In particular the embedment of the principals of integrated flood risk management within the planning framework, both regionally and locally, will help to deliver effective solutions in the long term.

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