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Environment Agency

delivering benefits through evidence

Local flood risk research roadmap

Report – SC130005

Flood and Coastal Erosion Risk Management Research and Development Programme

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We cannot do this alone. We work closely with a wide range of partners including government, business, local authorities, other agencies, civil society groups and the communities we serve.

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This report was produced by the Scientific and Evidence Services team within Evidence. The team focuses on four main areas of activity:

- **Setting the agenda**, by providing the evidence for decisions;
- **Maintaining scientific credibility**, by ensuring that our programmes and projects are fit for purpose and executed according to international standards;
- **Carrying out research**, either by contracting it out to research organisations and consultancies or by doing it ourselves;
- **Delivering information, advice, tools and techniques**, by making appropriate products available.

Miranda Kavanagh

Director of Evidence

Executive summary

We have prepared a research roadmap for local flood risk: flooding from surface water, groundwater and ordinary watercourses. It identifies a programme of projects addressing science, knowledge, sharing of best practice and capacity building needs. The purpose is to coordinate research commissioning so that it genuinely meets user needs and is delivered more effectively and efficiently.

We prepared this roadmap with input from individuals from across the local flood risk community. Organisations represented included lead local flood authorities, water companies, internal drainage boards, the Highways Agency, the Environment Agency, Defra, local community flood groups and the National Flood Forum. It benefitted from a huge amount of support from the private sector including several consultancy firms and two professional groups: CIWEM's Urban Drainage Group, and susdrain – the community for sustainable drainage. Several universities provided academic input, helping to validate the research questions. In this report 'we' refers to the valuable input from all involved.

The roadmap builds upon the previous Integrated Urban Drainage framework, which was published in 2009, through which over 85 research projects were delivered. It has also been developed with reference to the Sustainable Drainage Systems roadmap, the Living with Environmental Change roadmap, and the Working with Natural Processes framework to ensure research projects will complement rather than duplicate efforts.

We have developed this roadmap through close collaborative working and engagement with the local flood risk management community. We have undertaken workshops, held discussions and hosted an online survey to understand the needs of the local flood risk management community and generate ideas for possible research projects. More than 300 research ideas were proposed through this collaborative approach. These have been filtered and prioritised to focus on the most important and most urgent over the next 5 years. The most important and most urgent projects have been grouped together into research topic areas.

We have identified both practitioner-focused research projects (near term), and strategic research questions (medium to long term). There are over 30 practitioner-focused research projects identified in this research roadmap that are considered essential to enhance knowledge and understanding, and improve efficiency within the local flood risk management community. Many of the research projects will need to be delivered in partnership with local authorities, water companies, research institutions and universities, among others. Equally, some of the research projects identified will not be unique to local flood risk; they cut across all sources of flood risk. Where there is an overlap with all sources of flood risk we will identify who is best placed to undertake the research.

In addition, we have identified 15 strategic research questions which identify longer term needs to advance our knowledge in local flood risk management. These strategic research questions will need to be addressed primarily through university-led research, and further engagement is required to develop these proposals further.

The practitioner-focused research projects and strategic research questions will help to achieve the needs of the local flood risk management community in the short, medium and long term. We have defined local flood risk management outcomes and we anticipate that through the research identified in this roadmap we will make significant progress in realising these outcomes.

We have engaged widely during preparation of this roadmap. However, we recognise the continued engagement of the local flood risk management community is important to ensure we develop, deliver and disseminate the right research to meet user needs. Therefore we have developed an engagement plan which sets out who we want to work with, and how we will work with them over the 5-year lifetime of this roadmap. A key part of our engagement approach is to monitor the success of our research by identifying the awareness and use of research outputs, and the extent to which the research is delivering benefits to the local flood risk management community.

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1 Introduction

1.1 Project background

An integrated urban drainage (IUD) research framework was published by the Environment Agency in 2009. It successfully brought together the Environment Agency, Defra, local authorities, the Department for Communities and Local Government (DCLG), Ofwat and academia to help coordinate 85 research projects. Since it was published there have been a number of important changes. Following significant flooding in 2007 and the Pitt Review in 2008, government introduced new legislation to clarify roles and responsibilities for flood risk management. This was through the Flood and Water Management Act (2010), which made lead local flood authorities (LLFAs) the responsible body for local flood risk.[1] The Flood and Water Management Act also provided a legal framework for sustainable drainage systems (SuDS), and will remove the automatic right to connect surface water to sewers, once implemented. The capacity building programme for LLFAs has helped to enable them to fulfil new statutory duties and responsibilities. In the midst of this legislative change the economic downturn has placed renewed emphasis on spending funding more wisely. Therefore research needs to be focused on providing science and evidence to enable practitioners to do their work more efficiently and more effectively.

The new local flood risk research roadmap defines a 5-year programme of research that can be delivered in partnership with organisations who commission and use research outputs. We have developed the new research roadmap in close partnership with stakeholders to understand the most important research needs and to define a series of research projects. We have worked in close partnership by ensuring ongoing engagement with bodies such as UK Water Industry Research (UKWIR), Defra, LLFAs, academia, the private sector and the Highways Agency throughout the development of the roadmap. We have also made sure to include synergies with other ongoing roadmaps and frameworks, such as the UKWIR programme, the Joint Environment Agency/Defra R&D Programme, the Living with Environmental Change (LWEC) research roadmap (Moores and Rees 2011), the Working with Natural Processes (WWNP) framework (Environment Agency 2014) and the UKWIR SuDS roadmap (Ashley et al. 2014). While developing the roadmap we have avoided overlap with these roadmaps unless the research project was of direct importance to local flood risk. For all our research projects we have considered the delivery method, which includes joint delivery through these other roadmaps.

Our main objectives while developing the roadmap were to:

- review the existing research framework roadmap, and other relevant roadmaps to understand the successes, lessons to be learnt, and overlaps with the new local flood risk research roadmap;
- work with stakeholders to identify a set of long-term development needs;
- develop a prioritised roadmap of projects to achieve each need;
- produce a brief research proposal form for each project;
- develop an engagement plan covering the lifetime of the roadmap;

[1] Local flood risk is defines as flooding from surface run-off, ordinary watercourses and groundwater.

- develop an approach for monitoring the progress and benefits of the roadmap;
- disseminate the outputs to ensure the local flood risk management community are collectively involved in developing and delivering research projects.

Our vision for this roadmap is that in time it becomes the definitive place for practitioners, researchers and funders to collaborate about local flood risk research needs. We want to close the gap between research by different research institutions or organisations to maximise value for money and deliver the right research needs in a timely manner. We have set out a programme of research, but recognise that research priorities and proposals will evolve and merge over time. In future years new ideas or research may become a higher priority because of additional flooding incidents, new policy, new technologies, and collaboration across different research sectors. Our ongoing monitoring will ensure we are delivering the right research for the local flood risk management community in a timely manner.

1.2 Defining local flood risk

This roadmap is focused on 'local flood risk'. Local flood risk means surface water flooding, groundwater flooding and flooding from ordinary watercourses. This is aligned with the duties of LLFAs but also has effects on the role of district and borough councils and water utilities and the responsibilities of householders and businesses. The public sewer network can also affect local flood risk and therefore research on the operation, function and exceedance from the sewer network is included within the roadmap. The research roadmap is not focused on water quality issues. However, some projects may include aspects of water quality problems to enable partnership working and funding of research.

- **Surface water flooding** occurs when rainfall cannot soak into the ground or drain into local surface water drains, sewers or rivers. This leads to water flowing across the ground and pooling in low-lying areas. This flooding often occurs quickly during, or shortly after, a high intensity storm.[2]
- **Groundwater flooding** is caused when the water held within underground soil and rocks rises above the surface. Groundwater tends to respond to rainfall more slowly than water in rivers or on the surface. This slow response means that groundwater flooding can occur a long time after prolonged or heavy rainfall and can last for a long time (often several weeks or months).
- **Ordinary watercourse flooding** happens when water overtops the banks of the stream or river. This can occur because there is more water draining into the channel than it can hold, or because the channel is blocked. Local flooding only refers to flooding from ordinary watercourses, which are rivers, ditches and streams not classified as a 'Main River'. Flooding from larger rivers and streams, officially classed as Main Rivers, is not local flooding, although the interaction between local flood risk and Main Rivers is important.
- **Sewer flooding** happens when the capacity of the sewerage system is less than the amount of rain and sewage trying to flow through it. This leads to sewage being surcharged from manholes and gullies. The lack of capacity

[2] Refer to the Flood and Water Management Act (2010) for the legal definition.

can be caused by the system simply not being able to cope with the amount of rainfall and sewage, or it can be caused by blockages and collapses in the system.

1.3 Defining research

There are many different definitions for research. In this project, we based our definition on the Frascati Manual (OECD 2002) classification of research. We have defined research to cover a spectrum of activities, including basic research, applied research, development and pilots, and dissemination and training, as well as implementation in practice.

1.4 Structure of this report

This report covers the main outputs of the project as follows:

- section 2 considers links to other roadmaps and research programmes;
- section 3 defines the outcomes we are seeking to achieve for local flood risk management;
- section 4 outlines the process we have adopted to identify and prioritise the research projects for this roadmap;
- section 5 provides detail on the high priority research projects;
- section 6 considers how we will engage with the local flood risk management community and monitor the benefits of the roadmap.

This report is supplemented by an interactive summary document which highlights the most important points about the research roadmap. This report also has six appendices which summarise the online survey, provide research proposals for the ‘must do’ projects, provide background information on the ‘must do’ projects, identify the lower priority projects, describe the workshop outputs, and identify stakeholders we have engaged with.

2 The research landscape

2.1 Overview

This section describes the current research landscape, existing research roadmaps and frameworks, and how they link to the new local flood risk research roadmap. We have developed the local flood risk research roadmap in close collaboration with these to ensure our projects complement existing work rather than duplicate effort.

Research leads to new and innovative ways of understanding, planning and managing flood risk. The 'National Strategy' (Environment Agency 2011) states that 'The risk management authorities and other organisations involved in flood and coastal erosion risk management will take forward the aims and objectives. To support this work, the Environment Agency and Defra will continue to work with others to sponsor a collaborative Flood and Coastal Erosion Risk Management (FCERM) research programme to make sure that all involved in FCERM are able to benefit from world-class knowledge and science and have access to current good practice and risk management tools'.

The development of FCERM policy is led by Defra on behalf of the government. Policy is prepared within the context of wider government policy areas led by other departments, for example covering the use of public funds (Treasury), emergency response (Cabinet Office) and land-use planning (DCLG). The Environment Agency and other organisations support this by providing evidence and advice.

The Environment Agency has a strategic overview of the management of all sources of flooding and coastal erosion distinct from the operational function it has in relation to managing flood risk from Main Rivers and the sea. This strategy seeks to provide a clear national framework for FCERM, with all sources of flooding and coastal erosion identified and managed using a risk-based approach, allowing local responsibility and decision-making where appropriate. It also aims to ensure that the roles and responsibilities of those managing risk are defined and understood; that all involved, including communities at risk, know what they need to do; and that progress is monitored and understood. Activities carried out as part of the strategic overview include:

- **Providing the evidence and advice to inform government policy and to support others.** This includes national flood and coastal erosion risk information, data and tools to help risk management authorities exercise their FCERM functions, and advice on planning and development issues.
- **Supporting collaboration, knowledge-building and sharing of good practice.** This includes delivering programmes to support the development of FCERM skills and capacity, and working collaboratively with nationally representative bodies to provide an effective framework to empower local delivery.

Research carried out by Defra and the Environment Agency is delivered through the joint R&D Programme,[3] which serves all FCERM operating authorities and undertakes approximately £2.5 million of research each year. It was developed to ensure the government's investment in FCERM is based on robust and sound evidence. It

[3] Flood and Coastal Erosion Risk Management Research and Development: http://evidence.environment-agency.gov.uk/FCERM/en/Default/FCRM.aspx

develops information and tools to help practitioners reduce and mitigate the impact of flooding on the UK economy and local communities.

It includes three themes:

- Policy, Strategy and Investment
- Asset Management
- Incident Management and Modelling.

And four cross-cutting work areas:

- Local flood risk
- Coastal
- Reservoirs
- Working with Natural Processes (WWNP).

The joint R&D Programme is an end-user-oriented, applied research programme which is steered and peer-reviewed by relevant experts. There are numerous other delivery routes for research, such as UKWIR, academia, or European funding, for example. We will explore all of these sources to maximise funding opportunities for local flood risk research.

2.2 The integrated urban drainage (IUD) research framework

An IUD research framework was published by the Environment Agency in 2009. It successfully brought together the Environment Agency, Defra, local authorities, the DCLG, Ofwat and academia to help coordinate 85 research projects. As part of this updated roadmap we have reviewed all of the projects considered in the IUD research framework. We identified which of the proposed projects have been completed. We considered completed, ongoing and planned research from the Joint Environment Agency/Defra R&D Programme, UKWIR and LWEC for example. For each project we assessed whether the research project identified in the IUD framework was:

- Fully delivered – the research project had been fully completed either through the Joint Environment Agency/Defra Programme or other research.
- Partially delivered – the research project is considered to be partially completed, and further research may be needed.
- Not yet delivered – the research project had not been undertaken.

Nearly a third of the research projects had been fully delivered, half had been partially delivered, and the remainder had not yet been delivered. Where the initial review identified the research need had be partially or not met, we have considered whether future research may still be required, using the following categories:

- Yes – the research project will still be required in the future.
- No – the research project is not required, either due to legislative, policy or financial changes, or because there is ongoing research that fulfils the need.
- Uncertain – there is uncertainty as to whether the research project is still required.

Where there is still a research need we have included this within our roadmap, as described in section 4.

2.3 Living with Environmental Change (LWEC)

LWEC is a partnership of 22 public sector organisations with representatives from the private sector forming part of a business advisory board. LWEC aims to ensure decision-makers in government, business and society have the knowledge, foresight and tools to mitigate, adapt to and benefit from the effects of climate change.

LWEC has produced and is implementing the UK FCERM research strategy (Moores and Rees 2011), which has identified FCERM research priorities for the next 20 years. The LWEC partnership report outlines how the partnership will make a significant difference in meeting the scientific and practical challenges of FCERM. It aims to deliver outcome-focused research projects by fostering collaboration, improving dissemination and uptake of outputs, and increasing knowledge exchange. The strategy clearly sets out the different types of research it will consider as well as how the projects can be delivered; this includes funding and partnership working.

2.4 UKWIR SuDS

UKWIR developed a SuDS research roadmap (Ashley et al. 2014) that provides an overview of SuDS delivery and identifies the research issues to address. We have incorporated the recommended research projects into our local flood risk research roadmap.

2.5 Working with Natural Processes (WWNP)

As defined in the project briefing note in 2013, the aim of the WWNP research framework is to 'develop a comprehensive and prioritised programme of WWNP research, development and dissemination, which enables us to undertake FCERM sustainably, improving the environment for people and wildlife'. In developing the local flood risk research roadmap (Environment Agency 2014) we have considered the research projects in the WWNP framework to ensure projects will complement rather than duplicate efforts.

2.6 Coastal Research, Development and Dissemination (CoRDDi)

The CoRDDi research roadmap (Environment Agency 2012) is a cross-cutting work area in the joint R&D Programme. The CoRDDi roadmap provides a vision for FCERM research, development and dissemination. The roadmap has produced a list of research projects, which are laid out in four themes, each of which contains four sub-themes. The roadmap is clear about the types of research it will include and sets out how it aims to increase the amount of collaborative research that is undertaken and the sectors it is useful to. A method for evaluating the success of the roadmap annually is provided.

3 Defining the outcomes of research

The outcomes of research are a vital part of this roadmap. We want all research projects to deliver real benefits. This gives practitioners and funders more certainty that the research is making a difference on the ground.

We have developed a list of outcomes which can help us measure whether research is making a difference. These are not policy outcomes, which are set by Defra, nor are they performance measures for LLFAs. However, they give us a clear direction about what successful local flood risk management looks like from a practitioner perspective. They are the community generated/practitioner outcomes we want to achieve in the current policy landscape. We wanted to use outcomes in the framework to make it smarter and bridge the gap between research and delivery on the ground. The outcomes help clarify what the research needs to achieve. The outcomes can also stand alone to others (researcher/academia) as a description of what we want to achieve so that they can come up with their own ideas of technologies and innovation that can achieve those outcomes.

We agreed these outcomes following engagement with the local flood risk community. Although we recognise that changes in the policy or the funding landscape will be factors in delivering these outcomes, research should help us work towards achieving these outcomes.

Table 3.1 shows the final outcomes grouped under eight taxonomy headings and the taxonomy reference for each. We have created a taxonomy system to enable us to tag research projects to the outcomes they will help to deliver.

The proposed monitoring roadmap will identify how research is helping to deliver the outcomes listed in Table 3.1. The monitoring of the roadmap is discussed in section 6.5.

Table 3.1 Local flood risk management outcomes

Local flood risk management outcome	Taxonomy ref.
Partnerships and coordination	
Effective partnership groups that collectively understand and manage local flood risk	PC_01
Improved working across local government departments (e.g. spatial planning, local flood risk management and highways management)	PC_02
Organisations and communities capture, share and use data and information on local flood risk appropriately	PC_03
Community engagement	
Communities understand flood risks they face and what actions to take to reduce the impact	CE_01
Communities help make decisions for local flood risk management and understand their roles and responsibilities	CE_02
Hydrological processes and climate change	
Accurate and local real-time prediction of rainfall	HC_01
Local predictions of future rainfall patterns as a result of climate change	HC_02
Rainfall-run-off science informs better decisions	HC_03
Modelling and mapping	
Accurate real-time predictions of local flood risk inform better decisions	MM_01
Accurate models that predict all sources of local flood risk	MM_02
Flood mapping to help organisations and communities understand local flood risk	MM_03
Adaptation and resilience measures	
The right mix of structural and non-structural measures are used to manage local flood risk	AR_01
New buildings are planned, designed and located to be resilient and to reduce local flood risks	AR_02
Real-time information during incidents leads to organisations and communities taking effective action	AR_03
Sustainable drainage systems are designed, adopted and maintained to appropriate standards	AR_04
Multiple benefits are provided for communities and the environment through local flood risk management measures	AR_05
Understand the long-term effectiveness of different mitigation measures	AR_06
Local flood risk management measures are flexible in responding to an uncertain future	AR_07
Economic appraisal and funding	
Economic appraisals fully consider all costs and benefits to support decision-making	EF_01
Partnership contributions are made towards local flood risk management schemes	EF_02
Construction and maintenance	
Drainage networks and watercourses are maintained to manage local flood risk	CM_01
Policy and strategy	
Policy and strategy remains responsive to science and evidence	PS_01

4 Identifying and prioritising research needs

4.1 Overview

We must identify the right research needs for the roadmap to be successful. We undertook extensive stakeholder engagement and adopted a participatory approach throughout the development of the roadmap.

We held two workshops and hosted an online survey that we promoted widely. We generated research needs through both of these workshops, the online survey and outstanding ideas from the previous IUD research framework. At the second workshop, we used the MSCW ('must, should, could, would') system to prioritise the research needs based on importance and urgency. Finally, we developed the research ideas into research projects. During this process we worked with UKWIR, Defra, LLFAs, academia, the private sector and the Highways Agency to ensure we had identified the right research projects in the roadmap. The process is outlined in Figure 4.1. Each step in the process is explained in more detail in the sections below.

Through our collaborative approach the majority of research needs identified by stakeholders were near-term and end-user focused. These research projects are key to ensure the local flood risk management community can undertake their roles more effectively and efficiently. In addition, these fit within the overall aims of the Joint Environment Agency/Defra R&D Programme which is an end-user-oriented, applied research programme.

However, we recognise that the research roadmap needs to consider the potential strategic research needs which will help the local flood risk management community in the longer term. Therefore for this research roadmap we have developed two types of research needs:

Practitioner-focused research – Typically this research is more near market, so the outputs are useable to the local flood risk community immediately. More often this type of research is delivered by a research programme such as UKWIR, the Joint Defra/Environment Agency R&D Programme, or Highways Agency research. We have developed over 30 practitioner-focused research projects (each with a research proposal) in this roadmap. The research proposals are provided in Appendix B.

Strategic research – Typically research as part of longer term programmes. Final outputs are less likely to be immediately useable by practitioners, but would underpin the tools practitioners use. More often this research will be funded by research councils and universities. We have identified the strategic research questions, but have not provided research proposals for these as this will need to be undertaken through additional engagement with universities and research institutions.

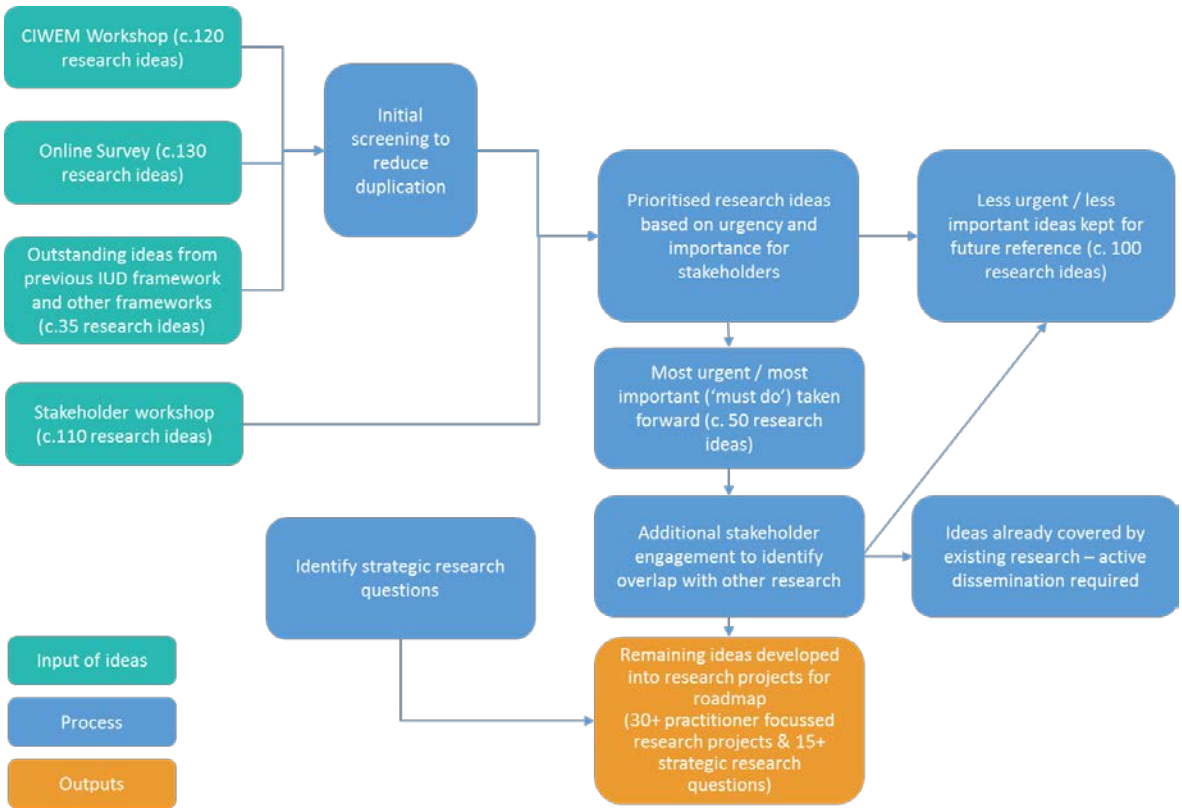


Figure 4.1 Diagram of the process undertaken to generate and refine research ideas into research topics

4.2 Generating research ideas

We generated research ideas in four main ways (as shown in the green boxes in Figure 4.1):

- **A workshop at the CIWEM Urban Drainage Group (UDG) conference 2013.** This captured ideas from a wide variety of people such as consultants, water utilities staff, the Environment Agency and local government staff.
- **An online survey.** We advertised this widely among our contacts in CIWEM, the Institution of Civil Engineers (ICE), government departments, the Environment Agency and the Local Government Association Knowledge Hub and by personal invitation. Respondents came from all of these organisations as well as from consultancies, internal drainage boards, water and sewerage companies and research institutions. Project ideas were captured through comments about the outcomes (see section 3) and through free text boxes for making research topic suggestions. The survey outputs are in Appendix A).
- **The outstanding ideas from the previous IUD framework.** We undertook a comprehensive review of the previous IUD framework. As part of this review we considered the extent to which each research aim has been achieved and whether each aim is still valid. This gave us a list of research ideas to include in the new roadmap.
- **A stakeholder workshop.** We compiled an invitation list from our knowledge and from people who expressed an interest during the online survey. Attendees came from a wide range of backgrounds, including

LLFAs, water companies, UKWIR, internal drainage boards, Defra, private sector, manufacturers, the Highways Agency, academia, National Farmers' Union and members of a local flood action group. Project ideas were captured an open discussion session. The outputs can be found in Appendix E.

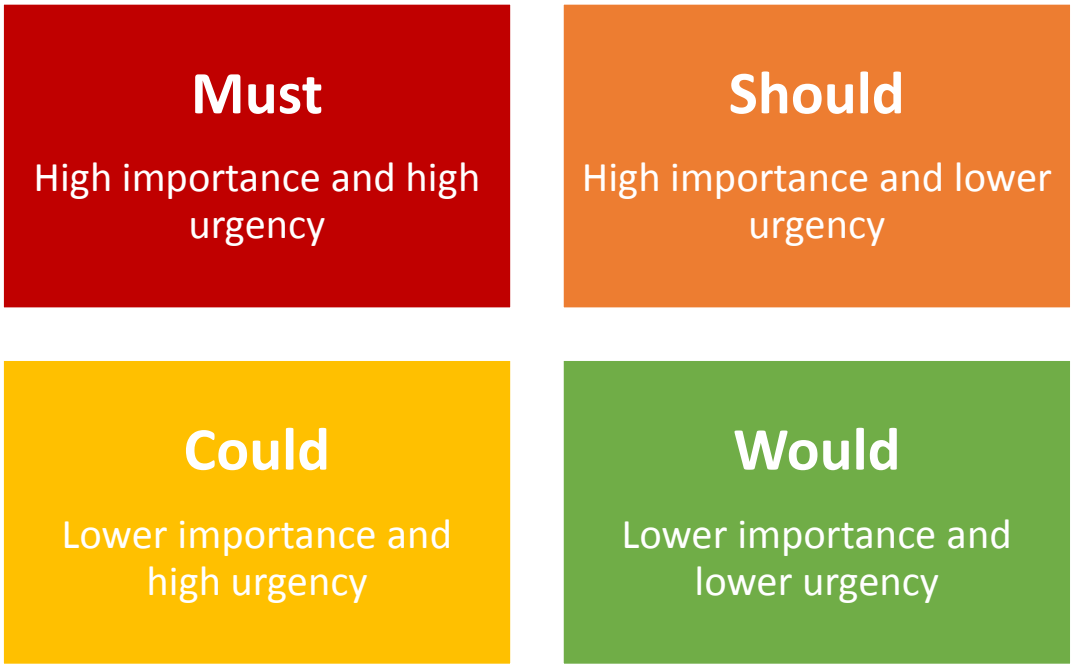


Figure 4.2 The MSCW prioritisation matrix

4.3 Prioritising research ideas

The process of prioritising research ideas is outlined in the blue boxes in Figure 4.1, with further details provided below.

- **Initial screening of ideas to remove duplication**. Prior to the second stakeholder workshop in March 2014 we carried out an initial screening of the research ideas proposed from the CIWEM Urban Drainage Group workshop, the online survey and the previous IUD framework where research ideas overlapped or were duplicated. In total we collated over 250 ideas, of which there were 70 unique ideas taken forward.
- **Prioritisation of ideas from second stakeholder workshop**. At the second stakeholder workshop a further 70 research ideas were proposed. At the workshop, attendees identified the importance and urgency of their research ideas using the MSCW system, as shown in Figure 4.2. At the workshop, 37 research ideas were classified as 'must do'.
- **Prioritisation of ideas from the CIWEM Urban Drainage Group workshop, online survey and previous IUD framework**. Following the second stakeholder workshop the MSCW system was also applied to the 70 unique ideas from the CIWEM Urban Drainage Group workshop, the online survey and the previous IUD framework. Through this approach 36 research ideas were taken forward as 'must do'.
- **Screening and stakeholder engagement of 'must do' list**. From the process outlined above there were 73 research ideas classified as 'must do'. Of the 73 there remained some overlap and duplication between ideas

from the CIWEM Urban Drainage Group workshop, online survey and previous IUD framework, and ideas generated at the second stakeholder workshop. Further screening of the overlaps and duplication resulted in 52 unique 'must do' research ideas being promoted. Subsequently, we undertook further engagement with the Environment Agency, Defra, UKWIR, LLFAs, and the University of Exeter to confirm where proposed research ideas may already be addressed by other completed, ongoing or planned research projects or were more suited to capacity building than new research. We did this to ensure that proposed research in the local flood risk research roadmap was necessary and did not duplicate other research. Research ideas that were considered to be addressed by other completed, ongoing or planned research projects or which would be more suited to capacity building were identified, and not taken forward for new research under this roadmap.

Following this more than 30 research ideas were taken forward to develop into practitioner-focused research projects, as described in section 4.4.

4.4 Selecting practitioner-focused research projects

The next stage of this process was to turn research ideas into research projects that could be promoted for funding through the Joint Environment Agency/Defra R&D Programme or other sources. In developing the research projects we combined some research ideas into a single project for efficiency. Proposed research projects were presented and agreed at a steering group meeting in June 2014 with representatives from LLFAs, UKWIR, the Environment Agency, Defra, the Highways Agency and the National Flood Forum. This is our final list of research projects. A full list can be found in Table 5.1 and Figure 5.1.

For each agreed research project we developed an outline proposal to provide more details on the project. The outline proposals contained the following information:

- research project title;
- why the research is required and the questions it will try to answer;
- a brief description of the project and main tasks;
- the difference this research project will make;
- possible project partners/funders;
- the local flood risk management outcomes it will help to deliver;
- the value and duration of the research project.

The outline proposals for each research project can be found in Appendix B.

Although there were over 30 'must do' projects identified through the process outlined in sections 4.2 to 4.4 we recognise these projects will need to be delivered over the 5-year period of the roadmap, in partnership with others. At a steering group meeting in June 2014 we identified the research projects which should be prioritised in year 1 of the roadmap (2014/15). There were 13 research projects identified as year 1 priorities, and for these we submitted an application for funding through the Joint Environment Agency/Defra Programme. The remaining research projects were identified as year 2 or years 3–5 priorities, as outlined in section 5. We recognise the importance of partnership delivery for this roadmap, and will seek to deliver the research projects through the Joint Environment Agency/Defra Programme, but also look for other funding sources.

4.5 Identify strategic research questions

As outlined in section 4.1 we have identified strategic research questions that will help deliver real benefits for the local flood risk management community over the longer term. We identified these through discussions with representatives from the project team and universities, and by identifying the strategic research questions from our practitioner-focused projects. We recognise there is currently a lack of synergy between academia-led and practitioner-focused research. Our vision for this roadmap is that we can achieve greater synergy so that practitioner-focused needs are increasingly addressed by academic-led research, and vice versa. We are at the beginning of this journey and we intend to undertake significant engagement with academia through the life of this roadmap. The strategic research questions identified in this roadmap are intended to enable initial discussions with academia, and to support joint initiatives and research.

5 Research projects

5.1 Overview

For the ‘must do’ practitioner-focused research projects we have developed a 5-year roadmap which sets out when research projects should be delivered, and the linkages between them. We recognise this will need to be flexible due to available funding, and as priorities change over the lifetime of the roadmap. Not all projects will receive funding. However, some research projects may be prioritised by the joint programme theme advisory groups, government policy groups or other research institutions. Figure 5.1 illustrates the roadmap. More detail on the practitioner-focused research projects is provided in section 5.2 and in Table 5.1. We have prepared a short proposal on each project in Appendix B.[4]

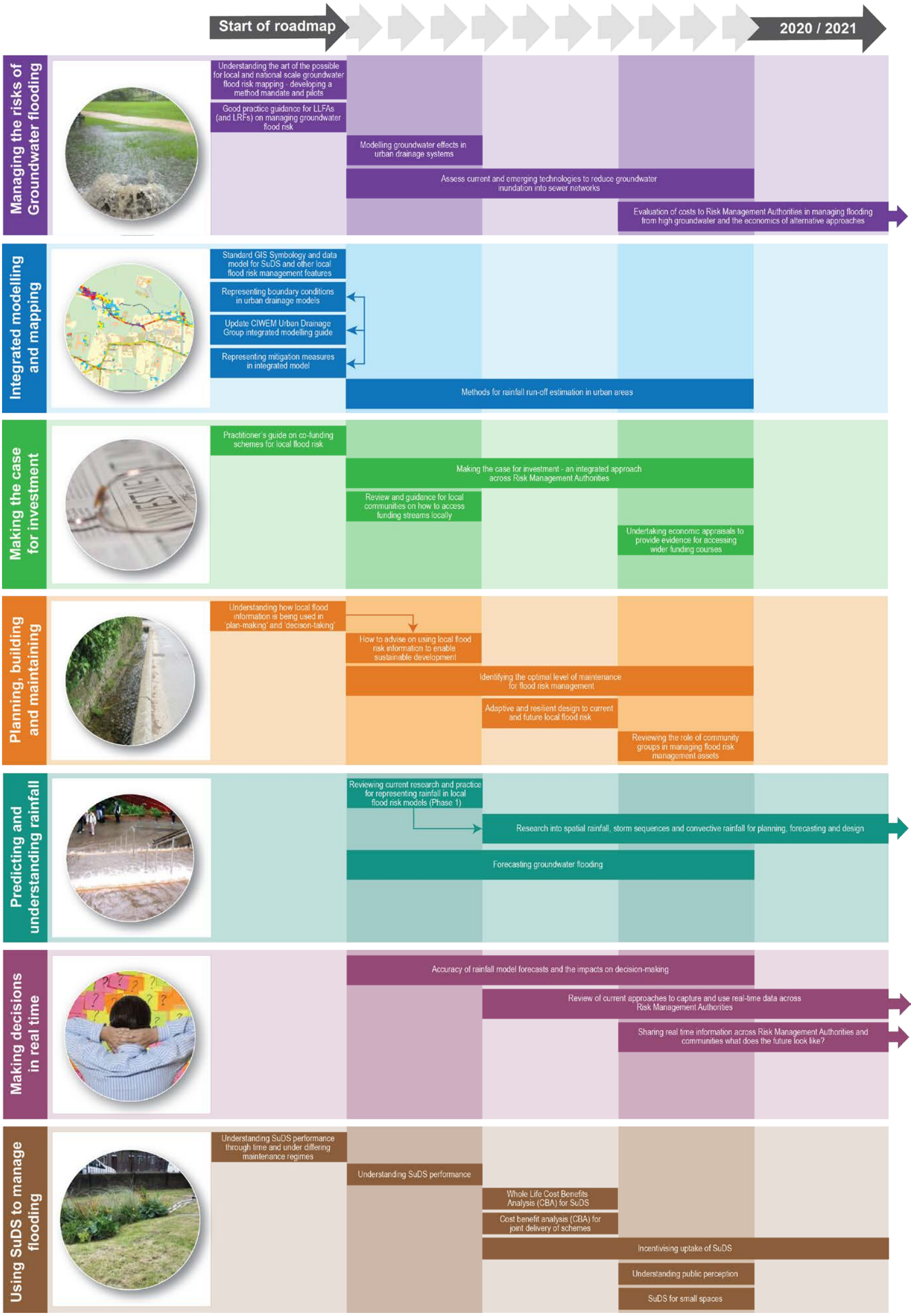
In addition, section 5.3 summarises the strategic research questions we have identified to support the long-term research required by the local flood risk management community.

5.2 Practitioner-focused research projects

We grouped research projects into topic areas. Sections 5.2.1 to 5.2.7 outline the research topics and the proposed research projects.

[4] Figure 5.1, Table 5.1 and Appendix B do not include work packages which are part of the committed investment in the 2014/15 programme as part of ‘Improving Surface Water Mapping’, as these are not new projects developed by this roadmap.

Figure 5.1 Local flood risk research roadmap



5.2.1 Managing the risks of groundwater flooding

Recent wet winters have highlighted the risks posed by groundwater flooding, and the effects of high groundwater on urban drainage systems. Local authorities, and in particular water companies, spent millions of pounds managing high groundwater levels during winter 2013/14. It is very difficult to predict where and when groundwater flooding will happen, and to make an economic case to manage wide-scale groundwater flooding. The set of research topics will consider tools and approaches to manage high groundwater levels in urban drainage systems, how to model groundwater, and supporting LLFAs in building a business case to manage groundwater flooding.

The research projects in this topic are:

- Evaluation of costs to risk management authorities in managing flooding from high groundwater, and the economics of alternative approaches
- Assess current and emerging technologies to reduce groundwater inundation into sewer networks
- Modelling groundwater effects in urban drainage systems
- Understanding the art of the possible for local and national scale groundwater flood risk mapping – developing a method, mandate and pilots
- Good practice guidance for LLFAs (and local resilience forums) on managing area-wide groundwater flood risk.

5.2.2 Integrated modelling and mapping

Modelling and mapping provides the basis for prediction and presentation of all types of flood risk, as well as for analysing intervention options. Improved prediction of flood risk is reliant on improving model robustness and input data. Modelling groundwater and integrated flood risks is important for fully understanding flooding problems and can therefore help identify solutions.

This topic area includes research into improving model predictions and how the outputs are presented, so that the outputs are easier for all stakeholders to access, are more robust, and represent relevant flooding mechanisms. This will ensure that modelling and mapping can be used as a more powerful tool as part of local flood risk management, and ensure the right investment decisions are made.

The research projects in this topic are:

- Standard GIS symbology and data model for SuDS and other local flood risk management features
- Improved guidance on drainage rates and percentage run-off for Flood Map for Surface Water*
- A scoping document exploring the costs, benefits and risks of integrated modelling of all sources of flooding*
- Representing boundary conditions in urban drainage models
- Update CIWEM Urban Drainage Group integrated modelling guide
- Representing mitigation measures in integrated models

- Methods for rainfall–run-off estimation in urban areas
- Guidance on how the Flood Map for Surface Water could represent future scenarios and varying levels of investment*.

* Part of committed investment in 2014/15 programme as part of ‘Improving Surface Water Mapping’

5.2.3 Making the case for investment

This topic includes research into enhancing economic appraisals, as well as accessing a variety of sources of funding, to improve our ability to justify all types of intervention measures. Valuing the benefits of flood risk management is particularly difficult if wider benefits are to be included, because it is difficult to assign a monetary value to many of these benefits. There is therefore a need for research into how to decide what benefits to include in an economic appraisal and how to account for wider benefits to ensure a robust business case can be represented. This can be further complicated if the business case needs to be presented to multiple parties to secure funding, as these parties are likely to have different priorities. This aspect of business cases is particularly important for securing supplementary funding from external contributions.

The research projects in this topic are:

- Review and develop guidance for local communities on how to access funding streams locally
- Undertaking economic appraisals to provide evidence for accessing wider funding sources
- Practitioner’s guide on co-funding schemes for local flood risk
- Making the case for investment – an integrated approach across risk management authorities.

5.2.4 Planning, building and maintaining

This topic covers research that will improve the information that is available for making planning decisions and building sustainable and resilient homes, and about where and when to undertake maintenance of assets. This topic aims to ensure decisions are made using the best available information so that the sustainability of development is considered. It will also ensure the most up-to-date information about adaptive and resilient design can be used by all relevant parties. Finally, it will provide methods and tools for identifying the optimal level of maintenance and ensure the roles of different parties in undertaking the maintenance is understood.

The research projects in this topic are:

- Understanding how local flood information is being used in ‘plan-making’ and ‘decision-taking’ (planning applications)
- 'How to’ advice on using local flood risk information to enable sustainable development
- Adaptive and resilient design to current and future local flood risk
- Identifying the optimal level of maintenance for flood risk management assets

- Reviewing the role of community groups in managing flood risk management assets.

5.2.5 Predicting and understanding rainfall

This covers improving understanding and prediction of rainfall, as well as understanding of a range of hydrological processes and how they interact with each other. Prediction of rainfall is increasingly important under a changing climate, where rainfall patterns may diverge from those normally seen in the UK. As part of this, improved ability to predict rainfall in real time is necessary to further improvements in real-time predictions of watercourse and surface water flooding hazards. Improved prediction of all sources of flooding is only possible with a sound understanding of the underlying processes. This theme covers research into processes as well as research aimed at collecting data on hydrological processes.

The research projects in this topic are:

- Reviewing current research and practice for representing rainfall in local flood risk models (Phases 1 and 2)
- Forecasting groundwater flooding
- A scoping document describing the best way to join up the work on the Flood Map for Surface Water with forecasting and warnings*.

* Part of committed investment in 2014/15 programme as part of ‘Improving Surface Water Mapping’

5.2.6 Making decisions in real time

Understanding and applying data in real time during flooding is a key management tool to minimise the impacts of flood incidents. The research under this topic will consider accuracy of existing real-time rainfall data, and emerging tools and technologies to capture and share real-time data.

The research projects in this topic are:

- Accuracy of rainfall/model forecasts and the impacts on decision-making
- Review of current approaches to capture and use real-time data across risk management authorities
- Sharing real-time information across risk management authorities and communities – what does the future look like?

5.2.7 Managing flood risk using SuDS

This topic covers research into source control to mitigate flood risk in new and existing developments, through SuDS. The research projects identified are largely from the UKWIR SuDS roadmap, and have been brought into this roadmap to ensure the synergies between the UKWIR and Joint Defra/Environment Agency programmes are realised.

The research projects in this topic are:

- Understanding SuDS performance*

- Understanding SuDS performance through time and under differing maintenance regimes
- Incentivising uptake of SuDS* (including options for private finance)
- Whole life cost benefit analysis (CBA) for SuDS*
- Cost benefit analysis (CBA) for joint delivery of schemes*
- Understanding public perception*
- SuDS for small spaces.*

* Research project identified in UKWIR SuDS roadmap

Table 5.1 Full list of prioritised practitioner-focused research projects

Topic	ID	Research project title	Priority year for project start date			Duration			Potential collaborative opportunities
			Year 1	Year 2	Years 3–5	<1 year	1–3 years	> 3 years	
Managing the risks of groundwater flooding	PR_01	Evaluation of costs to risk management authorities in managing flooding from high groundwater, and the economics of alternative approaches			✓		✓		Local authorities, UKWIR, water companies
Managing the risks of groundwater flooding	PR_02	Assess current and emerging technologies to reduce groundwater inundation into sewer networks		✓			✓		Local authorities, UKWIR, water companies, private sector suppliers, NERC/universities
Managing the risks of groundwater flooding	PR_03	Modelling groundwater effects in urban drainage systems		✓		✓			Local authorities, water companies, UKWIR, consultants working on behalf of organisations, software houses
Managing the risks of groundwater flooding	PR_04	Understanding the art of the possible for local and national scale groundwater flood risk mapping – developing a method, mandate and pilots	✓			✓			Local authorities, water companies, UKWIR, consultants working on behalf of organisations, software houses
Managing the risks of groundwater flooding	PR_05	Good practice guidance for LLFAs (and local resilience forums) on managing area-wide groundwater flood risk	✓			✓			Local authorities, water companies, UKWIR
Integrated modelling and mapping	PR_06	Standard GIS symbology and data model for SuDS and other local flood risk management features	✓			✓			Local authorities, water companies and UKWIR
Integrated modelling and mapping	PR_07, 08, 09	Update CIWEM Urban Drainage Group integrated modelling guide. Representing boundary conditions in urban drainage models. Representing mitigation measures in integrated models	✓			✓			CIWEM Urban Drainage Group, UKWIR, water companies
Integrated modelling and mapping	PR_10	Methods for rainfall–run-off estimation in urban areas		✓			✓		CIWEM Urban Drainage Group, UKWIR, water companies
Making the case for investment	PR_11	Review and develop guidance for local communities on how to access funding streams locally		✓		✓			Local authorities, National Flood Forum
Making the case for investment	PR_12	Undertaking economic appraisals to provide evidence for accessing wider funding sources			✓	✓			Local authorities, water companies, Defra, National Flood Forum, local enterprise partnerships
Making the case for investment	PR_13	Practitioner's guide on co-funding schemes for local flood risk	✓			✓			Local authorities, water companies, Defra, UKWIR
Making the case for investment	PR_14	Making the case for investment – an integrated approach across risk management authorities		✓			✓		Local authorities, Environment Agency, water companies, internal drainage boards
Planning, building and maintaining	PR_15	Understanding how local flood information is being used in 'plan-making' and 'decision-taking' (planning applications)	✓			✓			Local authorities, Home Builders Federation, Department for Communities and Local Government, Defra, water companies
Planning, building and maintaining	PR_16	'How to' advice on using local flood risk information to enable sustainable development		✓		✓			Local authorities, Home Builders Federation, Communities for Local Government, Defra

Topic	ID	Research project title	Priority year for project start date			Duration			Potential collaborative opportunities
Planning, building and maintaining	PR_17	Adaptive and resilient design to current and future local flood risk			✓	✓			Local authorities, Home Builders Federation, Communities for Local Government, Defra, product suppliers
Planning, building and maintaining	PR_18	Identifying the optimal level of maintenance for flood risk management assets		✓			✓		Local authorities, Environment Agency, water companies, internal drainage boards
Planning, building and maintaining	PR_19	Reviewing the role of community groups in managing flood risk management assets			✓	✓			Local authorities, National Flood Forum
Predicting and understanding rainfall	PR_20, 21	Reviewing current research and practice for representing rainfall in local flood risk models (Phases 1 and 2)			✓			✓	Flood Forecasting Centre, Met Office, universities, risk management authorities
Predicting and understanding rainfall	PR_22	Forecasting groundwater flooding		✓			✓		UKWIR, water companies, local authorities, local resilience forums, Flood Forecasting Centre, Met Office
Making decisions in real time	PR_23	Accuracy of rainfall/model forecasts and the impacts on decision-making		✓			✓		UKWIR, water companies, local authorities, Flood Forecasting Centre, Met Office
Making decisions in real time	PR_24	Review of current approaches to capture and use real-time data across risk management authorities			✓		✓		UKWIR, water companies, local authorities, internal drainage boards, Flood Forecasting Centre, Met Office
Making decisions in real time	PR_25	Sharing real-time information across risk management authorities and communities – what does the future look like?			✓		✓		UKWIR, water companies, local authorities, internal drainage boards, Flood Forecasting Centre, Met Office
Managing flood risk using SuDS	PR_26	Understanding SuDS performance		✓		✓			Local authorities, water companies, UKWIR
Managing flood risk using SuDS	PR_27	Understanding SuDS performance through time and under differing maintenance regimes	✓				✓		Local authorities, water companies, UKWIR
Managing flood risk using SuDS	PR_28	Incentivising uptake of SuDS			✓		✓		Local authorities, water companies, UKWIR
Managing flood risk using SuDS	PR_29	Whole life cost benefit analysis (CBA) for SuDS			✓	✓			Local authorities, water companies, UKWIR
Managing flood risk using SuDS	PR_30	Cost benefit analysis (CBA) for joint delivery of schemes			✓	✓			Local authorities, water companies, UKWIR
Managing flood risk using SuDS	PR_31	Understanding public perception			✓	✓			Local authorities, water companies, UKWIR
Managing flood risk using SuDS	PR_32	SuDS for small spaces			✓	✓			Local authorities, water companies, UKWIR

5.3 Strategic research questions

Under the same seven topic areas outlined in section 5.2 we have identified the potential strategic research questions which should be developed to deliver the longer term research needs of the local flood risk research community. We have identified over 18 strategic research questions for further discussion with universities and research institutions. As outlined in section 4.5 our vision is for greater synergies between practitioner-focused and academic-led research. Therefore we will continue to engage with academia throughout this roadmap. The strategic research questions identified below are intended to facilitate discussions with academia, and to support joint initiatives and research. We anticipate that these strategic research questions will be updated, or new questions may emerge, through our engagement with academia.

1. How can we manage groundwater flooding more cost-effectively across a catchment?

Water companies and local authorities have spent millions of pounds over recent wet winters in managing high groundwater levels and the interaction with urban drainage networks. We will experience more wet winters over the next 50–100 years due to climate change. Managing groundwater is challenging because of the large volumes of water over a wide geographical area, and because water emerges from the ground rather than overland. Current practice tends to focus on managing the consequences of high groundwater, typically through property protection, pumping or tankering. We need new technologies and ways of thinking to provide more cost-effective and sustainable ways to manage the problem. We also need greater synergy in how we manage groundwater during periods of flooding and drought.

2. What better ways are there to model the interaction of all sources of flooding?

Flooding rarely occurs from a single source. While legislative responsibilities differ depending on the source of flooding, our understanding of flood risk through hydraulic modelling and measures to mitigate flooding will be most technically sound and cost-effective when we consider all sources of flooding. Hydraulic modelling of multiple sources is becoming increasingly common. Indeed, current modelling approaches can represent more than one source of flooding, but it is difficult to represent all sources in an integrated manner. As a result it is hard to represent groundwater interactions within sewerage networks, for example. In addition, existing models are in different formats, at different spatial and temporal scales, and cultural silos within different technical disciplines can make it difficult to truly integrate modelling. Research which improves levels of integration either within single modelling platforms, or across different software, will help to overcome these challenges.

3. Can we develop accurate systems that identify where infiltration occurs when pipes are fully surcharged?

Locating infiltration into urban drainage systems is a time-consuming process, typically involving camera surveys. These surveys cannot be undertaken when pipes are full and we have to wait for drier periods to undertake surveys, or respond when flooding from the network occurs. What if the specific locations of infiltration could be identified remotely and before floods occur, and communicated to relevant risk management authorities? Could locations of known infiltration be monitored in real time? Technological advance would enable organisations to warn communities of likely flooding or loss of service, or take actions immediately to reduce flood risks to people and property.

4. How can we run models rapidly to help optimise investment decisions?

Hydraulic modelling is a key tool to understand flood risk and the effectiveness of proposed mitigation measures. Due to limitations in model simulation times[5] it is rarely, if ever, possible to run the 'true' full range of scenarios. Therefore, we cannot be sure we have identified or implemented the optimal suite of mitigation measures across a catchment to reduce flood risk. Long-term research is needed to understand the right balance between:

- hardware improvements;
- model reduction (e.g. data and physical complexity);
- model encapsulation (using a full model to 'train' a faster model).

5. Can bespoke models be built more easily by flood risk modellers and stakeholders?

Building a traditional model is time-consuming and expensive. We do not have models for every flooding situation and sometimes an understanding of flooding may need to be answered more quickly than it would take to build a traditional model. Can practitioners build a model during a 'live' flooding incident that is good enough to support decision-making and emergency response?

Alternatively, for a small local flood risk scheme, which may be community driven, there may be insufficient funding to build a complex model. What new modelling tools could help risk management authorities or local communities model flood risk simply and at low cost to better understand the effectiveness and costs of proposed solutions? Involving communities in the modelling process can help support more engaged communities.

6. Can we improve the representation of physical processes in models?

Given the critical role of hydraulic modelling in decision-making we need increasing confidence that these models can robustly represent physical processes such as rainfall–run-off and hydraulics. It remains difficult to fully represent mathematical equations in hydraulic models due to the complexity of the natural environment. New and ongoing research is needed to understand the key physical processes and the current level of confidence within hydraulic models, and to recommend new/enhanced ways to represent these processes to give greater confidence in model outputs.

7. Are there better ways to value the multiple benefits of local flood risk management?

Economic appraisals of the benefits of local flood risk management tend to consider a limited set of benefits, focusing on damages avoided to infrastructure. We know that flood risk management can have significant positive societal and environmental benefits, yet these are rarely considered in the same way as damages avoided to infrastructure. To ensure the right local flood risk management measures are implemented we need a more robust mechanism for assessing the whole life benefits to infrastructure, society and the environment. New evidence and data are needed, as well as the development of tools to enable end users to include the multiple benefits within economic appraisals.

8. How can we optimise investment for multiple stakeholders across a catchment and ensure all flood risks are considered collectively?

Irrespective of the sources of flooding we want to optimise levels of investment across a catchment so that the right balance of capital and operational investment is made, by the right organisation, at the right times, to achieve the most cost-beneficial outcome to society, the economy and the environment. Currently, investment by different risk management authorities is not optimised, and the appropriate balance between capital and operational expenditure is hard to define. We need new research to answer some key catchment-wide questions, such as:

[5] There are rapid simulation models available but these are less frequently used as part of detailed studies to understand flood risk and identify mitigation measures.

- Can we improve data collection, modelling and process to fully understand total catchment management issues and hydrological response? and, if so, how?
- Can we produce plans to manage maintenance and capital investment on a catchment basis using surveys and integrated catchment models?
- Can we test scenarios and identify opportunities to 'squeeze' maximum hydraulics across different parts of the system?

9. Are there new materials or technologies that could help us build more adaptive and resilient properties and infrastructure?

It is widely recognised that we need to build more adaptive and resilient properties and infrastructure in light of future uncertainties. Climate change will bring more intense convective rainfall events, wetter winters, and more periods of drought. The way we design and build infrastructure in new locations and the existing urban fabric need to reflect the inherent uncertainty that future climate change will bring. New materials and technology will be needed to make properties more resilient to flooding. Similarly, we need our flood risk infrastructure to be easily adaptable to future increases in rainfall, groundwater levels or flooding from watercourses.

10. Can local flood risk management assets be designed to need substantially less maintenance?

There is increasing pressure on budgets across risk management authorities, and this trend is likely to continue over the forthcoming 5 to 10 years. This creates challenges to secure funding for appropriately maintaining local flood risk assets, both in terms of regular maintenance and asset replacement. New technologies and approaches could pave the way for significant cost savings with respect to maintenance. For example, new research could identify whether assets can be self-cleansing, whether more durable materials can be used to increase asset life, or whether assets can send real-time information, using cost-effective technologies, to identify when maintenance is required.

11 and 12. Can we identify where drainage assets are without on-the-ground surveys? Can we map the underworld and share data to speed up retrofitting of SuDS?

Many highways authorities do not have accurate and up-to-date maps of their highways assets. Surface water drainage networks are often mapped in partial detail. The transfer of private sewers has increased the asset base of water and sewerage companies, but these systems are rarely mapped. There is no central repository of information on buried services. Without a comprehensive understanding of the location, ownership or condition of flood risk assets it is more difficult to understand sources of flooding and possible mitigation measures. Equally, it can take significant effort to identify buried services and the location of some services can remain unknown until construction, which can result in increased costs on site. Therefore it is critical to improve our understanding of the location and condition of existing drainage assets and services, but this is an expensive and timely activity. Innovative ways to reduce costs and to speed up data collection are needed, and research could focus on remote sensing or geophysical techniques, for example.

13. Can we improve our understanding and predictions of convective rainfall systems now and under a changing climate?

Surface water flooding often occurs as a result of intense rainfall events which overwhelm our drainage systems. They are often short duration and localised, making them harder to predict with any confidence. As a result it is more difficult for risk management authorities to warn and prepare communities for flooding. There is a wealth of existing research, but there are some outstanding questions which need research to enable risk management authorities to make robust decisions based on accurate forecasts. These questions include:

- How can we improve the accuracy, confidence and resolution of rainfall forecasts, especially for convective events?
- How can we improve the reliability of flood warnings within urban areas?
- How will more reliable flood warnings reduce the impacts of flooding to people, property and infrastructure?

14. How can we predict groundwater flooding using medium-term rainfall forecasts?

In recent winters we have seen significant flooding as a result of groundwater flooding, both in terms of direct groundwater flooding, and the impacts on the operation of the urban drainage network. It is difficult to predict, with any certainty, how groundwater levels might fluctuate over a 1 to 4 week period, for example. As a result our management response to high groundwater tends to be reactive. Research which considers short to medium-term rainfall forecasts (i.e. 1 to 4 weeks) and predicts the effects on groundwater levels could help risk management authorities prepare for likely flooding, and therefore reduce the overall impacts to people and property. Some possible questions to be addressed include:

- What models and tools do we need to develop to predict groundwater levels?
- Can these models be sufficiently accurate to use in decision-making?
- Can medium-term rainfall forecasts be accurate enough?

15. Can we develop new tools to support decision-makers in the face of uncertain rainfall/model forecasts?

Probabilistic rainfall/flood forecasts already exist, but it is difficult to use these to plan operational responses because the confidence tends to be too low. Given that improvements in convective rainfall forecasting will take significant time we are unlikely to increase the confidence in the short term. Are there new approaches risk management authorities could use when deciding how to respond to probabilistic forecasts that balance risks of not responding against the costs of operational responses. Alternatively, could new operational responses be developed that are effective yet low cost so that they can be undertaken even with low confidence forecasts?

16. Are there new approaches to capture and share real-time data across stakeholders?

There are existing ideas, technologies and examples of risk management authorities sharing data in real time to support decision-making, particularly to support coastal monitoring of combined sewer overflow spills. However, across the local flood risk management community this is not commonplace. Furthermore, there is limited evidence of sharing of real-time data with local communities who are affected by flooding, apart from the Environment Agency's flood warning service. The challenge is to develop technologies and processes to enable sharing of real-time data across risk management authorities to facilitate decision-making in advance and during a flooding incident, but also to communicate appropriate information to local communities. We also need to better understand how social media can be an effective tool to communicate to local communities, and gather feedback in real time (e.g. crowd-sourcing). This will need to balance widespread, unreliable information against sparse, reliable information.

17. How do we understand societal perception and engagement about new approaches to managing stormwater?

Professional stakeholders are becoming increasingly aware of the need for new approaches to stormwater management in the face of climate change. We cannot afford to continue to build bigger and bigger underground infrastructure. The right balance between grey and green infrastructure will be key in managing stormwater in the most sustainable manner. While technical barriers during design can be overcome there remain societal barriers about new approaches to stormwater

management. For example, a community might oppose dual use of a recreational area for flood storage. Therefore, we need new research to understand societal perceptions, public understanding of risk, and willingness for new approaches and incentives to encourage uptake. This research will identify current barriers and how the local flood risk management community can overcome these.

18. What new SuDS technologies do we need to develop?

SuDS will continue to play a key role in managing surface run-off, improving water quality, and enhancing amenity and biodiversity both in new developments and within the existing urban fabric. Continued innovation and research is needed to enhance existing technologies and develop new ones that will maximise flood risk and water quality treatment of SuDS, while also maximising societal benefits to communities who interact with SuDS infrastructure in the places they live and work.

6 Engagement plan

6.1 Introduction

We need to continue to work collaboratively to provide research which meets the needs of the local flood risk management community. This engagement plan sets out who we want to engage with and how we will do it. It outlines activities undertaken as part of the development of the research roadmap, and future activities to implement the roadmap. The approach has been based on the Environment Agency's 'Working with Others' approach.

Figure 6.1 illustrates the range of stakeholders who we need to engage with. These stakeholders all have a key role to play in local flood risk management, and as such we need to ensure they are fully involved. Some of the stakeholders will be end users of research while others will have a role to play in developing research and enabling it to happen.

ADA = Association of Drainage Authorities; UKRLG = UK Roads Liaison Group; DfT = Department for Transport

Figure 6.1 Stakeholders we need to work with during development and implementation of the research roadmap

We have split our engagement approach into four steps: the first two relate to development of the research roadmap and are complete, while the latter two relate to implementation of the research roadmap:

- Step 1 – Raise awareness of the research roadmap

- Step 2 – Collaboration during development of the research roadmap
- Step 3 – Promote the published research roadmap
- Step 4 – Implement the research roadmap through engagement and monitoring.

These are described in sections 6.2 to 6.5 below, and summarised in Figure 6.2.

6.2 Step 1 – Raise awareness

The purpose of this step was to raise awareness and generate interest in the project to develop a new research roadmap, and to identify opportunities for involvement across the local flood risk management community. This step was completed in the first month of developing the research roadmap. This involved:

- attending the project board meeting of the LLFA capacity building programme to discuss the new research roadmap;
- undertaking structured interviews with representatives from the Environment Agency, water and sewerage companies and UKWIR;
- preparing a briefing note which summarised the new research roadmap and identified opportunities for involvement, which was published via the CIWEM Urban Drainage Group, FlowNet, susdrain, and the Environment Agency's internal FCERM newsletter ('Needs to Know');
- facilitating a workshop at the CIWEM Urban Drainage Group Autumn 2013 Conference to inform delegates of the new research roadmap and to generate research ideas;
- creating a project board with representatives from LLFAs, Defra, the Environment Agency, the Highways Agency, the National Flood Forum and academia.

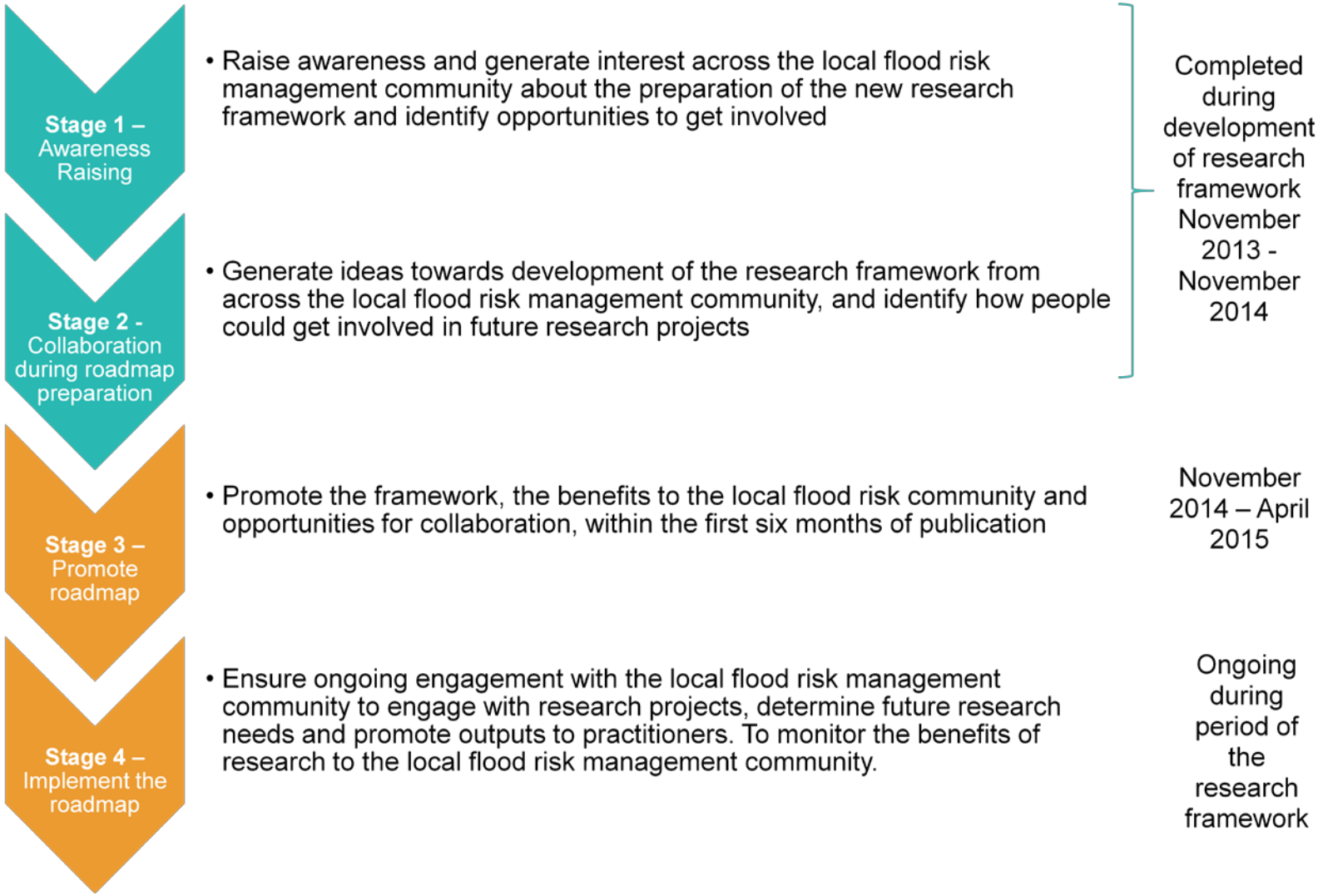


Figure 6.2 Summary of engagement plan steps

6.3 Step 2 – Collaboration during development of the research roadmap

During development of the research roadmap we collaborated with the local flood risk community to generate research ideas. This was primarily achieved by running two facilitated workshops in November 2013 and March 2014, and hosting an online survey for a 4-week period in January 2014. We successfully engaged with a wide range of stakeholders, which gave us confidence our research ideas would meet the needs of, and bring real benefit to, the local flood risk community.

The first workshop was held during the CIWEM Urban Drainage Group Autumn Conference in November 2013. Over 30 delegates from across the local flood risk community attended the workshop and had the opportunity to contribute research ideas which were taken forward as part of the development of the roadmap. Over 100 research ideas were generated from this workshop alone.

In January 2014 we undertook an online survey to understand research needs and gather additional research ideas from the local flood risk community. The online survey was widely publicised via CIWEM, ICE, the Environment Agency FCERM newsletter, FlowNet, the newsletter of the UK Water Research and Innovation Partnership (UKWRIP) and Defra, as well as by direct invitation through known contacts. Over the 4-week period 73 people responded to the online survey, and collectively generated over 100 research ideas for the roadmap. Respondents by organisation are shown in Figure 6.3.

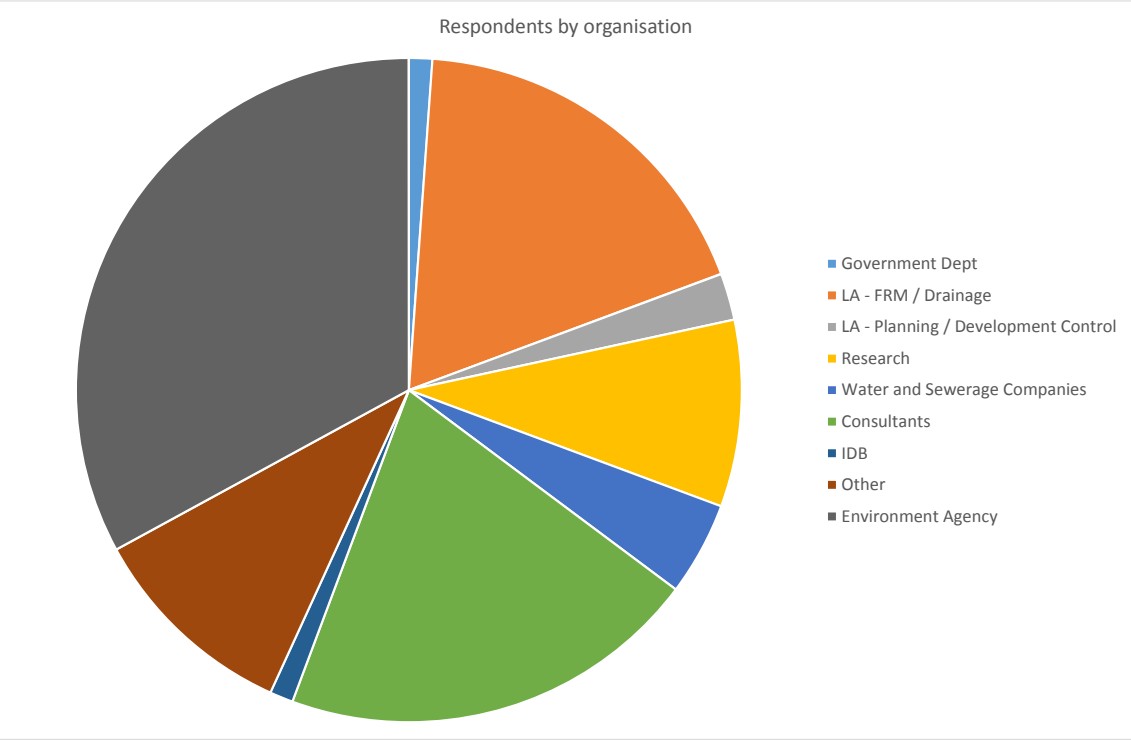


Figure 6.3 Respondents to online survey by organisation

Lastly, we held a second workshop in March 2014. The purpose of this second workshop was to generate additional research ideas and to begin to prioritise these ideas. Over 40 delegates attended the workshop, and included representatives from LLFAs, the Environment Agency, water and sewerage companies, internal drainage boards, Defra, private sector including consultants and manufacturers, the National Flood Forum, the Highways Agency, academia, the National Farmers Union and

representatives from a local flood action group. Following the workshop delegates were sent a list of the prioritised research projects and invited to provide further comment on the projects or identify where they would be interested in being involved in specific research projects over the next 5 years. The draft outputs were also reviewed by an independent peer reviewer.

6.4 Step 3 – Promote the research roadmap

Within the first 6 months of the research roadmap being completed (November 2014 to April 2015) we will promote the roadmap, the benefits to the local flood risk community, and opportunities for collaboration. Key messages should be tailored to the stakeholders being addressed, but should:

- outline what the research roadmap is;
- say how and why it will deliver benefits to the local flood risk community;
- summarise the research projects;
- inform stakeholders how they can participate.

During this step we will also agree with our partners how best to engage in the future and to understand the research needs of other organisations. A summary of proposed activities is outlined in Table 6.1. The impact of these activities will be to maximise awareness about the roadmap, thus giving greater opportunity for the local flood risk management community to get involved and make use of research outputs.

Table 6.1 Engagement plan to promote the roadmap

Activity to promote roadmap	Date	Stakeholders who will be reached	Communication method
Publish the research roadmap on the Joint Defra/Environment Agency R&D website	Spring 2015	All stakeholders potentially (but low reach in isolation)	Website
On social media and online forums, including: CIWEM, susdrain and FlowNet	Winter 2014	LLFAs, district councils, Environment Agency, private sector	Twitter or forum posts
Through professional institutions (e.g. CIWEM, ICE, Chartered Institution of Highways and Transportation, and Royal Town Planning Institute)	Autumn 2014	Members of these organisations, which span right across the local flood risk management community	Briefing note to be inserted in communications to their members
Environment Agency's FCERM 'Needs to Know' and communities of practice	Spring 2015	Environment Agency	Briefing note
Engage with Joint Defra/Environment Agency Evidence team and theme leads (Mapping and Risk and Sustainable Asset Management)	Summer and autumn 2014	Environment Agency and Defra	Briefing note and personal communication

Publish in the 6-monthly Joint Defra/Environment Agency 'Research News' newsletter	Summer 2015	TBC	Newsletter
Direct to LLFAs teams and FlowNet discussion	Spring 2015	Environment Agency and LLFAs	Personal communication
Newsletter of UKWRIP	TBC	Academia, NERC, LWEC, EPSRC	Newsletter
Present paper to UK Roads Board on framework	TBC	Highways authorities and Highways Agency	Paper and presentation
At future LLFA capacity building days	Ongoing	LLFAs and Environment Agency	Presentation and discussion

6.5 Step 4 – Implement the roadmap through engagement and monitoring

Continued involvement and engagement across the local flood risk management community will be important to ensure the right research projects are delivered, they are disseminated to the right people, and they result in real benefits. This will involve continual monitoring of the roadmap and the research landscape. The proposed approach below sets out how we will engage and monitor the delivery of the roadmap from 2014 to 2020. The approach involves engagement and monitoring at a project-specific level and at specific time periods up to 2020.

6.5.1 Monitoring of specific projects

Each project delivered should be monitored to assess its progress and the difference it has made. Irrespective of how a research project is delivered (i.e. through the Joint Environment Agency/Defra Programme or another organisation) it is important to capture and understand the benefits of research. A standard template should be adopted to monitor progress and the benefits of the research projects in the roadmap, including:

- name of research project;
- description;
- outcomes of research;
- types of outputs from the research (e.g. science, tools and guidance);
- start and end date;
- costs (proposed or actual);
- lead organisation and partners;
- how the project supports delivery of outcomes listed in section 3.2;
- progress;
- hyperlinks to project outputs (the feasibility of using LWEC's database to store project outputs should be explored).

Each research project should have a dissemination plan which identifies how outputs should be disseminated and to whom. At a time 12 months after completion of a research project the awareness and uptake of the research within the local flood risk management community should be considered through engagement with end users.

6.5.2 Annual engagement and monitoring

Each year, in partnership with others, we will monitor the delivery of research projects from the roadmap, assess the success of engagement and dissemination, and consider the programme for the following 12-month period. At the same point we will also review the 5-year roadmap to identify whether the proposed research needs remain relevant. The actions are summarised below, and in Figure 6.4.

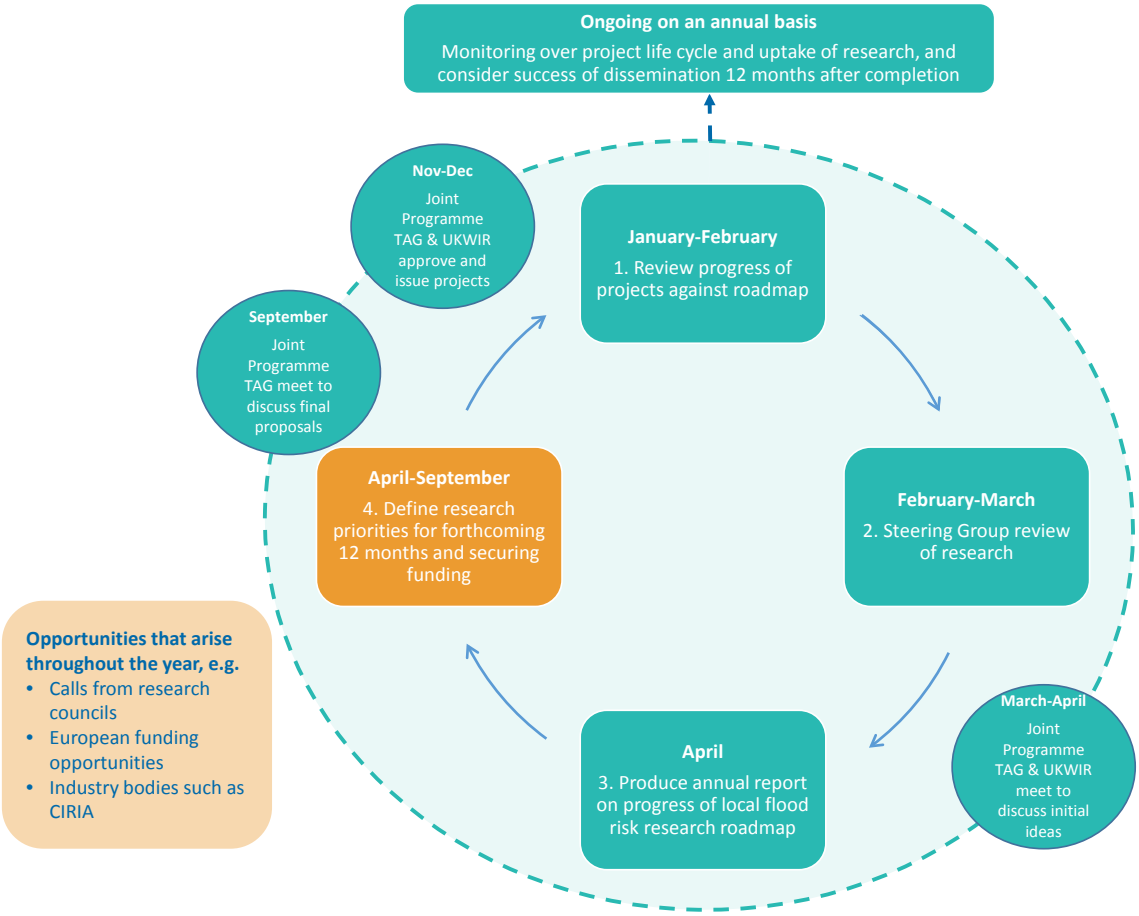


Figure 6.4 Annual engagement

1. **Review progress of projects against roadmap** – This will involve evaluating what research projects (delivered through the Joint Environment Agency/Defra Programme or by others) have been completed or are ongoing. This will enable us to understand progress against the original programme. Finally, as a useful metric of the success of our engagement, we will monitor the number of hits to the Environment Agency's FCERM research and development website,[6] and the number of downloads of research outputs linked to local flood risk management. We recognise this metric does not give an indication of the effectiveness of research, but it will provide additional evidence that the local flood risk management community are engaging with research outputs.

[6] http://evidence.environment-agency.gov.uk/FCERM/en/Default/FCRM.aspx

2. **Steering group review of research** – During development of the local flood risk research roadmap a steering group was established. It consisted of members from LLFAs, the Environment Agency, Defra, UKWIR, the Highways Agency, the National Flood Forum and academia. For continuity this steering group will meet annually to review research from the previous 12 months, evaluate the success of engagement and dissemination, and consider research priorities for the forthcoming 12 months (including who is best placed to deliver the research). This group will also consider the continued validity of the 5-year programme of research identified in this roadmap.
3. **Produce annual report on progress with local flood risk research roadmap** – Following the steering group meeting we will produce a report outlining the progress of local flood risk research, money spent to date, lessons learnt, the success of engagement and dissemination, and benefits from completed research.
4. **Define research priorities for the forthcoming 12 months** – By working with others we will agree the priority research projects for the following 12 months, and agree who is best placed to lead and contribute towards the research. This will include attendance at UKWIR research planning days, for example, and will use feedback gained from the steering group meeting as described above.

6.5.3 Two-yearly engagement and monitoring

We believe the most effective mechanism to monitor the benefits of local flood risk research is to establish a user testing group,[7] made up of a cross-section of the organisations listed in Figure 6.1. The purpose of the user testing group will be to assess awareness of completed research, whether the research is being used, and whether it is delivering real benefits to the local flood risk management community. We are proposing to form the user testing group in 2015 to formulate a baseline position and monitoring, and will then seek feedback from this group in January 2016, 2018, and 2020. Feedback will be sought from the user testing group through a survey which includes the following:

- awareness of research projects which have been completed;[8]
- confirmation of whether research outputs are being used;
- whether research is helping to deliver outcomes and what further research is required to achieve outcomes.

The last point will be addressed by asking the user testing group a set of questions to establish whether outcomes are being delivered, and what further research may be needed. The questions will be linked to the local flood risk management outcomes defined in Table 3.1, and will provide us with a metric to assess whether desired outcomes have been achieved. Where feedback from the user testing group and the steering group indicates that an outcome has been met then no further research would be proposed at that stage. Over time, we anticipate that an increasing number of outcomes will be realised through research delivered by the Joint Environment Agency/Defra Programme and other organisations. An example is provided in Table 6.2, which will be refined during 2015/16.

[7] Or specific groups such as LLFA Capacity Building, Water UK members or CIWEM for example. The advantage of this is that the membership changes.

[8] This will enable us to test whether engagement and dissemination has been successful.

Table 6.2 Example form for assessing whether outcomes have been met and what further research is needed

Outcome	Outcome achieved	Research needed					Don't know
		1	2	3	4	5	
1. Effective partnership groups that collectively understand and manage local flood risk	Yes/No						
2. Improved working across local government departments (e.g. planning, flood risk and highways)	Yes/No						
3. Organisations and communities capture, share and use data and information appropriately	Yes/No						
4. Communities understand flood risks they face and what actions to take to reduce the impact	Yes/No						
5. Communities help make decisions and understand their roles and responsibilities	Yes/No						
6. Accurate and local real-time prediction of rainfall	Yes/No						
7. Local predictions of future rainfall patterns as a result of climate change	Yes/No						
8. Rainfall-run-off science informs better decisions	Yes/No						
9. Accurate real-time predictions of local flood risk inform better decisions	Yes/No						
10. Accurate models that predict all sources of local flood risk	Yes/No						
11. Flood mapping to help organisations and communities understand local flood risk	Yes/No						
12. The right mix of structural and non-structural measures are used to manage local flood risk	Yes/No						
13. New buildings are planned, designed and located to be resilient and to reduce local flood risks	Yes/No						
14. Real-time information leads to organisations and communities taking effective action	Yes/No						
15. Sustainable drainage systems are designed, adopted and maintained to appropriate standards	Yes/No						
16. Local flood risk measures provide multiple benefits for communities and the environment	Yes/No						
17. Understand the long-term effectiveness of different mitigation measures	Yes/No						
18. Local flood risk management measures are flexible in responding to an uncertain future	Yes/No						
19. Economic appraisals fully consider all costs and benefits to support decision-making	Yes/No						
20. Partnership contributions are made towards local flood risk management schemes	Yes/No						
21. Drainage networks and watercourses are maintained to manage local flood risk	Yes/No						
22. Policy and strategy remains responsive to science and evidence	Yes/No						

1. **No new research is needed.** The barriers to achieving this outcome concern operations or policy.
2. **Dissemination and knowledge transfer.** All of the necessary research is already available, but it needs more work to pull it through in to practice.
3. **A few key gaps remain.** The field of research that supports this outcome is fairly mature but some areas still need work.
4. **Some existing work.** While there are some promising new ideas, much work is needed to move the research in to practice.
5. **A fundamentally new approach.** We need a revolution in how this outcome is approached. It will take a concerted effort and several years of work.

To capture views across the local flood risk management community, we will also undertake a survey mid-way through the roadmap. This will take place in spring 2017, and will seek feedback on research projects delivered to date, and gaps in knowledge. We will promote this survey widely across the local flood risk management community. We will also undertake surveys at some key conferences, which is a quick and low cost method to capture feedback on the success of the roadmap. This feedback will be used to help refine the research roadmap during the 5-year programme.

As research needs change quickly we are also proposing to undertake an intermediate review of the research priorities in spring 2017. This will reset research needs and priorities and ensure the right research is delivered in a timely manner.

6.5.4 Other actions

In addition, we will undertake regular actions to promote outputs of research which will encourage uptake and use by the local flood risk management community. These will include:

- promoting research outputs through online forums;
- attending and presenting at key industry conferences to promote research outputs;
- attending and presenting at LLFA capacity building events;
- publishing summaries of research in the Joint Defra/Environment Agency 'Research News' newsletter (published every 6 months);
- engaging with LLFAs and risk management authorities;
- engaging with the FCERM.net group of academics involved in research related to flooding;
- publishing information in the UKWRIP;
- publishing research outputs on LWEC's Envirobase website (http://www.envirobase.info/).

During this project we also found that telling people about where to find existing research is just as important as commissioning new research. Stakeholders told us about research needs that were urgent and important, some of which are already addressed by existing research outputs. Examples of these high priority projects are outlined in Table 6.3 and details of existing research will need to be disseminated across the local flood risk management community to ensure wider uptake.

Table 6.3 Examples of existing research projects which need to be disseminated

Research need	Link to specific topic (where relevant)	Existing research which meets the need
Communicating uncertainties in flood mapping	Integrated modelling and mapping	RISKMAP
Raising community awareness and educating communities on flood risk management	-	Communicating Local Flood Risk, FD2664 and WWNP framework
Review of National Planning Policy Framework (NPPF)	Planning, building and maintaining	DCLG review of the NPPF (ongoing as of autumn 2014)
Government's response to Pitt Evaluation and post-implementation review of the Flood and Water Management Act	-	Defra review of Pitt Review implementation and Flood and Water Management Act (ongoing as of autumn 2014)
Valuing the wider benefits of flood risk management	Making the case for investment	WWNP framework
Best practice guidance on surface water separation techniques and approaches	Using SuDS to manage flooding	Guidance on retrofitting stormwater management measures
Valuing the multiple benefits of sustainable drainage	Using SuDS to manage flooding	SC100003
Best practice guidance on practicalities of securing funding for local flood risk management	Making the case for investment	FD2643
Impacts of land management and agricultural techniques on local flood risk	-	FD2120, FD2114, SC060092, WWNP framework

References

Ashley, R., Shaffer, P. and Walker, L. (2014) *Sustainable drainage systems (SuDS) research roadmap*. UK Water Industry Research.

Environment Agency (2009) *Research framework – the implementation of integrated urban drainage*. Report SC070064/R1

Environment Agency (2011) *Understanding the risks, empowering communities, building resilience. The national flood and coastal erosion risk management strategy for England*.

Environment Agency (2012) *A framework for Coastal Research, Development and Dissemination (CoRDDi).* Report SC090035/R.

Environment Agency (2014) *Working with natural processes to reduce flood risk*. R&D framework: science report. Report SC130004/R2.

Green, C., Wilson, T. and Boothby, N. (2006) *An assessment of the additional flood losses associated with groundwater flooding: a report to Hampshire County Council and Winchester City Council*. Enfield: Flood Hazard Research Centre, Middlesex University.

Jacobs (2004) *Strategy for flood and coastal erosion risk management: groundwater flooding scoping study (LDS 23)*. Final Report, Volume 1 of 2, Defra.

Moores, A.J. and Rees, J.G. (eds) (2011) *UK flood and coastal erosion risk management research strategy*. Living with Environmental Change.

OECD (2002) *Frascati Manual 2002: Proposed standard practice for surveys on research and experimental development*.

Onof, C., Faulkner, D. and Wheater, H.S. (1996) Design rainfall modelling in the Thames catchment. *Hydrological Sciences*, 41(5), 715–733.

List of abbreviations

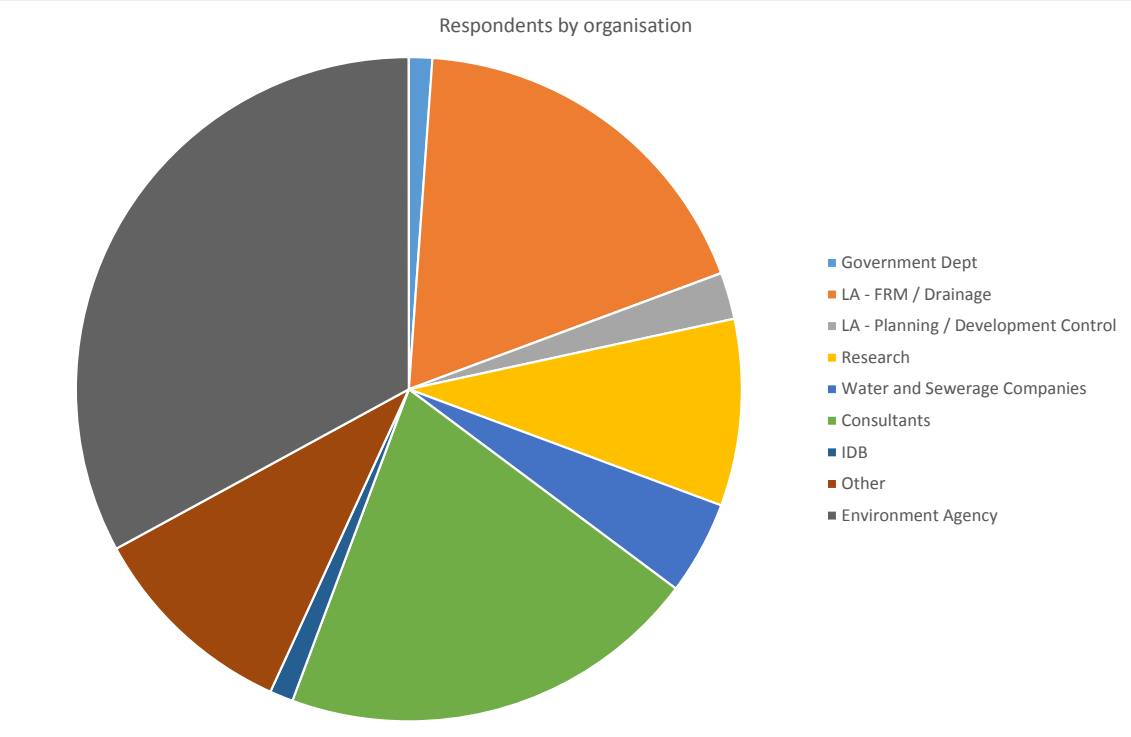
CIRIA	Construction Industry Research and Information Association
CIWEM	Chartered Institution of Water and Environmental Management
CoRDDi	Coastal Research, Development and Dissemination
DCLG	Department for Communities and Local Government
EPSRC	Engineering and Physical Sciences Research Council
FCERM	Flood and Coastal Erosion Risk Management
GIS	geographic information system
ICE	Institution of Civil Engineers
IUD	integrated urban drainage
LLFA	lead local flood authorities
LWEC	Living with Environmental Change
MSCW	must, should, could, would
NERC	Natural Environment Research Council
SuDS	sustainable drainage systems
TAG	Theme Advisory Group
UDG	Urban Drainage Group (CIWEM)
UKCIP	UK Climate Impacts Programme
UKWIR	UK Water Industry Research
UKWRIP	UK Water Research and Innovation Partnership
WWNP	Working with Natural Processes

Appendix A – Summary of online survey

During January 2014 an online survey was undertaken to understand the priority research needs of the local flood risk management community. The purpose of the survey was to identify research outcomes needed to support those involved in local flood risk management. In addition, respondents were given the opportunity to provide research ideas that could be undertaken as part of the local flood risk research framework. The survey was promoted through numerous channels including the Local Government Association Knowledge Hub (formerly FlowNet), the CIWEM Urban Drainage Group, ICE, government departments and the Environment Agency, and by personal invitation.

This appendix provides a summary of the responses to the online survey. This includes the identification of research themes under which projects will be classified in the framework. In total there were 73 completed responses to the online survey. Figure A.1 shows the number of responders from each type of organisation, as classified by each responder. Of the 73 completed responses, 56 were from the Environment Agency, local authorities or consultants.

Figure A.1 The number of responders from each type of organisation



A key part of the online survey was asking respondents to identify the need for additional research to meet a range of pre-identified outcomes. A total of 23 outcomes were specified at this stage, and for each outcome respondents were asked to provide a score of 1 to 5 identifying how much more information or knowledge they needed to undertake their job more effectively or efficiently, 1 equating to no further information or knowledge being required and 5 equating to new knowledge or information required to enable a completely new way of working. A score of 3 represented a neutral position. The purpose of this question was to help prioritise the outcomes where respondents

require new knowledge or information which in turn will help to ensure that research projects will meet the priority outcomes.

Table A.1 Summary of the responses about the amount of information needed in a range of outcomes. The percentage of people who scored the outcome 4 or 5 (more information needed) is shown and the projects are listed in rank order

Outcome	Outcome ID	% scoring 4 or 5	Rank
Reduced local flood risk through implementation of non-structural measures	3d	63%	1
Better outcomes because of improved linkages across local government responsibilities (e.g. spatial planning and local flood risk management)	3a	61%	2
Reduced groundwater flood risks due to improvements in groundwater flooding predictions	2e	60%	3
Local flood risk management delivers multiple benefits for communities and the environment, including synergies with the Water Framework Directive	3h	59%	4
Understanding the long-term impacts of mitigation measures (e.g. use of highways to store water)	3j	59%	5
Reduced duplication of data through facilitating data transfer between organisations	1b	56%	6
Reduced local flood risk due to improved real-time monitoring of sewer networks and watercourses	2c	56%	7
Sustainable drainage systems which are designed, adopted and maintained to appropriate standards	3b	56%	8
Greater confidence in understanding local flood risk through improved model accuracy	2d	53%	9
Hydraulic models which can appropriately represent local flood risk management measures	3f	53%	10
Funding for local flood risk management is supplemented by external contributions	4a	53%	11
Communities aware of flood risks they face which results in appropriate action	1c	52%	12
Communities are central to decision-making for local flood risk management	1d	51%	13
Reduced local flood risk due to improved real-time prediction of flooding	2b	49%	14
Robust economic appraisals which fully consider costs and benefits of intervention, and support business cases	3g	49%	15
Consistent flood mapping that helps organisations and communities understand local flood risk and take action	2f	48%	16
Drainage networks and watercourses are maintained to manage local flood risk	4b	47%	17
Value for money and efficient delivery through partnering between risk management authorities and contractors	4c	46%	18
Reduced local flood risk through implementation of property-level protection	3c	44%	19
Strong and diverse partnerships that make effective decisions	1a	43%	20

Reduced local flood risk due to improved real-time prediction of rainfall	2a	42%	21
Reduced local flood risk through design and implementation of structural measures	3e	34%	22
Health and safety issues are integral to development and delivery of mitigation measures	3i	25%	23

Table A.1 shows that overall the responders consider the outcomes listed to be relevant as almost all gained a high percentage of scores at 4 or 5, although the range is quite small. The top five outcomes as ranked in the table are:

- reduced local flood risk through implementation of non-structural measures;
- better outcomes because of improved linkages across local government responsibilities (e.g. spatial planning and local flood risk management);
- reduced groundwater flood risks due to improvements in groundwater flooding predictions;
- local flood risk management delivers multiple benefits for communities and the environment, including synergies with the Water Framework Directive;
- understanding the long-term impacts of mitigation measures (e.g. use of highways to store water).

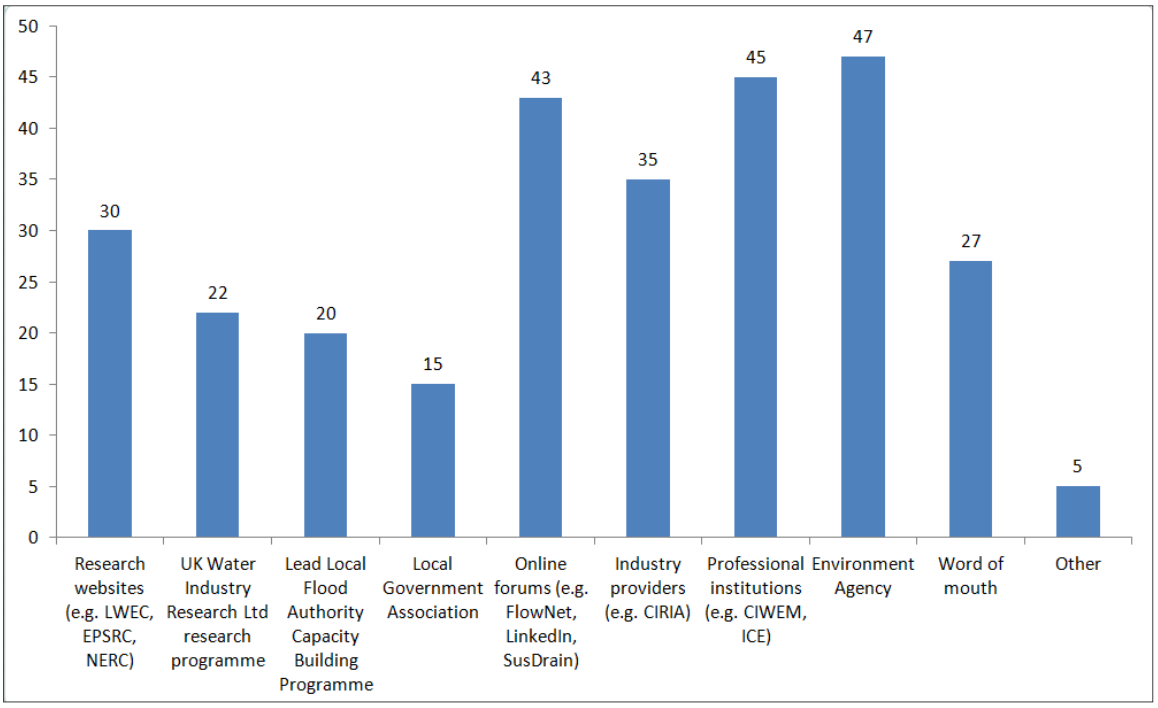
The outcomes 3e and 3i scored extremely low scores and therefore these outcomes were excluded from the final list for the framework.

Respondents were also asked to provide additional outcomes if they felt the outcome was not covered in the previous list. Many of the suggested outcomes could be linked to existing outcomes. However, some new outcomes were suggested:

- communities understand their roles and responsibilities for supporting local flood risk management (e.g. riparian ownership);
- reduced local flood risk through improved design and location of new buildings;
- improved capture and use of flood incident information across the local flood risk management community;
- reduced local flood risk through real-time control and management of drainage networks and watercourses.

The responders were asked where they would look to find information on the outputs of commissioned research. The results (see Figure A.2) show that the most common place the responders would look for this information is the Environment Agency, followed by professional institutions, online forums, industry providers and research websites. This is a helpful guide to identify where the outputs of the research projects in this framework should be stored although the limited sample size means that there will inevitably be other locations where people will look for research outputs.

Figure A.2 The number of people who would look at each institution to understand the outputs of commissioned research



For the online survey 23 outcomes were proposed, of which two have been removed based on feedback from respondents. Four new outcomes have been added following the online survey. Table A.2 lists the research themes that have been identified, along with the associated research outcomes. These research themes and outcomes were validated at the workshop in March 2014.

Table A.2 Research themes and outcomes

Research theme	Research outcomes	Taxonomy
Partnerships and coordination	Strong and diverse partnerships which make effective decisions	PC_01
	Better outcomes because of improved linkages across local government responsibilities (e.g. spatial planning and local flood risk management)	PC_02
	Improved capture and use of flood incident information across the local flood risk management community	PC_03
	Reduced duplication of data through facilitating data transfer between organisations	PC_04
Community engagement	Communities aware of flood risks they face which results in appropriate action	CE_01
	Communities are central to decision-making for local flood risk management	CE_02
	Communities understand their roles and responsibilities for supporting flood risk management (e.g. riparian ownership)	CE_03

Research theme	Research outcomes	Taxonomy
Rainfall and hydrological Processes	Reduced local flood risk due to improved real-time prediction of rainfall	RH_01
	Localised predictions of future rainfall frequency–-intensity–duration trends	RH_02
Modelling and mapping	Reduced local flood risk due to improved real-time prediction of flooding	MM_01
	Reduced local flood risk due to improved real-time monitoring of sewer networks and watercourses	MM_02
	Greater confidence in understanding local flood risk through improved model accuracy	MM_03
	Reduced groundwater flood risks due to improvements in groundwater flooding predictions	MM_04
	Consistent flood mapping that helps organisations and communities understand local flood risk and take action	MM_05
	Hydraulic models which can appropriately represent local flood risk management measures	MM_06
Intervention measures	Reduced local flood risk through implementation of property-level protection	IM_01
	Reduced local flood risk through implementation of non-structural measures	IM_02
	Reduced local flood risk through design and implementation of structural measures	IM_03
	Reduced local flood risk through improved design and location of new buildings	IM_04
	Reduced local flood risk through real-time control and management of drainage networks and watercourses	IM_05
	Sustainable drainage systems which are designed, adopted and maintained to appropriate standards	IM_06
	Understanding the impacts (i.e. benefits) of different intervention approaches	IM_07
	Local flood risk management delivers multiple benefits for communities and the environment, including synergies with the Water Framework Directive	IM_08
	Understanding the long-term impacts of mitigation measures (e.g. use of highways to store water)	IM_09
	Reduced local flood risk through real-time control of sewers/waterways	IM_10

Research theme	Research outcomes	Taxonomy
Economic appraisal and funding	Robust economic appraisals which fully consider costs and benefits of intervention, and support business cases	EF_01
	Funding for local flood risk management is supplemented by external contributions	EF_02
Construction and maintenance	Drainage networks and watercourses are maintained to manage local flood risk	CM_01
	Value for money and efficient delivery through partnering between risk management authorities and contractors	CM_02
Policy and strategy		PS_01

Appendix B – Outline research proposals for 'must do' projects

Project Title: Evaluation of costs to risk management authorities in managing flooding from high groundwater, and the economics of alternative approaches
Topic Area: Managing the risks of groundwater flooding
Local Flood Risk Framework ID: 1

Why does this research matter?
Long before rising groundwater emerges from the ground, it can disrupt the infrastructure below. It can seep in to underground drainage, requiring expensive pumping and tankering to be put in place. In winter 2013/14, groundwater infiltration affected many areas of the south of England. The typical way of managing this is to pump water out of the system, which is an expensive procedure that can last days or weeks. For example, in June 2014 Bromley Borough Council were spending £1,000 per day on pumping and have had to replace the pumps twice since February 2014. Transport for London has to pump 365 days a year to remove water from its infrastructure. The cost to water companies over winter 2013/14 was millions of pounds. Left unmanaged groundwater infiltration can cause surface water drainage to fail. If the drainage is a foul or combined sewer then it can also lead to pollution.

What is the research project about?
This research project will seek to understand the recent costs of managing high groundwater, and consider the costs and benefits of current and emerging technologies. Specific tasks will include:

- collate information from local authorities, water companies and the Environment Agency on the costs of managing high groundwater levels over the recent two wet winters (e.g. pumping costs);
- consider the range of current management practices used to manage high groundwater levels, and review some of the emerging Infiltration Reduction Plans being prepared by water companies;
- identify a suite of alternative management approaches (including evidence gained from project ID 2);
- consider the costs and benefits of current and alternative management approaches, including how this will change with wetter winters as forecast with climate change;
- provide a consistent method to consider the optimal economic management approach.

What difference will the research make?
It will provide a clear understanding of the costs associated with current management practices as well as the options and economics of alternative approaches. The impact of climate change on the possible options and economics will also be considered.

Links to other projects in roadmap
This project should occur after ID 2 ('Assess current and emerging technologies to reduce groundwater inundation into sewer networks') to ensure the review of technologies informs this research. In addition, there are several relevant UKWIR projects (e.g. 'Strategic Infiltration') which need to be considered in this research project.

Possible collaborative opportunities	Local authorities, UKWIR, water companies

Links to local flood risk outcomes	AR_01, AR_06, AR_07, EF_01
Outputs from research	Technical report, guidance and method
Proposed start year	Year 3–5
Approximate budget	£100,000 – £250,000
Duration of project	1–3 years

Project Title: Assess current and emerging technologies to reduce groundwater inundation into drainage networks
Topic Area: Managing the risks of groundwater flooding
Local Flood Risk Framework ID: 2

Why does this research matter?
Long before rising groundwater emerges from the ground, it can disrupt the infrastructure below. It can seep in to underground drainage, requiring expensive pumping to be put in place. In winter 2013/14 groundwater infiltration affected many areas of the south of England. The dominant way of managing this is to pump water out of the system, which is an expensive procedure that can last days or weeks. For example, in June 2014 Bromley Borough Council were spending £1,000 per day on pumping and have had to replace the pumps twice since February 2014. Transport for London has to pump 365 days a year to remove water from its infrastructure. The cost to water companies over winter 2013/14 was millions of pounds. Left unmanaged groundwater infiltration can cause surface water drainage to fail. If the drainage happens to be part of a combined sewer then it can also lead to pollution.

What is the research project about?
We need to review current and emerging technologies to identify if there are more cost-effective approaches to manage this problem, and this project will seek to do this. It will provide a clear understanding of the current and emerging technologies, but also consider future innovative technologies which may be required to cost-effectively manage high groundwater flooding. Specifically this project will:

- consider current and emerging technologies to manage groundwater inundation, through discussion with suppliers, water companies and local authorities;
- liaise with universities and suppliers to identify possible future innovations through a workshop environment;
- identify future research needs and recommend a programme of future research.

What difference will the research make?
We will understand the products and techniques to reduce groundwater inundation which can be implemented by local authorities and water companies. We will identify what additional blue sky research is required to ensure there are innovative technologies to manage this flooding scenario.

Links to other projects in roadmap
This project should occur prior to ID 1 ('Evaluation of costs to risk management authorities in managing flooding from high groundwater, and the economics of alternative approaches'). In addition, there is a current (autumn 2014) UKWIR project which is evaluating this from the water company perspective, so this project should use evidence from the UKWIR project where possible.

Possible collaborative opportunities	Local authorities, UKWIR, water companies, private sector suppliers, NERC/universities
Links to local flood risk outcomes	AR_01, AR_06, AR_07, EF_01
Outputs from research	Review and guidance (long-term guidance needed on future research)
Proposed start year	Year 2
Approximate budget	£100,000 – £250,000
Duration of project	1–3 years

Project Title: Modelling groundwater effects in urban drainage systems
Topic Area: Managing the risks of groundwater flooding
Local Flood Risk Framework ID: 3

Why does this research matter?
Long before rising groundwater emerges from the ground, it can disrupt the infrastructure below. It can seep in to underground drainage, requiring expensive pumping to be put in place. In winter 2013/14 groundwater infiltration affected many areas of the south of England. For example, in June 2014 Bromley Borough Council were spending £1,000 per day on pumping and have had to replace the pumps twice since February 2014. Transport for London has to pump 365 days a year to remove water from its infrastructure. The cost to water companies over winter 2013/14 was millions of pounds. Left unmanaged groundwater infiltration can cause surface water drainage to fail, as happened on highways in Bromley and Croydon in Winter 2013/14. If the drainage happens to be part of a combined sewer then it can also lead to pollution.

There is very little advice on how to robustly model groundwater interactions with underground infrastructure and drainage systems. This makes it difficult for practitioners to manage the risk and to identify suitable solutions. The June 2014 Asset Management TAG recommended that research into modelling the problem was required to enable asset-based solutions to be delivered.

What is the research project about?
This research would deliver modelling guidance that would ensure a consistent approach is used for modelling groundwater effects in urban drainage systems. This would help to ensure the modelling is proportionate to the scale of the problem. The project would look at current options to model groundwater effects in urban drainage systems, and recommend the most robust methodology for different situations. It could provide simple tools for mapping hotspots through to estimates of the scale of the problem, and also more detailed modelling and mapping.

What difference will the research make?
Through the research there will be Improvements in representing groundwater in urban flood modelling, resulting in more robust understanding of flood risk

Possible collaborative opportunities	Local authorities, water companies, UKWIR, consultants working on behalf of organisations, software houses
Links to local flood risk outcomes	MM_02, EF_01
Outputs from research	Methodology and guidance
Proposed start year	Year 2
Approximate budget	<£100,000
Duration of project	<1 year

Project Title: Understanding the art of the possible for local and national scale groundwater flood risk mapping – developing a method, mandate and pilots
Topic Area: Managing the risks of groundwater flooding
Local Flood Risk Framework ID: 4

Why does this research matter?
The Flood and Water Management Act (2010) gave LLFAs powers to manage groundwater flooding and a responsibility to develop local flood risk management strategies. A key first step in managing flooding is to understand the location and scale of risk. The Environment Agency has a strategic overview role for all sources of flooding. Mapping the risk of flooding from groundwater is complex. There are currently no national, publicly available maps showing the chance of groundwater flooding. The British Geological Survey has produced groundwater flooding susceptibility maps for England, Wales and Scotland and also provides information to environmental regulators to help assess the risk of groundwater flooding. This data also shows areas where emergence, rather than flooding, might occur. This information was simplified by the Environment Agency to identify Flood Risk Areas as defined under the Flood Risk Regulations.

An action from the Groundwater Expert Panel that met in Winter 2013/14 was for the British Geological Survey and Environment Agency to review the number of properties potentially at risk from groundwater flooding. Previous estimates have been based on numbers of properties in areas susceptible to groundwater emergence. The general view is that the actual number at risk is much lower than this. The review will report in Spring 2015 using best available information and expert judgement to identify a more appropriate range for properties at risk.

What is the research project about?
This research proposal will build on the above and provide a review of the cost and benefits of improved groundwater flood risk mapping, looking at how it could and should be done. The research will provide a range of principles, criteria and minimum standards to incorporate in national and/or local mapping so that future mapping developments are fit for purpose. The work would include samples and pilots to test and prove the methods and approaches.

What difference will the research make?
The benefit of the work is that:

- we will know the feasibility, costs and benefits of wide-scale groundwater mapping that can be applied at county or national scales;
- we can provide a steer to the market on future development needs in this area;
- LLFAs carrying out local mapping have recommendations on approaches to use.

Possible collaborative opportunities	Local authorities, water companies, UKWIR, consultants working on behalf of organisations, software houses
Links to local flood risk outcomes	MM_03, AR_02, PS_01
Outputs from research	Methodology and technical report
Proposed start year	Year 1
Approximate budget	<£100,000
Duration of project	<1 year

Project Title: Good practice guidance for LLFAs (and local resilience forums) on managing area-wide groundwater flooding
Topic Area: Managing the risks of groundwater flooding
Local Flood Risk Framework ID: 5

Why does this research matter?
Groundwater flooding is the poor relative of other sources of flooding. Good practice in how to manage groundwater flood risk is not as well established as that for flood risk from rivers and the sea. In the 2014/15 investment programme there are only three schemes to address groundwater flooding. Work on the 6-year investment programme shows that the appetite for managing groundwater risk is growing. Some local authorities are planning to develop schemes to reduce groundwater risk but have a limited evidence base to use to carry out appraisal for potential solutions that could span several dispersed communities.

There have been a number of groundwater flood events in recent years: 700 properties were affected in 2000, 200 properties in 2012 and hundreds more in 2014. It has been estimated that around 1.6 million properties in England and Wales are susceptible to groundwater flooding (Jacobs 2004). The British Geological Survey and the Environment Agency are reviewing the number of properties at risk of flooding and will report in Spring 2015 using best available information and expert judgement to identify a more appropriate range for properties at risk. Although the number of properties affected in recent events is smaller than for other sources of flooding the duration of flooding means that it can be severe for those affected. Green et al. (2006) estimated that a flood lasting 1 week resulted in losses which are 240% of the damages expected for short duration flooding; for a flood lasting 3 months, the damages increased to 360%.

What is the research project about?
This project will collate case studies to demonstrate how groundwater flood risk can be managed. This may include using local authority boreholes to monitor and forecast groundwater flooding, managing overland pathways of groundwater emergence, and recovery options for properties affected by long duration flooding. A particular challenge is to develop cost-effective solutions that span wide areas of groundwater flood risk. From this work LLFAs will have better tools and knowledge to prepare bids and approaches to manage groundwater flooding.

What difference will the research make?
As a result of the research LLFAs will have tools and knowledge about how to successfully bid for schemes to manage groundwater flooding, and there will be groundwater flooding schemes on the Medium Term Plan. There will be greater collaboration between risk management authorities in managing groundwater flooding.

Possible collaborative opportunities	Local authorities, water companies, UKWIR and CIRIA
Links to local flood risk outcomes	PC_02, AR_01, AR_06, EF_01
Outputs from research	Guidance
Proposed start year	Year 1
Approximate budget	<£100,000
Duration of project	<1 year

Project Title: Standard GIS symbology and data model for SuDS and other local flood risk management features
Topic Area: Integrated modelling and mapping
Local Flood Risk Framework ID: 6

Why does this research matter?
The UKWIR SuDS roadmap identified the need for standard GIS symbology for SuDS to ensure consistency across risk management authorities in GIS mapping and local authority assets. In addition to this there is no consistency in representing other local flood risk management features.

What is the research project about?
This project is about how to define GIS symbology for SuDS and other local flood risk management features to ensure consistency across all organisations. Specifically it will:

- develop an agreed national standard for GIS symbols representing different SuDS and other components for use in GIS mapping, asset registers etc;
- facilitate a standard methodology for recording data for future use such as maintenance logs and modelling.

The research is intended to build upon existing work on building information modelling (BIM) in the water sector.

What difference will the research make?
The research will help to ensure consistency in modelling and mapping of local flood risk management. This improves efficiency in communication across organisations, and helps to improve accuracy of data.

Possible collaborative opportunities	Local authorities, water companies and UKWIR
Links to local flood risk outcomes	PC_03
Outputs from research	Technical report and guidance
Proposed start year	Year 1
Approximate budget	<£100,000
Duration of project	<1 year

Project Title: Update CIWEM Urban Drainage Group Integrated modelling guide. Representing boundary conditions in urban drainage models. Representing mitigation measures in integrated models
Topic Area: Integrated modelling and mapping
Local Flood Risk Framework ID: 7, 8 and 9

Why does this research matter?
In 2009 the CIWEM Urban Drainage Group produced an integrated urban drainage modelling guide to support best practice in the development of integrated models. The guide has supported local authorities in deciding how to invest in modelling for plans and strategies. (Note: £10 million has been spent on Surface Water Management Plans since 2009, with a significant portion of the investment spent on modelling.)

There have subsequently been significant changes in technology, policy and legislation, and advancements of integrated modelling. To ensure we spend money wisely on integrated modelling, and use models to support the most effective investment approaches, we need to update this modelling guide. Through our engagement we know that local authorities have highlighted the importance of updating this guidance, to support them as intelligent clients and adopters of best practice.

What is the research project about?
This project will review and update the existing modelling guide to ensure it can be used as a best practice guide for the next 5 years. The update will address some of the key areas of uncertainty which affect the confidence of integrated models:

- Identifying a modelling approach that is proportionate to the scale of the problem.
- Understanding and representing groundwater interactions in drainage networks.
- Representing upstream and downstream boundary conditions.
- Representing the effectiveness of maintenance regimes to understand the costs and benefits of maintenance.
- Defining a consistent approach to represent innovative and natural flood management techniques, including land management and green infrastructure (there is no current best practice in this area and these are difficult to model which makes it difficult to assess their effectiveness at reducing flood risk).

What difference will the research make?
The project will ensure that those commissioning and delivering integrated models will understand best practice. It will ensure we know how and when to use integrated models to ensure maximum value for local flood risk management and the most appropriate level of detail required in different circumstances. It will build capacity within risk management authorities. It will also provide guidance to local authorities to undertake quality assurance checks on integrated models and therefore will improve consistency and quality of integrated models, leading to greater confidence in their use to support the optimal capital and maintenance investment choices.

Possible collaborative opportunities	CIWEM Urban Drainage Group, UKWIR
Links to local flood risk outcomes	MM_01, MM_02, AR_01, EF_01
Outputs from research	Guidance and methodology
Proposed start year	Year 1
Approximate budget	<£100,000
Duration of project	<1 year

Project Title: Methods for rainfall–run-off estimation in urban areas
Topic Area: Integrated modelling and mapping
Local Flood Risk Framework ID: 10

Why does this research matter?
Representation of how run-off occurs in urban areas as a result of rainfall is critical to the robustness of our hydraulic models. If predicted run-off does not accurately represent physical processes then models will be less robust to support decisions about investment in flood risk infrastructure. While there has been significant recent research in this area, feedback from users demonstrates that new approaches (e.g. the UKWIR run-off model) require further testing and development.

What is the research project about?
This project is covered in part by the recent UKWIR/CIWEM UDG work on a new urban run-off model. However, based on feedback received during the development of this roadmap it is clear there are still gaps in our evidence base and the model needs to be tested and fully implemented. Specifically this project will need to review the recent UKWIR/WaPUG new run-off equation. Subsequently it will need to undertake some further testing to identify the robustness of the new approach and identify gaps in our evidence base. It will also need to consider how to ensure uptake and implementation of the most robust run-off models for hydraulic modelling. The project will include some empirical measurement and monitoring to evaluate the robustness of the new run-off method.

What difference will the research make?
This project will enable us to further develop the new UKWIR run-off method, which will improve its robustness. This will in turn improve the confidence in hydraulic models for making decisions about future investment in flood risk infrastructure.

Possible collaborative opportunities	CIWEM Urban Drainage Group, UKWIR, water companies
Links to local flood risk outcomes	HC_01, HC_02, HC_03, MM_02
Outputs from research	Method and tools
Proposed start year	Year 2
Approximate budget	£100,000 – £250,000
Duration of project	1–3 years

Project Title: Review and develop guidance for local communities on how to access funding streams locally
Topic Area: Making the case for investment
Local Flood Risk Framework ID: 11

Why does this research matter?
There is an increasing recognition of the vital work local communities can play in managing flood risk in partnership with risk management authorities. However, there is limited evidence and information out there for local communities about how they can access funding to take on some flood risk management responsibilities. Communities need access to tools, equipment and expertise in order to take on some flood risk management responsibilities, and the absence of funding will be a barrier to wider uptake.

What is the research project about?
This research project will:

- identify good practice in the UK and internationally about how communities can raise funding towards flood risk management;
- identify potential funding sources which can be accessed by local communities, and consider how these funding sources can be accessed;
- provide easy-to-use guidance for local communities on what funding sources are available and how they can be accessed.

What difference will the research make?
This research will enable communities to be aware of the funding available to support flood risk management and how the money can be accessed. It will support local communities to feel more empowered to raise funding and undertake some flood risk management activities within their communities.

Possible collaborative opportunities	Local authorities, National Flood Forum
Links to local flood risk outcomes	CE_01, CE_02, EF_01
Outputs from research	Review and guidance
Proposed start year	Year 2
Approximate budget	<£100,000
Duration of project	<1 year

Project Title: Undertaking economic appraisals to provide evidence for accessing wider funding sources
Topic Area: Making the case for investment
Local Flood Risk Framework ID: 12

Why does this research matter?
In 2013/14, of the total reserved funding (grant-in-aid) plus all contributions, only £46 million (12%) was from private sector contributions (note: 50% of private sector contributions was for 1 scheme). There are few good examples of securing funding from across private sector organisations. Typically economic appraisals for flood risk management assess the direct flood benefits from intervention measures but do not consider the wider economic, environmental and social benefits of these measures, which can be critical in accessing a wider range of funding sources.

What is the research project about?
This project seeks to provide practical guidance and tools to help risk management authorities unlock wider funding sources to contribute towards flood risk management. Specifically the project would:

- review potential funding sources for flood risk management, building on the Defra FD2643 research;[9]
- identify the benefit required to access each funding source;
- identify the economic analysis required to build a business case for relevant funders;
- produce guidance and easy-to-use tools to guide users through identifying and appraising wider benefits of flood risk management interventions, which will unlock additional funding.

What difference will the research make?
Risk management authorities will know how to prepare a business case to secure wider private funding; there will be an increase in schemes on the Medium Term Plan with private funding. This will unlock greater investment in flood risk management.

Possible collaborative opportunities	Local authorities, water companies, Defra, National Flood Forum, local enterprise partnerships
Links to local flood risk outcomes	EF_01, EF_02
Outputs from research	Guidance and tools
Proposed start year	Years 3–5
Approximate budget	<£100,000
Duration of project	<1 year

[9] http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17085

Project Title: Practitioner's guide on co-funding schemes for local flood risk
Topic Area: Making the case for investment
Local Flood Risk Framework ID: 13

Why does this research matter?
Solutions to reduce local flood risk, sewer, river and sea flooding are often very similar, meaning costs and resources can be shared. The Environment Agency, LLFAs and water companies should work together on solutions for multiple sources of flooding. Surface water schemes made up approximately £11 million in the recent FCERM announcements for 2014/15. This appears to be a relatively low value given the scale of the risk, but the programme is growing. Defra have recently published an evaluation report of 'partnership funding' (Defra 2014), that recognises the learning curve risk management authorities are on and that capacity building is needed to support them in this area.

Risk management authorities have identified a gap in a shared understanding, on applying flooding definitions, and on a common language and appraisal approaches when discussing potential solutions to flooding problems. This is hampering the development of co-funded schemes for local flood risk management.

What is the research project about?
The research will produce a practitioner's guide to be used across all risk management authorities on how to deliver the partnership funding policy. It will include how to apportion costs and benefits when using different organisational appraisal approaches.

What difference will the research make?
This research will mean that:

- risk management authorities have a common understanding of how to prepare business cases for co-funded schemes and have access to the latest and relevant case studies;
- more co-funded schemes are proposed, leading to efficiencies and more properties protected from all sources of flooding.

Possible collaborative opportunities	Local authorities, water companies, Defra, UKWIR
Links to local flood risk outcomes	EF_02
Outputs from research	Guidance
Proposed start year	Year 1
Approximate budget	<£100,000
Duration of project	<1 year

Project Title: Making the case for investment – an integrated approach across risk management authorities. Identifying the optimal level of maintenance for flood risk management assets
Topic Area: Making the case for investment/Planning, building and maintaining
Local Flood Risk Framework ID: 14 and 18

Why does this research matter?

There are often four or five different risk management authorities involved in managing flood risk in any given area: the Environment Agency, internal drainage board, highway authority, local council, water and sewerage companies. Over a large catchment this can increase significantly as the catchment crosses authority boundaries. Each authority has different priorities and funding streams, which can lead to varying and at times conflicting investment strategies. Each authority also has a different set of assets and assessment of risk (usually based solely on its own assets), which will inform this. For example the Environment Agency may manage a river system with large-scale events primarily in mind. However, on a day-to-day basis this river will serve as the discharge point for a network of ordinary watercourses, highway sewers and surface water drains managed by the internal drainage board, highway authority, sewerage undertaker and landowners. If water levels on the river are not managed for routine events it can lead to poor performance of these other assets as they may not be able to discharge freely. Conversely, if these other assets discharge significant volumes of water the levels on the river can become a risk. In this situation the Environment Agency may not have sufficient data to assess the impact of a given management regime on these other assets so may not have the requisite drivers to change it. Similarly the other authorities may not have the means to assess the downstream impact of their system and have no financial incentive to reduce it or may be able to achieve the same standard of service with lower maintenance.

What is the research project about?

Many of the remaining flood risks that need to be managed are complex interactions of flows from different sources, rather than excessive flows from one source. There may also be lower consequence but higher frequency events that cause significant local disruption. In order reduce these flood risks in an era of reduced funding we must harmonise all the available funds to ensure they are working most effectively and align the risk assessments so that each risk management authority has the same drivers to reduce all risks. This will include optimising the maintenance of assets and identifying the most appropriate way to deliver this optimisation (which can be sharing/devolving responsibility to another authority or passing this to a local body/community). Thus all risk management authorities share in agreed risk management goals.

This project aims to develop policy that allows for a holistic assessment of flood risk across a catchment and delivers an integrated long-term strategy for managing the investment in flood risk management on the catchment for both capital and revenue for all stakeholders to contribute to the reduction of all flood risks.

What difference will the research make?

There will be an improved understanding of how to optimise investment levels across a catchment , which will result in the most cost-effective balance of capital and operational expenditure.

Possible collaborative opportunities	Local authorities, Environment Agency, water companies, internal drainage boards
Links to local flood risk outcomes	PC_01, AR_05, AR_06, AR_07, EF_01
Outputs from research	Methodology

Proposed start year	Year 2
Approximate budget	<£100,000
Duration of project	1–3 years

Project Title: Understanding how local flood information is being used in 'plan-making' and 'decision-taking' (planning applications) (and 'How to' advice on using local flood risk information to enable sustainable development)
Topic Area: Planning, building and maintaining
Local Flood Risk Framework ID: 15 and 16

Why does this research matter?

On average over 100,000 new homes are built each year. A significant proportion of flood risk is from local sources (3 million existing properties are at risk from surface water). Decisions that local authorities take on the location and type of new development are the first line of defence in local flood risk management. The benefits of avoiding damages are well documented. The National Planning Policy Framework (2012) and earlier Planning Policy Statement 25 on development and flood risk (2006) requires all sources of flooding to be considered in the planning system. Local flood risk information is relatively new and immature compared to rivers and the sea in the way it is considered within the planning system.

Environment Agency surface water maps have been available for local planning authorities since 2009, with a recommendation they are used to inform SFRAs. In December 2013, a new and improved Flood Map for Surface Water was published and made available. The Flood and Water Management Act (2010) brought in new roles for LLFAs to manage surface water and groundwater flooding and develop local flood risk management strategies. This is in addition to Surface Water Management Plans carried out by local authorities since Defra made funding available in 2009.

What is the research project about?

Now is a good time to understand what difference these changes are making on the ground. The proposal is to take a general look at how local flood risks are being dealt with in the planning system. Where local flood risks are known (e.g. in SFRAs or the new surface water maps), how has this information been taken into account in the decision-making process, both at plan and planning application stages?

This project matters as changes since the Flood and Water Management Act mean that LLFAs are now the lead on primary local flood risk issues (e.g. groundwater, surface water and ordinary watercourse flooding). The local flood risk framework consultation has identified that there is a lack of awareness and engagement on planning in respect of local sources of flood risk. The potential gaps need to be understood and recommendations for improvements suggested.

What difference will the research make?

This research will mean:

- local planning authorities and LLFAs know about and can learn from best practice on how to use the best local flood risk information available;
- new developments are not adversely impacted by, or exacerbate local flooding and the impacts of buildings on local flood risk are fully considered.

Extension to the project (ID 16)

Off the back of this research project a separate piece of work should be undertaken which provides a 'how to' guidance on using local flood risk information to enable sustainable development.[10] This work will build upon the recent 'Water Planning Advice Note',[11] and be specific to local flood risk management issues.

[10] Sustainability as defined in the National Planning Policy Framework.

Possible collaborative opportunities	Local authorities, Home Builders Federation, Department for Communities and Local Government, Defra, water and sewerage companies
Links to local flood risk outcomes	PC_02, AR_02, PS_01
Outputs from research	Review
Proposed start year	Year 1
Approximate budget	<£100,000
Duration of project	<1 year

[11] University of Cambridge, Planning Advice for Integrated Water Management
http://www.susdrain.org/news/articles/planning_advice_integrated_water_management.html

Project Title: Adaptive and resilient design to current and future local flood risk
Topic Area: Planning, building and maintaining
Local Flood Risk Framework ID: 17

Why does this research matter?
Our climate is changing and decisions we make now will make homes and communities resilient to flooding, reducing the cost and damage of flooding. In the last 10 years there have been a number of developments in resilience and adaptation, but a 'how to' guide (including costs, options and case studies) is not available.

What is the research project about?
This project will help to address a gap in current research to provide a comprehensive guidance on how to build adaptation and resilience into building design to account for current or future local flood risks. It will engage with policy-makers, house builders, and product suppliers to provide a view across the industry about how and when to build adaptation and resilience into design of new buildings to protect them from flooding.

What difference will the research make?
Building alterations and new builds are resilient to expected future climate changes and could adapt to differing levels of changes.

Possible collaborative opportunities	Local authorities, National Homebuilders Federation, Communities for Local Government, Defra, product suppliers
Links to local flood risk outcomes	PC_02, AR_02, PS_01
Outputs from research	Guidance
Proposed start year	Years 3–5
Approximate budget	<£100,000
Duration of project	<1 year

Project Title: Reviewing the role of community groups in managing flood risk management assets
Topic Area: Planning, building and maintaining
Local Flood Risk Framework ID: 19

Why does this research matter?
Community groups are getting more involved in local flood risk management. The role of community flood wardens in St Blazey (Cornwall) and Calderdale (Yorkshire) are good examples of how they can help manage local flood risk. The Defra Pathfinder projects will be completed in 2015. A project that takes this learning and applies it to local flood risk assets is needed.

What is the research project about?
There is some recent evidence which can feed into this project. The Defra Pathfinder projects, which will report in June 2015, will provide information on how local communities can take action. In addition there is a pilot study being run by the University of Warwick and Lincolnshire Local Resilience Forum looking at the use of 'technical' volunteers to undertake response activities. This research project should take place after the Pathfinder and pilot projects. In essence this research project should focus on providing local communities with clear guidance on the technical requirements for undertaking flood risk management assets, and associated health and safety requirements. There will also be an overlap with the R&D project in this framework entitled 'Review and guidance for local communities on how to access funding streams locally'. The research project should also consider international examples and recommendations to identify frameworks, models and processes that currently exist and could be applied within the UK.

What difference will the research make?
More local communities will know how they can manage flood risk assets, resulting in more local communities taking action. It will also support risk management authorities in understanding how they can get the local community more involved and provide the right levels of support to them.

Possible collaborative opportunities	Local authorities, National Flood Forum
Links to local flood risk outcomes	CE_01, CE_02, EF_02
Outputs from research	Review and guidance
Proposed start year	Years 3–5
Approximate budget	<£100,000
Duration of project	<1 year

Project Title: Reviewing current research and practice for representing rainfall in local flood risk models (Phases 1 and 2)
Topic Area: Predicting and understanding rainfall
Local Flood Risk Framework ID: 20 and 21

Phase 1

Why does this research matter?

Rainfall is the key input into all local flood risk models, which in turn underpin our investment and management choices in local flood risk. However, current practice uses a single uniform storm event. It means we do not account for spatial variability, antecedent conditions, storm sequences and future climate change. By not representing rainfall well, we are not using the best evidence base for making investment choices.

The shortcomings of the current approach have been well documented (e.g. Onof et al. 1996), but there remain many unanswered questions about how the use of design rainfall affects confidence in decision-making and the robustness of our predictions about future rainfall patterns. In addition, practitioners are not using the latest science. We recognise there is a significant body of completed and ongoing research into rainfall processes by the Met Office, NERC and the UKWIR. However, there is an urgent need to get this research embedded into the local flood risk management community and to identify future scientific and meteorological research needs.

What is the research project about?

This research project will review ongoing, completed or planned research projects related to rainfall predictions and patterns. Key tasks for the research project are to:

- review research by the Met Office, NERC and the UKWIR on the current scientific understanding of rainfall predictions and patterns to support local flood risk management;
- understand how end users such as local authorities, the Environment Agency and water companies are using this science in practice to support decision-making;
- understand whether the use of spatially varying rainfall and long duration events in planning and design is related to our scientific understanding of rainfall processes and/or implementation by end users;
- consider whether there is evidence that current design practice is inappropriate;
- develop guidance for appropriate approaches, when and how to apply different aspects and the benefits it will give you in those circumstances.

What difference will the research make?

The key output will be a recommended approach which considers science needs, demonstration projects, and/or best practice guidance to ensure the local flood risk management community have access to, and can make use of, the most effective rainfall data for planning, forecasting and design.

Phase 2

Phase 2 will build upon the findings of Phase 1, and the scope of this work should be an output from the Phase 1 study.

Possible collaborative opportunities	Flood Forecasting Centre, Met Office, universities, risk management authorities
Links to local flood risk outcomes	HC_01, HC_02, MM_01, MM_02, PS_01
Outputs from research	Review
Proposed start year	Years 3–5
Approximate budget	£100,000 – £250,000

Duration of project	1–3 years

Project Title: Forecasting groundwater flooding
Topic Area: Predicting and understanding rainfall
Local Flood Risk Framework ID: 22

Why does this research matter?
High groundwater levels cause millions of pounds of impacts, both in terms of direct groundwater flooding and impacts on the operation of the urban drainage network. Currently mitigation tends to happen reactively as events occur. We need to understand whether we can proactively plan for the impacts of high groundwater, based on looking at trends in groundwater levels against rainfall forecasts.

What is the research project about?
The key objective of this research project will be to define processes and approaches to enable risk management authorities to proactively forecast future groundwater levels based on rainfall predictions. Specifically, the research will:

- gather data from recent wet winters on groundwater levels, rainfall forecasts and observed rainfall data;
- establish relationships and trends to predict groundwater levels based on forecast rainfall for different soil types – this may include the development of tools to enable risk management authorities to simply forecast groundwater levels;
- recommend processes and approaches which can be used by risk management authorities to plan for high groundwater levels.

The research will need to consider various current and previous UKWIR projects on groundwater and intelligent sewers.

What difference will the research make?
The research will mean that it will be easier for risk management authorities to forecast for high groundwater levels and/or groundwater flooding. This will enable them to be more proactive, thus reducing the overall consequences of a flooding incident.

Possible collaborative opportunities	UKWIR, water companies, local authorities, local resilience forums, Flood Forecasting Centre, Met Office
Links to local flood risk outcomes	CE_01, MM_01
Outputs from research	Review and guidance
Proposed start year	Year 2
Approximate budget	£100,000 – £250,000
Duration of project	1–3 years

Project Title: Accuracy of rainfall/model forecasts and the impacts on decision-making
Topic Area: Making decisions in real time
Local Flood Risk Framework ID: 23

Why does this research matter?
The Met Office issues extreme rainfall alerts, but there is limited evidence about their uptake and accuracy compared with actual events. We do not know how these alerts have affected decision-making and hence reduced flood impacts. As part of the development of this framework we received evidence from local authorities that significant property flooding had occurred, despite an 'amber' warning being issued. This demonstrates the difficulties in using such rainfall forecasts to accurately predict where and when flooding will occur. There is also an issue about how we can use hydraulic models in real time to forecast flooding based on rainfall predictions, although there are some examples of good practice in this area from water companies.

What is the research project about?
This research is primarily about gathering evidence about the accuracy of rainfall forecasts, understanding how risk management authorities are using the rainfall forecasts from the Met Office, establishing best practice with respect to predicting flooding using models, and identifying principles and guidance for risk management authorities to support decision-making based on the rainfall forecasts. Specifically, it will involve:

- identifying pilot locations with good records of flooding, and preferably where there is a hydraulic model in place;
- identifying the differences between rainfall forecasts and observed rainfall over a range of rainfall events to understand how robust the rainfall forecasts are;
- running scenarios through hydraulic models in pilot study areas to identify running a model simulation with forecast rainfall robustly predicts where flooding has occurred;
- collaborating with local authorities and water companies to identify how they are using the rainfall forecast data to establish good practice;
- providing recommendations and guidance on how local authorities and water companies can apply the rainfall forecasts to predict likely flooding, and with what confidence.

What difference will the research make?
This research will mean we can understand the current accuracy of real-time predictions of flooding based on Met Office forecasts, and how risk management authorities can use the Met Office forecasts to make the most appropriate response to forecast rainfall and flooding.

Possible collaborative opportunities	UKWIR, water companies, local authorities, Flood Forecasting Centre, Met Office
Links to local flood risk outcomes	HC_01, HC_02, HC_03, AR_03
Outputs from research	Guidance
Proposed start year	Year 2
Approximate budget	£100,000 – £250,000
Duration of project	1–3 years

Project Title: Review of current approaches to capture and use real-time data across risk management authorities
Topic Area: Making decisions in real time
Local Flood Risk Framework ID: 24

Why does this research matter?
We know that water companies have an increasing programme of real-time monitoring, in particular to monitor spills from combined sewer overflows into rivers and bathing waters, but also to monitor flooding from sewer networks. Local authorities, in particular, tend not to capture and use real-time data to plan and respond to floods, and to give advance warning of imminent flooding. The capture and use of real-time data would enable local authorities to more proactively plan and respond to flooding incidents, and ensure local communities get adequate warnings of flooding. It would also help identify any operational issues within the drainage network (e.g. blocked culverts) which could be cleared to reduce flood risks.

What is the research project about?
This project would involve close collaboration with local authorities, internal drainage boards and water companies to understand what current approaches and technologies are being used by these organisations to capture and use real-time data. It will consider how effective these approaches and technologies are in helping risk management authorities to plan and respond to flood incidents, and hence reduce the overall impacts of flooding. It will also identify barriers to wider uptake of real-time data, particularly among local authorities who tend to have less advanced real-time monitoring networks compared to water companies. The output from the research will be a review of current approaches and technologies, barriers to wider uptake, and recommendations for improving capture and use across real-time data throughout risk management authorities.

What difference will the research make?
Through this research we will understand current and emerging technologies for capturing, using and sharing real-time data; this will support better use of real-time data thus enabling risk management authorities to operate more proactively in planning and preparing for flooding incidents.

Possible collaborative opportunities	Local authorities, internal drainage boards, water companies and UKWIR
Links to local flood risk outcomes	PC_01, HC_01, MM_01, AR_03
Outputs from research	Review
Proposed start year	Years 3–5
Approximate budget	£100,000 – £250,000
Duration of project	1–3 years

Project Title: Sharing real-time information across risk management authorities and communities – what does the future look like?
Topic Area: Making decisions in real time
Local Flood Risk Framework ID: 25

Why does this research matter?
There are existing ideas, technologies and examples of risk management authorities sharing data in real time to support decision-making, particularly to support coastal monitoring of combined sewer overflow spills. However, across the local flood risk management community this is not commonplace, and it is uncommon for organisations to share information readily in real time. Furthermore, there is limited evidence of sharing of real-time data with local communities who are affected by flooding, apart from the Environment Agency's flood warning service. We consider that improved sharing of real-time data across organisations and to local communities is important to proactively plan and respond to flooding, and reduce the impact of flooding to local communities.

What is the research project about?
This project will involve:

- identifying current good practice within risk management authorities in the UK and across Europe from a flood risk management (or water quality) perspective;
- considering technologies that currently exist to share real-time data, including the costs of implementing them;
- considering future technology advancements required to facilitate sharing of real-time information;
- considering how local communities could interact with real-time information.

What difference will the research make?
Through this research we will understand current and emerging technologies for capturing, using and sharing real-time data; this will support better use of real-time data thus enabling risk management authorities to operate more proactively in planning and preparing for flooding incidents.

Possible collaborative opportunities	Local authorities, internal drainage boards, water companies and UKWIR
Links to local flood risk outcomes	PC_01, PC_03, CE_01, CE_02, HC_01, MM_01, AR_03
Outputs from research	Review, technical report
Proposed start year	Years 3–5
Approximate budget	<£100,000
Duration of project	1–3 years

For projects related to 'Using SuDS to manage flooding' most of the projects have been taken from the UKWIR SuDS roadmap. Therefore details on the research projects have largely been taken from the UKWIR SuDS roadmap to ensure consistency. For more details on these projects the SuDS roadmap should be reviewed.

Project Title: Understanding SuDS performance
Topic Area: Using SuDS to manage flooding
Local Flood Risk Framework ID: 26

Why does this research matter?
There is a lack of consistency in how we understand the performance of SuDS from a quality, quantity and amenity/biodiversity perspective.

What is the research project about?
This project would include an assessment of current information about the performance of SuDS and where necessary what improvement in our understanding is required. The focus of the research would be on water quality, but would need to take into account a range of influences and pollutants. In addition, there is a need to understand the interaction with groundwater from both a quantity and quality perspective. Other parameters to include would be biodiversity and community feedback.

What difference will the research make?
The research could:

- improve approaches to setting performance criteria and SuDS design, as well as the monitoring and modelling of SuDS;
- result in producing a performance database;
- facilitate improvements in setting regulatory targets;
- ensure more cost-effective delivery of SuDS components.

Possible collaborative opportunities	Local authorities, water companies, UKWIR
Links to local flood risk outcomes	AR_01, AR_04
Outputs from research	Guidance and tools
Proposed start year	Year 2
Approximate budget	<£100,000
Duration of project	<1 year

Project Title: Understanding SuDS performance through time and under differing maintenance regimes
Topic Area: Using SuDS to manage flooding
Local Flood Risk Framework ID: 27

Why does this research matter?
Ofwat recently showed that in many cases SuDS offer a cheaper alternative to traditional solutions. The average cost saving across the case studies was 40%. The government is currently looking at implementation of SuDS for new developments. However, we have yet to see widespread uptake of SuDS in retrofit situations. There are about 25 million homes in the UK that could benefit from SuDS. One of the barriers to wider uptake is uncertainty around the performance of SuDS and the level of effort required to maintain them. The Lamb Drove case study indicated some SuDS measures performed well despite lack of maintenance. This is an isolated case study; we do not have a sufficient evidence base to understand the real maintenance needs and costs. This is critical as SuDS approval bodies are established and will require funding for maintenance of SuDS.

What is the research project about?
This project would commit to a long-term study of recently implemented SuDS under a range of maintenance regimes to show how their performance changes through time. This will mean local authorities and others have the information they need to choose and deliver SuDS solutions and maximise the best outcomes for people and the natural, managed and built environments.

What difference will the research make?
The research will enable us to understand the true maintenance requirements of SuDS, which will help local authorities and house builders (in particular) identify the correct funding approach for long-term SuDS maintenance. This is important for implementation of the SuDS approval body.

Possible collaborative opportunities	Local authorities, water companies, UKWIR
Links to local flood risk outcomes	AR_04, CM_01
Outputs from research	Technical report
Proposed start year	Year 1
Approximate budget	>£250,000
Duration of project	1–3 years

Project Title: Incentivising uptake of SuDS
Topic Area: Using SuDS to manage flooding
Local Flood Risk Framework ID: 28

Why does this research matter?
There is no financial model or incentivisation in the UK for retrofitting SuDS to manage surface run-off for property owners, local authorities or water companies, which is one of the key barriers. In the absence of finance or incentivisation there is little progress on using these techniques as part of the management approach for surface run-off.

What is the research project about?
The UKWIR SuDS roadmap considers that the key tasks in this project are:

- 'Understanding and methods for measuring acceptability, demand and satisfaction that span the multiple benefits of SuDS are needed.
- Explore the potential for incentivisation of SuDS delivery for homeowners and property owners.
- Understand what kind and level of incentivisation and support is needed to encourage the public to install property-level source control.
- Research how a mechanism might be delivered and determine who will fund and manage an incentive mechanism.
- Improve the understanding of economic regulation and behaviours. Options could include a one-off payment or continued subsidy. Lower insurance costs may also be an incentive.
- Explore how incentivisation can be devised following international practices in the USA and Australia; these may need to encompass the wider water cycle; cf Low Impact Development / Water Sensitive Urban Design.'

What difference will the research make?
Clear understanding of possible incentivisation approaches and their costs/benefits and understanding from international best practice about how to finance retrofit SuDS should ultimately lead to greater retrofitting to manage surface water.

Possible collaborative opportunities	Local authorities, water companies, UKWIR
Links to local food risk outcomes	AR_04, EF_02
Outputs from research	Guidance, tools and method
Proposed start year	Years 3–5
Approximate budget	£100,000 – £250,000
Duration of project	1–3 years

Project Title: Whole life cost benefit analysis for SuDS. Cost benefit analysis for joint delivery of schemes
Topic Area: Using SuDS to manage flooding
Local Flood Risk Framework ID: 29 and 30

Why does this research matter?
The UKWIR SuDS roadmap states that the government's focus on sustainable growth and the requirement for sewer capacity and the role of SuDS is increasingly recognised by those in the industry. SuDS (by reducing the amount of surface water in sewers) may provide additional adaptive capacity, reduce pressures on the sewer network and potentially defer investment. There is pressure to understand and appropriately manage the whole life costs of SuDS delivery. SuDS may provide an opportunity for sewerage undertakers to reduce both their capital (CAPEX) and operational expenditure (OPEX). SuDS may also provide an opportunity to prolong existing asset lives and manage deterioration by reducing sewer flows. Conversely, there is also concern that reduced sewer flows could lead to more blockages (increased costs). This uncertainty is a cause for concern by sewerage undertakers. There is also growing appreciation of the need to facilitate partnership approaches to funding SuDS schemes. This needs to be supported by an understanding of the multiple benefits of SuDS to encourage the contribution of funds from diverse organisations.

This research project (along with ID 30) will enhance our understanding of how to value the whole life costs and benefits of SuDS and consider joint delivery of SuDS schemes.

What is the research project about?
It is recognised that there is existing research into the multiple benefits of SuDS being undertaken by CIRIA. This project should occur later in the research roadmap to enable the outputs from this research to embed into the local flood risk management community. These projects would consider:

- the benefits of SuDS (including intangibles) based on new evidence which emerges over the coming 2–3 years;
- the risks of SuDS delivery including legal and financial risks;
- how to quantify multi-agency benefits to support joint funding of SuDS schemes;
- the business case for potential funders;
- development of an agreed sustainability assessment protocol, picking up on many existing tools in an integrated way.

What difference will the research make?
The research will enable us to:

- better quantify the costs and benefits of SuDS across organisations and to society;
- undertake whole life cost benefit analysis with a robust evidence base;
- identify approaches to jointly fund SuDS schemes in existing developments depending on the breakdown of costs and benefits.

Possible collaborative opportunities	Local authorities, water companies, UKWIR
Links to local food risk outcomes	AR_04, EF_01
Outputs from research	Guidance
Proposed start year	Years 3–5
Approximate budget	<£100,000
Duration of project	<1 year

Project Title: Understanding public perception
Topic Area: Using SuDS to manage flooding
Local Flood Risk Framework ID: 31

Why does this research matter?
The UKWIR SuDS roadmap clearly defines the need for this research project: 'The public's perception of SuDS varies, where there are negative views these tend to focus on health and safety issues. Where there is negativity this will potentially delay the delivery of SuDS and compromise the realisation of the many benefits. It would be useful to explore these perceptions and also understand acceptability of particular SuDS components and especially their maintenance needs.

Traditionally drainage systems have been buried and out-of-sight-out-of-mind. There has been a lack of communication, engagement and education of communities on the purpose and benefit of SuDS and the increasing need to manage drainage on the surface. This is also analogous with the need to engage with the public on general water management, where surface water needs to be seen as an opportunity rather than a nuisance. Greater acceptance of SuDS within the industry and public should lead to improved SuDS delivery and a greater demand for the associated multiple benefits. Where successful engagement with communities is achieved they often take an active role in the use and management of SuDS components, particularly where these are used in the public realm.'

What is the research project about?
This project will need to consider the following:

- understand current attitudes related to SuDS;
- identify strategies to improve awareness and education;
- identify the most effective means to engage a range of socio-economic groups, using techniques such as school education, homeowner education.

What difference will the research make?
We will understand any perception issues of SuDS, and will be able to overcome these to increase public acceptability of SuDS.

Possible collaborative opportunities	Local authorities, water companies, UKWIR
Links to local food risk outcomes	CE_01, CE_02, AR_04
Outputs from research	Non-technical report
Proposed start year	Years 3–5
Approximate budget	£100,000 – £250,000
Duration of project	<1 year

Project Title: SuDS for small spaces
Topic Area: Using SuDS to manage flooding
Local Flood Risk Framework ID: 32

Why does this research matter?
There is a lack of awareness about how to implement SuDS in highly urbanised areas and small developments while minimising land take and recognising site constraints. This is especially an issue in highly urbanised areas. We are missing opportunities to implement SuDS on small sites, and the net result is developments with little, if any, on-site attenuation.

What is the research project about?
The project will need to consider the following:

- review and update available information to identify suitable SuDS that make appropriate use of space, particularly in highly urbanised areas;
- provide guidance on minimising land take while maximising aesthetics and surface water management benefits (e.g. use of green walls);
- explore potential for developing guidance on delivering multi-functional spaces (e.g. planters as vegetable plots and SuDS);
- engage proprietary manufacturers to encourage innovation once there is a clear market potential.

What difference will the research make?
Greater awareness about how SuDS can be used effectively in small development sites, particularly in highly urbanised areas. This will result in greater uptake and therefore reduce surface water run-off from small development sites and highly urbanised areas.

Possible collaborative opportunities	Local authorities, water companies, UKWIR
Links to local food risk outcomes	AR_04
Outputs from research	Guidance
Proposed start year	Years 3–5
Approximate budget	<£100,000
Duration of project	<1 year

Appendix C – Background information on ‘must do’ projects

A separate spreadsheet is available which gives information on the source of the ‘must do’ projects and links to existing research. The spreadsheet has not been published bu is available by request fcerm.evidence@environment-agency.gov.uk

See ‘Appendix C – Background info on ‘must do’ projects’

Appendix D – List of lower priority research projects identified

There were a further 100 (approx) research projects identified as being lower priority (‘should, would, could or unclassified’; S, W, C, U) than those considered in Appendix B ‘must do’). Each of these research proposals was assigned a score based on the following:

0. Not assessed
1. Existing research outputs fully meet the research need and therefore the research project has not been taken forward
2. Further research required to build on previous publications and outputs
3. Brand new research required to deliver outcomes
4. Covered by question on 'high priority' list
5. ‘Other’ with some additional commentary provided.

For completeness the full list of projects is provided in Table D.1. However, we only propose to promote projects assigned a score of 2 or 3, although these are still lower priority than the ‘must do’ projects in Appendix B.

Table D.1 Lower priority research projects

Research need identified by stakeholders	Summary of whether new research is needed	Comments	Priority S, C, W or U
Best practice guidance on surface water separation techniques and approaches	1 – Existing research outputs fully meet this need	CIRIA retrofit stormwater management measures covers this	S
Best practice guidance on practicalities of securing funding for local flood risk management'	1 – Existing research outputs fully meet this need	Defra guidance on joint funding	S
Tools and techniques for economic appraisal of surface water separation measures	1 – Existing research outputs fully meet this need	CIRIA retrofit stormwater management measures	S
Communicating modelling outputs	1 – Existing research outputs fully meet this need		S
- How best to retrofit properties/infrastructure - How to share best practice by some planners/authorities with others	1 – Existing research outputs fully meet this need	Retrofit covered by CIRIA guidance Best practice is a dissemination issue	S
Mapping of combined hazards from flooding and gusts – impacts on individuals and properties	2 – Further research required to build on previous publications and outputs		S
Adapting houses in areas at risk – examine policies for incremental change through use of suitable materials etc when properties are refurbished	2 – Further research required to build on previous publications and outputs		S
Examine whether maintenance should be applicable for grant-in-aid. What benefits/disadvantages (?) would this cause?	2 – Further research required to build on previous publications and outputs	A policy issue – as we may generally move to more operational/maintenance this will become more important	S
Guidance on the range of measures available to manage local flood risk, their impact and applicability in different catchments	2 – Further research required to build on previous publications and outputs	Some way to complete an initial screening tool to speed up what could be done in different areas	S
Evaluate performance and accessibility of flood resilience products, and engage with building products suppliers to increase availability of products	2 – Further research required to build on previous publications and outputs		S

Research need identified by stakeholders	Summary of whether new research is needed	Comments	Priority S, C, W or U
Assess the use of rainfall threshold criteria in predicting urban flooding events, to assist in predicting potential flooding locations	2 – Further research required to build on previous publications and outputs		S
Modelling of health risk associated with flooding	2 – Further research required to build on previous publications and outputs	Link to work being done by Lancaster University, and Health and Safety Laboratory	S
Modelling of health impacts following sewage mixing with surface water (exposure, population)	2 – Further research required to build on previous publications and outputs	Link to work being done by Lancaster University, and Health and Safety Laboratory	S
Collection and assessment of data on flood impacts and vulnerability (extends the work of the Multicoloured Manual to include health and safety factors)	3 – Brand new research required to deliver outcomes		S
Longer term funding models (e.g. rates (?) going to a longer horizon), make more focused on good outcomes/more insulated from poor short-term reactions	3 – Brand new research required to deliver outcomes	This is as much about policy as research	S
Using real-time monitoring and management to reduce impacts of local flooding OR (idea from previous framework): 'Evaluation of real-time control in integrated urban drainage and future solutions approach'	4 – Covered by question on 'high priority' list	Review of current approaches to capture and use real-time data across risk management authorities AND Sharing real-time information across risk management authorities and communities – what does the future look like?	S
Practicalities of aligning design standards across risk management authorities	4 – Covered by question on 'high priority' list	The issue is not so much about aligning design standards, more about how to approach cost benefit and partnership contributions, which is picked up by a 'high priority' project	S
(Idea from previous framework): Low cost monitoring of	4 – Covered by question on 'high	Review of current approaches to capture	S

Research need identified by stakeholders	Summary of whether new research is needed	Comments	Priority S, C, W or U
drainage system performance. To develop equipment for better understanding of system performance and real-time control	priority' list	and use real-time data across risk management authorities AND Sharing real-time information across risk management authorities and communities – what does the future look like?	
(Idea from previous framework): Improved fast response modelling for real-time interventions OR Intelligent interpretation of real-time monitoring information	4 – Covered by question on 'high priority' list	Review of current approaches to capture and use real-time data across risk management authorities AND Sharing real-time information across risk management authorities and communities – what does the future look like?	S
Understanding the confidence of rainfall radar measurement	4 – Covered by question on 'high priority' list	Accuracy of rainfall/model forecasts and the impacts on decision-making	S
Comparing response and interactions of different flooding mechanisms to rainfall OR (Previous framework idea): 'Comparing the statistical distributions of urban rainfall, run-off and flooding. Improving land-use modelling in 2D surface models for urban areas'	4 – Covered by question on 'high priority' list	Representing boundary conditions in urban drainage models	S
Further analysis of Met Office climate change model outputs to improve certainty of downscaling. Validation of hourly data and improved sub-hourly downscaling to remove uncertainties inherent in UKCIP Weather Generator	4 – Covered by question on 'high priority' list		S
Development of tools and guidance on modelling operational changes in catchments	4 – Covered by question on 'high priority' list	Representing mitigation measures in integrated models	S
Verification, calibration, validation – assessing best practice for	4 – Covered by question on 'high	Update CIWEM UDG modelling guide	S

Research need identified by stakeholders	Summary of whether new research is needed	Comments	Priority S, C, W or U
river and drainage models	priority' list		
Development of software and guidance to ensure that high intensity rainfall can be modelled and correctly replicated (performance of models in extreme events)	4 – Covered by question on 'high priority' list	Update CIWEM UDG modelling guide, might also need some fundamental research	S
Design of new buildings – needs statutory underpinning	4 – Covered by question on 'high priority' list	Adaptive and resilient design to current and future local flood risk	S
Produce better guidance on local fundraising for flood risk management – generating a pot to supplement grant-in-aid/local levy etc	4 – Covered by question on 'high priority' list	Review and guidance for local communities on how to access funding streams locally	S
Innovation and guidance on low cost intervention measures	5 – Other (see comments column)	Could be an interesting one to see if there are materials and techniques resulting in lower construction costs	S
Understanding how non-structural measures are more flexible to an uncertain future	5 – Other (see comments column	Not sure this is really a research question worth exploring	S
Collection and sharing of data on costs of structural and non-structural mitigation measures	5 – Other (see comments column)	Not sure this is really a research question worth exploring; there are standard costing approaches, and risk management authorities could approach contractors for quotes if needed	S
Improve speed modelling technology	5 – Other (see comments column)	This is something the software houses are looking at improving all the time; unsure it requires funding as a research project as it will happen anyway	S
Enhance hydrology models to better account for different planting regimes and how type/configuration of plants affects run-off and hydrology	5 – Other (see comments column)	Links to WWNP framework	S
Link between rural land management practices and hydrological impact – could we do a Red/Amber/Green analysis	5 – Other (see comments column)	Links to WWNP framework	S

Research need identified by stakeholders	Summary of whether new research is needed	Comments	Priority S, C, W or U
to help change hearts and minds?			
Improve resolution and speed of flooding models to allow warning/forecasting to actually be possible	5 – Other (see comments column)	This is something the software houses are looking at improving all the time; unsure it requires funding as a research project as it will happen anyway. It is starting to happen already (e.g. ICMLive)	S
Mainstreaming engaging communities in adaptation and resilience	5 – Other (see comments column)	This is a capacity building and communication issue	S
Development of existing knowledge to improve rapid 1D overland flow modelling (tools)	0 – Not assessed		C
Cascading catchment based approach down to 'sub-catchment' plans and partnerships	0 – Not assessed		C
Impact on business from flooding (local and supply chain)	0 – Not assessed	This is about indirect impacts on business and how we value	C
How best to engage partnership groups/stakeholders (social science)	1 – Existing research outputs fully meet this need	There is plenty of existing research which meets this need, disseminating the research is key	C
Clearly identifying who are the relevant stakeholders	1 – Existing research outputs fully meet this need	There is plenty of existing research which meets this need, disseminating the research is key	C
Establishment of test urban catchments for the use in long-term multi-disciplinary research into IUD	2 – Further research required to build on previous publications and outputs		C
Use of improvised engineering solutions in emergencies. The last few months have seen: - pumps from Holland - shipping containers as sea wall (Danish) - dumpy bad weir to create flood storage on the Itchen	2 – Further research required to build on previous publications and outputs		C

Research need identified by stakeholders	Summary of whether new research is needed	Comments	Priority S, C, W or U
(Winchester) - sand bag canals for groundwater floods Guide for use in emergencies			
Review who should 'own' flood risk management assets. This could lead to better investment and more investment	2 – Further research required to build on previous publications and outputs		C
Health impacts of flooding – long-term physical and mental	2 – Further research required to build on previous publications and outputs	Link to work being done by Lancaster University, and Health and Safety Laboratory	C
Vulnerability: characterisation, reducing vulnerability, increasing resilience	3 – Brand new research required to deliver outcomes		C
Impact on people's long-term health due to flooding	3 – Brand new research required to deliver outcomes	Link to project 'Health Impacts of flooding'	C
How to model entry and exit from urban drainage systems to improve accuracy of flooding predictions	4 – Covered by question on 'high priority' list	Update CIWEM UDG modelling guide	C
Developing code of practice for modelling small watercourses	4 – Covered by question on 'high priority' list	Update CIWEM UDG modelling guide	C
Improve the capability of below-ground flood modelling (models flooding due to backing up through property connections)	4 – Covered by question on 'high priority' list	Modelling groundwater effects in urban drainage systems	C
Improve inlet representation	4 – Covered by question on 'high priority' list	Update CIWEM UDG modelling guide	C
Enhance understanding of infiltration process into sewers/drains and impact on hydrology and how it affects hydraulic capacity of networks. Include two way -> infiltration/exfiltration into groundwater/soil water	4 – Covered by question on 'high priority' list	Modelling groundwater effects in urban drainage systems	C
Enhance understanding of inlets (gully etc) and modelling of these issues:	4 – Covered by question on 'high priority' list	Update CIWEM UDG modelling guide	C

Research need identified by stakeholders	Summary of whether new research is needed	Comments	Priority S, C, W or U
- data collection - simplification - operational condition			
Coordination – improving coordination and sharing info between authorities during an event (e.g. Environment Agency and LLFA and others)	4 – Covered by question on 'high priority' list	Review of current approaches to capture and use real-time data across risk management authorities AND Sharing real-time information across risk management authorities and communities – what does the future look like?	C
Aligning timelines across organisations	4 – Covered by question on 'high priority' list	The issue is not so much about aligning design standards, more about how to approach cost benefit and partnership contributions, which is picked up by a 'high priority' project	C
Understanding of land value and potential gains for partners -> initial encouragement to potential partners/investors	4 – Covered by question on 'high priority' list	Should be picked up by: 'Undertaking economic appraisals to provide evidence for accessing wider funding sources'	C
Guidance on land and surface water management adaptation for redevelopment and regeneration	5 – Other (see comments column)	Links to WWNP framework	C
Making use of historical rainfall data to evaluate local flood risk	5 – Other (see comments column)	Not sure this is really a research question worth exploring; risk management authorities already use historical data	C
Removal or prioritise (?) 'focus groups' whose agenda may detract from preventative measures. - Clear lines of communication - Point of contact on the ground and of higher authority Willingness of higher authority to listen (?) to 'local knowledge'	5 – Other (see comments column)	This is a capacity building and communication issue	C

Research need identified by stakeholders	Summary of whether new research is needed	Comments	Priority S, C, W or U
Cross-fertilisation of info across all areas			
Best practice sharing of case studies and examples of partners working together, how, benefits, outcomes	5 – Other (see comments column)	This is a capacity building issue	C
How to host a community roadshop (see Torbay) - photos, CCTV of past events - confirmation of modelling tools - modelling tools used to plan measures Awareness raising and show people what we are doing to keep them safe	5 – Other (see comments column)	This is a capacity building issue	C
Engage with community regarding breakdown of community funding (?) for issues such as flood protection via council tax. Money has to come from somewhere	5 – Other (see comments column)	This is a capacity building and communication issue, but also picked up by: 'Review and guidance for local communities on how to access funding streams locally'	C
Benchmarking of the impact of high capacity road gullies on surface water flood risk	0 – Not assessed		W
Using uncertainty in assessing and managing flood risk, where and how it will be used, and how it affects solutions	2 – Further research required to build on previous publications and outputs		W
Broader interpretation of partnerships/collaboration for education and for building capacity for planning and response	1 – Existing research outputs fully meet this need	There is plenty of existing research which meets this need, disseminating the research is key	W
Drainage asset deterioration modelling	2 – Further research required to build on previous publications and outputs	Link to works on asset deterioration for rivers and coasts	W
Approaches to optimise investment in local flood risk management	4 – Covered by question on 'high priority' list	Making the case for investment – an integrated approach across risk management authorities	W

Research need identified by stakeholders	Summary of whether new research is needed	Comments	Priority S, C, W or U
Making the case for maintenance to manage local flood risk in light of future catchment changes	4 – Covered by question on 'high priority' list	Making the case for investment – an integrated approach across risk management authorities	W
Representation of buildings in direct rainfall modelling - stubby buildings and roughness lacking - semi permeable lines?!	4 – Covered by question on 'high priority' list	Update CIWEM UDG modelling guide	W
Review international practice in other developed countries to determine what regulatory/funding system works best	4 – Covered by question on 'high priority' list	Partly covered by ' Incentivising uptake of SuDS', but may need broader research	W
Flood Tsar (??) – one stop shop to go for help with attaining the outcome (e.g. maintenance of drainage/watercourses)	5 – Other (see comments column)	Unsure what the research question is here	W
National gazetteer of who owns what: sluice gates, penstocks, culverts, ancillaries etc	5 – Other (see comments column)	LLFA Asset Register and Environment Agency Asset Information Management System covers this – key issue is how to share across risk management authorities	W
Communities understand where actions are and are not being undertaken	5 – Other (see comments column)	This is a capacity building and communication issue	W
Integrating community base flood risk management with community resilience systems and infrastructure	5 – Other (see comments column)	This is a capacity building and communication issue	W
Does greenfield development run-off equate to greenfield?	0 – Not assessed		U
Partners: who does what after an event flooding recovery best practice Recovery coordination – learning lessons post event from aftermath of winter 2014 floods	5 – Other (see comments column)	Organisational structure rather than R&D	U
Collect flood event data for model calibration - guidance on what to collect and how - existing guidance needs to be updated for social media	1 – Existing research outputs fully meet this need	There are British and European standards for this type of activity, plus certifications for flow monitoring (e.g. MCERTS)	U
Detailed spatial flood modelling needed (current models/maps too coarse)	1 – Existing research outputs fully meet this need	Detailed spatial flood modelling already possible	U

Research need identified by stakeholders	Summary of whether new research is needed	Comments	Priority S, C, W or U
Real-time fully integrated modelling - increased resolution of gauge info - Increased processing capacity - neuro-thinking --> simplified but detailed info	2 – Further research required to build on previous publications and outputs		U
Valuation of reduced duration extent and frequency of flooding rather than simply protection	3 – Brand new research required to deliver outcomes		U
Move away from design events towards event-based scenarios, sequencing of events etc Multiple sources, fluvial -> groundwater Guidance for developing these scenarios	4 – Covered by question on 'high priority' list	Scoping document on current data and practice for spatially varying rainfall, long duration events and convective rainfall AND Review and evidence gathering on whether to use single or multiple rainfall events for planning and design	U
Guidance for developing local flood warnings from national data - Met Office feeds, ensembles, uncertainty - local receptor information - customisation of Environment Agency/Met Office consequence matrix - reuse of local modelling - communication and visualisation of results to i) general public and ii) non-technical decision-makers - hierarchy of methods depending on resources, available model and data and other local considerations	4 – Covered by question on 'high priority' list	Quite a few proposed research projects will address this need	U
SuDS interaction groundwater	4 – Covered by question on 'high priority' list	Understanding SuDS performance	U
Groundwater project – research solutions into managing groundwater flooding	4 – Covered by question on 'high priority' list	Series of proposed research projects into groundwater flooding	U

Research need identified by stakeholders	Summary of whether new research is needed	Comments	Priority S, C, W or U
Realistic costing of SuDS maintenance and flexibility for SAB to establish cost-effective and efficient charging mechanisms	4 – Covered by question on 'high priority' list	SuDS research projects will address this need	U
Standardised approaches for cost benefit analysis	4 – Covered by question on 'high priority' list	Guidance and case study examples on valuing benefits and appraising mitigation measures across risk management authorities	U
Incorporate laws for sustainable losses drainage from business module to residential module. Engage and encourage by financial incentive to 'residential developers'	4 – Covered by question on 'high priority' list	Incentivisation for SuDS [including options for private finance]	U
Achieving a common framework for assessing infrastructure investment including environmental externalities	4 – Covered by question on 'high priority' list	Practitioner's guide on co-funding schemes for local flood risk	U
Support the engagement of non-technical experts within model development process Sketch tools to enable model conceptualisation - enable partners to contribute to model development without being technical experts - to understand key flood risk mechanisms and ensure that they are represented in the model	5 – Other (see comments column)	This is a capacity building issue	U
Cost compared to accuracy of modelling	5 – Other (see comments column)	Not sure this is really a research question that is considered necessary	U
Better use of catchment sensitive farming: funding, support, guidance	5 – Other (see comments column)	Links to WWNP framework	U

Appendix E – Stakeholder list

Table F.1 lists all of the stakeholders we have engaged with during the development of the local flood risk research framework, or who have expressed interest in being engaged throughout the lifetime of the framework.

Table F.1 Stakeholder list

Name	Organisation
Mike Adams	Environment Agency
Deonie Allen	Herriot-Watt University
Alan Allison	
Andy Bailey	Highways Authority
Ian Benn	Internal Drainage Boards
Laura Benton	URS
Wendy Brooks	Environment Agency
Andy Brown	Environment Agency
Fay Bull	Nottingham City Council
Mark Cheetham	
Peter Close	
Paul Cobbing	National Flood Forum
Robbie Craig	Defra
Owen Davies	Royal Borough of Greenwich
Gill Dent	Environment Agency
Jo Diamond	Environment Agency
Chris Digman	MWH
Slobodan Djordevic	CWS
David Edwards	Shropshire County Council
Stuart Elks	Environment Agency
Paul Ellis	ESI
Martin Fairley	ACO
Keith Fenwick	Met Office/FFC
Mark Fermor	ESI
Bethan Flynn	Environment Agency
Dave Fortune	XP Solutions
Trevor Goodhew	UWE (capacity building)
Dave Hart	Environment Agency
Rod Hawnt	ISODAQ Technology
Stuart Hemmings	
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Kevin Keating	AECOM
Ron Kidson	
Paul King	Environment Agency
Emily Lawson	Nottingham University
Owen Lee	Surrey County Council
Ian Linley	Bradford University
Colin Liptrot	Environment Agency
Adam Littler	
Russell Long	Environment Agency

John Lymer	Environment Agency
Jamie Margetts	Clear
Phil Marshall	Environment Agency
Dan Martin	Somerset County Council
Andrew McLachlan	East Riding of Yorkshire County Council
Babs Mitcheson	Member of the community
Tony Mitcheson	Member of the community
Grant Moffatt	Environment Agency
Ian Moodie	NFU
Fiona Morris	Environment Agency
Nick Mount	Nottingham University
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Hannah O'Callaghan	Nottinghamshire County Council
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Roger Orpin	Defra
Astrid Paget	East Riding of Yorkshire County Council
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Max Tant	Kent County Council
Stephen Tingle	Tingle Consulting
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