PROJECT INCEPTION REPORT

Delivering and Evaluating Multiple Flood Risk Benefits in Blue-Green Cities

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1. INTRODUCTION

1.1 Context

Flooding impacts on thousands of lives every year in the UK and the adverse social, economic and environmental effects of flooding are increasing year on year. Globally, flooding on average kills more than 9,000 people and affects more than 115 million people, annually. Putting loss of life together with the economic damages caused by flooding makes it the World's most serious natural hazard. There is also increasing evidence that anthropogenic climate change is leading to sea level rise, increased occurrence of extreme precipitation events and, hence, flooding (http://www.bis.gov.uk/foresight/our-work/projects/published-projects/flood-and-coastal-defence). Flooding adversely affects people, communities, businesses, insurers, governments and the environment nationally and internationally, and the need for new and innovative research that can help reduce the probability and/or consequences of flood has never been more urgent. The fact is that the great majority of flood-related risks are associated with cities, as that is where the consequences of flooding are particularly severe.

Concepts of water sensitive cities and tools for water centric urban design are developing in many countries (Howe and Mitchell 2012). During the first decade of the 21st century, Portland, Oregon began its 'grey to green initiative' (http://www.portlandoregon.gov/bes/47203) and Melbourne, Australia reached the "water cycle city" stage (Brown et al. 2008), but few if any UK cities have progressed beyond "the drained city" stage, with water managed for a series of single functions (including flood risk management) mostly through distribution, collection and treatment systems, and drainage infrastructure that are energy intensive and which continue to degrade urban environments in general and urban watercourses, in particular. If the UK is to catch up, the pace of transition to connected and adaptive practices in urban water management that integrate flood risk management (FRM) with new forms of sustainable and socially equitable urban planning and design must increase. This can only be achieved if Local Authorities, Institutional Stakeholder Organisations, Citizens and their Elected Representatives negotiate a shared vision of the 'Blue-Green City'.

A Blue-Green City aims to recreate a naturally-oriented water cycle while contributing to the amenity of the city by bringing water management and green infrastructure together (Hoyer et al. 2011) (Figure 1).

This is achieved by combining and protecting the hydrological and ecological values of the urban landscape while providing resilient and adaptive measures to deal with flood events. Key functions include protecting natural systems and restoring natural drainage channels, mimicking pre-development hydrology, reducing imperviousness, and increasing infiltration, surface storage and the use of water retentive plants (Novotny et al. 2010). These principles were embodied in the EU SWITCH project, which envisaged water management in the 'city of the future', challenged current paradigms and promoted sustainable alternatives to conventional ways of managing urban water (http://www.switchurbanwater.eu/).

The paradigm shift necessary to progress towards achieving the 'Blue-Green Dream' (BGD) is being promoted through a project led by Čedo Maksimović at Imperial College, London (Maksimović et al. 2013). The BGD paradigm sets out the main blue services (and goods) as being, broadly: water supply (drinking water and energy), climate regulation (equitable climate), detoxification and purification of water (pollution control) and hazard regulation. Green services (and goods) include parks and recreation grounds, brownfield sites, woodlands, gardens, churchyards and green corridors that provide crops, trees and standing vegetation (food and timber), wild species diversity, regulating (detoxification) and cultural services

(physical health, aesthetics, spiritual), in addition to their natural ability to improve the delivery of climate-related services. The BGD project is developing a rating system to assess and quantify the current state of goods and services, identify natural and engineered solutions to enhance them and rate them according to the level of services (and goods) supplied. The BGD project is currently being pursued through the network of regional centres throughout Europe, but plans to go global in 2013/14.

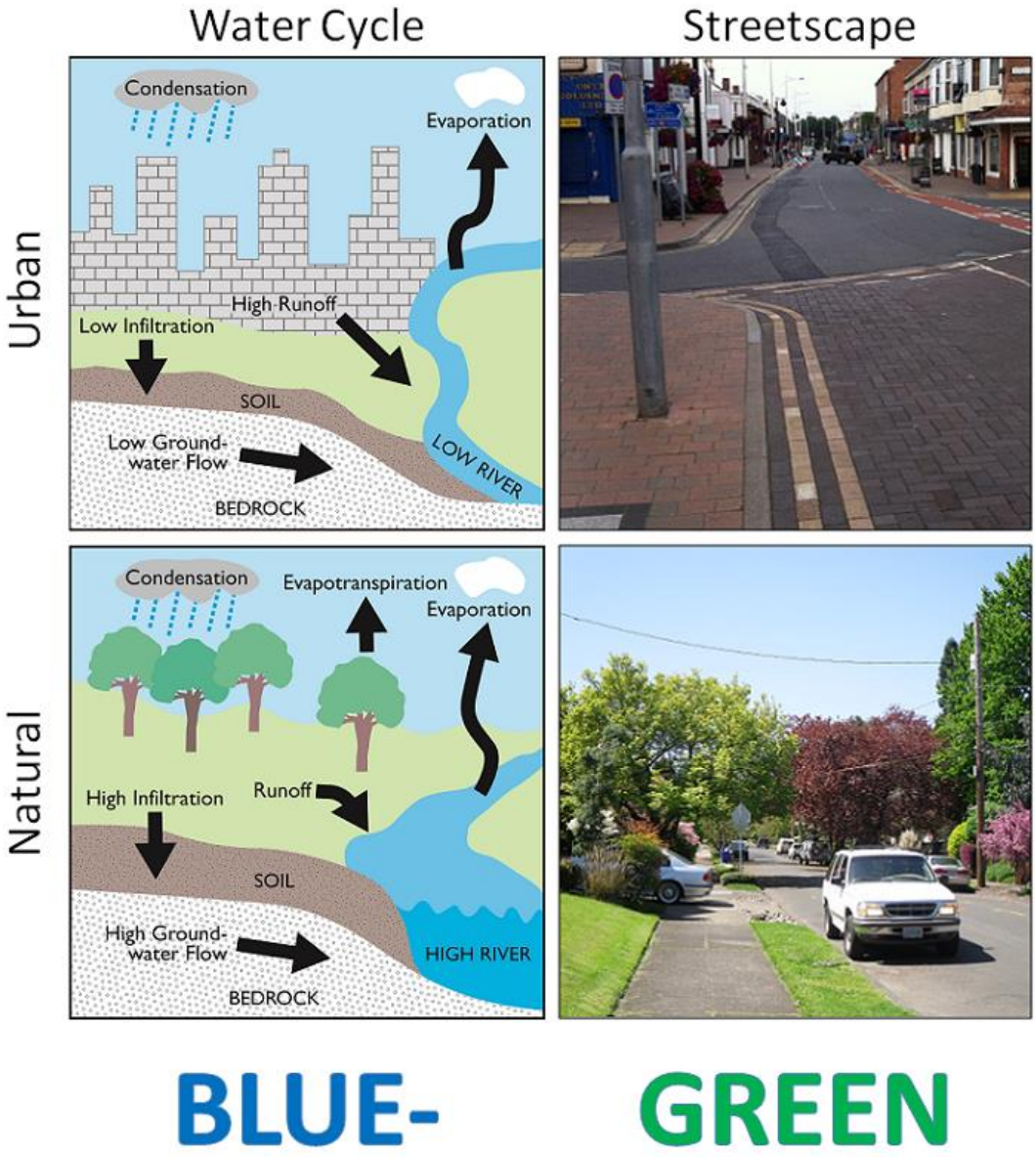


Figure 1. Comparison of hydrologic (water cycle) and environmental (streetscape) attributes in conventional (upper) and Blue-Green Cities.

However, barriers to achieving the Blue-Green Dream remain because the functionality, effectiveness and reliability of decentralised FRM measures are often underestimated. Also, these approaches are not integrated into overall planning concepts due to lack of awareness that their advantages extend to multiple stakeholders. Specifically, there is a need for research to better understand the connectivities between:

1) individual components of urban flood risk management systems, including grey and green infrastructure and spaces, surface and subsurface drainage networks and sustainable urban drainage (SuDS) features (including blue roofs, green streets, rain gardens and bioswales);
2) the flood risk management system and other urban infrastructure, which is essential to achieving integrated urban planning, and;
3) technical and institutional measures adopted for Urban Flood Risk Management (UFRM) and the attitudes and behavioural responses to these measures of stakeholder bodies, urban communities, individual citizens and their elected representatives.

A further research need relates to how flood risk mitigation measures are evaluated and their performances assessed.

The Department of Environment, Farming and Rural Affairs' (Defra) approach to flood and coastal risk management has been to seek multi-functional benefits from Flood and Coastal Erosion Risk Management (FCERM) interventions and enhance the clarity of social and environmental consequences in the decision making process. Defra note, however, that flood risk reduction benefits provided by ecosystems are not well understood and this is an area where more systematic research is needed (Defra 2007). Social responses to flood measures by people and stakeholders have been examined through multi-criteria approaches (Kenyon 2007), with criteria typically being grouped into flooding, economic, social and environmental categories. The UK's FCERM research strategy notes that quantifying, monitoring and challenging benefit claims is crucial, stressing that benefits should not be overstated.

Consequently, reliable and accurate evaluation of UFRM benefits needs to be extended to quantifying the wide range of benefits that are indirectly related to the enhanced flood risk management that will accrue in Blue-Green Cities and which impact on, for example, the urban heat island effect, carbon reduction/mitigation, biodiversity, habitat enhancement, public amenity, the health and well-being of citizens and the competitive edge gained by Blue-Green Cities over otherwise comparable, conventional cities.

1.2 Research Team

The names, affiliations and research interests of the Consortium Team are listed overleaf in Table 1. Bio sketches of the team may be found in Annex I.

Table 1. Blue-Green Cities Research Consortium Team

Team Member	**University and home page**	**Research Areas in the Blue-Green City Project**
Colin Thorne	Nottingham: http://www.nottingham.ac.uk/geography/people/colin.thorne	Urban flooding, geomorphology and sustainable flood risk management
Emily Lawson	Nottingham: http://www.nottingham.ac.uk/geography/people/emily.lawson	Delivering sustainable urban flood risk management in Blue-Green Cities
Shaun Maskrey (PhD student) supervised by Nick Mount	Nottingham: http://www.nottingham.ac.uk/geography/research/currentresearchstudents/shaunmaskrey.aspx https://www.nottingham.ac.uk/geography/people/nick.mount	Bayesian Networks as a tool for involving stakeholders in the adaptive management of urban flood risk
Lindsey Air	Nottingham	Consortium Administrator
Faith Chan	Nottingham Ningbo Campus: http://www.nottingham.edu.cn/en/engineering/staffprofile/faith-chan.aspx	International water management policies, sustainable flood management and planning practices.
Nigel Wright	Leeds: http://www.engineering.leeds.ac.uk/people/civil/staff/n.g.wright	Urban flood modelling (surface water, river flooding and coincident flooding events)
Dabo Guan	Leeds: http://www.see.leeds.ac.uk/people/d.guan	Environmental economics and governance (the *flood footprint* and multiple costs of flooding)
Sangaralingam Ahilan	Leeds: http://www.engineering.leeds.ac.uk/people/civil/staff/s.ahilan	Urban flood modelling (surface water, river flooding and coincident flooding events)
Andrew Sleigh	Leeds http://www.engineering.leeds.ac.uk/people/civil/staff/p.a.sleigh	Urban flood modelling (surface water, river flooding and coincident flooding events)
Richard Fenner	Cambridge: http://www-csd.eng.cam.ac.uk/people/staff/fenner	Urban drainage systems and multi-criteria analysis of flood risk management benefits
Lan Hoang	Cambridge: http://www-csd.eng.cam.ac.uk/people/staff/lan-hoang	Urban drainage systems and multi-criteria analysis of flood risk management benefits
Scott Arthur	Heriot –Watt: http://www.sbe.hw.ac.uk/staff-directory/scott-arthur.htm	Risks of blockage at structures in urban watercourses due to sediment and/or debris
Heather Haynes	Heriot –Watt: http://www.sbe.hw.ac.uk/staff-directory/heather-haynes.htm	Sediment dynamics, geomorphology, habitats and ecosystems in urban watercourses
Deonie Allen	Heriot –Watt:	Sediment and debris dynamics, blockage risks,

	http://www.sbe.hw.ac.uk/staff-directory/deonie-allen.htm	and geomorphology in urban watercourses
Chris Kilsby	Newcastle: http://www.ncl.ac.uk/ceg/staff/profile/chris.kilsby	Urban inundation modelling (coupled surface and sub-surface systems)
Vassilis Glenis	Newcastle: http://www.ncl.ac.uk/ceg/staff/profile/vassilis.glenis	Urban inundation modelling (coupled surface and sub-surface systems), CityCAT development
Vedrana Kutija	Newcastle http://www.ncl.ac.uk/ceg/staff/profile/vedrana.kutija	Computational hydraulics and Hydroinformatics, CityCAT development
Jessica Lamond	University of the West of England: http://people.uwe.ac.uk/Pages/person.aspx?accountname=campus%5Cje-lamond	Citizen and stakeholder attitudes and behaviours with respect to flood risk management (agent-based modelling)
Glyn Everett	University of the West of England: http://people.uwe.ac.uk/Pages/person.aspx?accountname=campus\gd-everett	Processes of social inclusion/exclusion as they relate to and affect citizen and stakeholder engagement in flood risk management.
Jenny Mant	Cranfield: http://www.cranfield.ac.uk/sas/aboutus/staff/mantj.html	Urban river restoration (including sediments, morphology, habitats and ecosystems)
Ian Holman	Cranfield: http://www.cranfield.ac.uk/sas/aboutus/staff/holmani.html	Influence of catchment characteristics in runoff generation, erosion and sediment delivery
Leonard Smith	Oxford/London School of Economics (LSE)/Chicago: http://www.rdcep.org/researchers/leonard-smith	Stakeholder and community communications (especially with respect to flood risk & uncertainty)

1.3 Aim and Objectives

The aim of the Consortium is to develop new strategies for managing urban flood risk as part of wider, integrated urban planning intended to achieve environmental enhancement and urban renewal in which multiple benefits of Blue-Green Cities are rigorously evaluated and understood.

The Consortium's objectives are to:

1. Put competent authorities, businesses and communities at the centre of the research by establishing feedback pathways between them and the UFRM modellers, planners and decision makers to ensure co-production of knowledge.
2. Model existing flood risks using coupled surface/sub-surface hydrodynamic models linked to semi-quantitative assessments of sediment/debris dynamics and habitats, using fieldwork where necessary to fill knowledge gaps in urban drainage network forms and functions;
3. Identify and assess candidate options for adaptive strategies combining hard and soft responses to flood risk that are capable of functioning as spatially-integrated, UFRM systems;
4. Use fieldwork to identify and understand the behavioural responses of individual and institutional stakeholders to the candidate options for UFRM. Develop rules to represent these behaviours and employ agent-based modelling to simulate the responses of citizens to UFRM options. This will support an iterative process of re-evaluation, leading to identification of preferred options and selection of the means of delivering them;
5. Synthesise existing and novel performance measures to identify 'value added' at a range of scales and under flood/non-flood conditions, in an ensemble of contrasting, possible flood futures;
6. Illustrate how this approach can be used to support learning from multiple feedback loops at every stage of UFRM appraisal, decision making, implementation, evaluation and adaptation.

1.4 Project Duration

The Project commenced on 1st February 2013 and is due to be completed within 36 months: i.e. by 31st January 2016.

2. RESEARCH PROGRAMME

2.1. Research Structure and Schedule

Research will be performed as a closely integrated and carefully sequenced set of five Work Packages (Figure 2) performed within a research space defined by the economic-social-environmental and ecological benefits generated in a Blue-Green City and the Blue (flood) versus Green (no flood) performance of flood risk management infrastructure and spaces (Figure 3). The Work Packages (WP) will run partially in parallel, with their completions designed to supply their deliverables at the times necessary to meet key milestones (Figure 4, Table 2).

Essentially, effort will focus on developing the research during years 1 and 2, and testing and applying it through the Demonstration Project in Year 3.

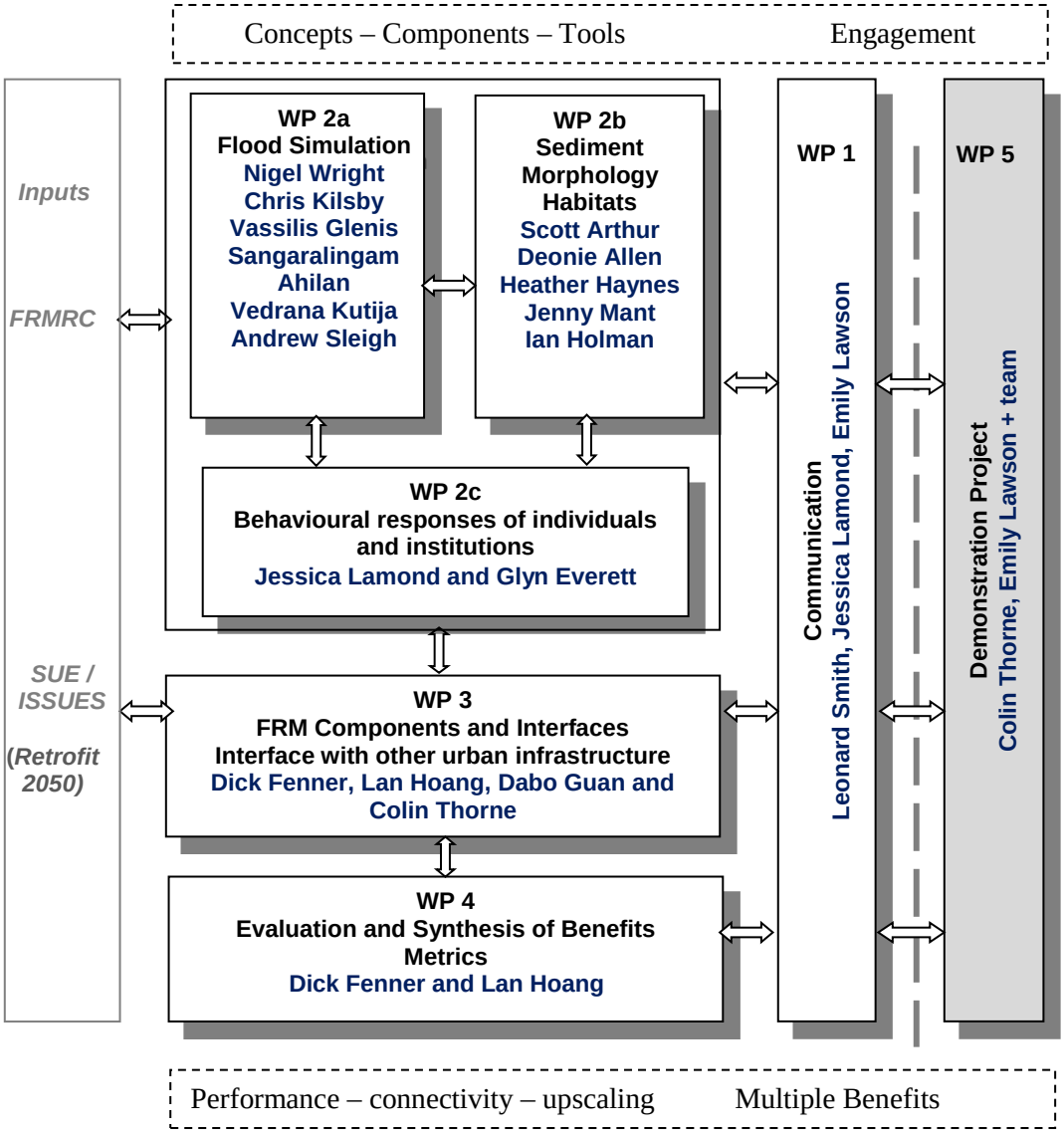


Figure 2. Research Structure

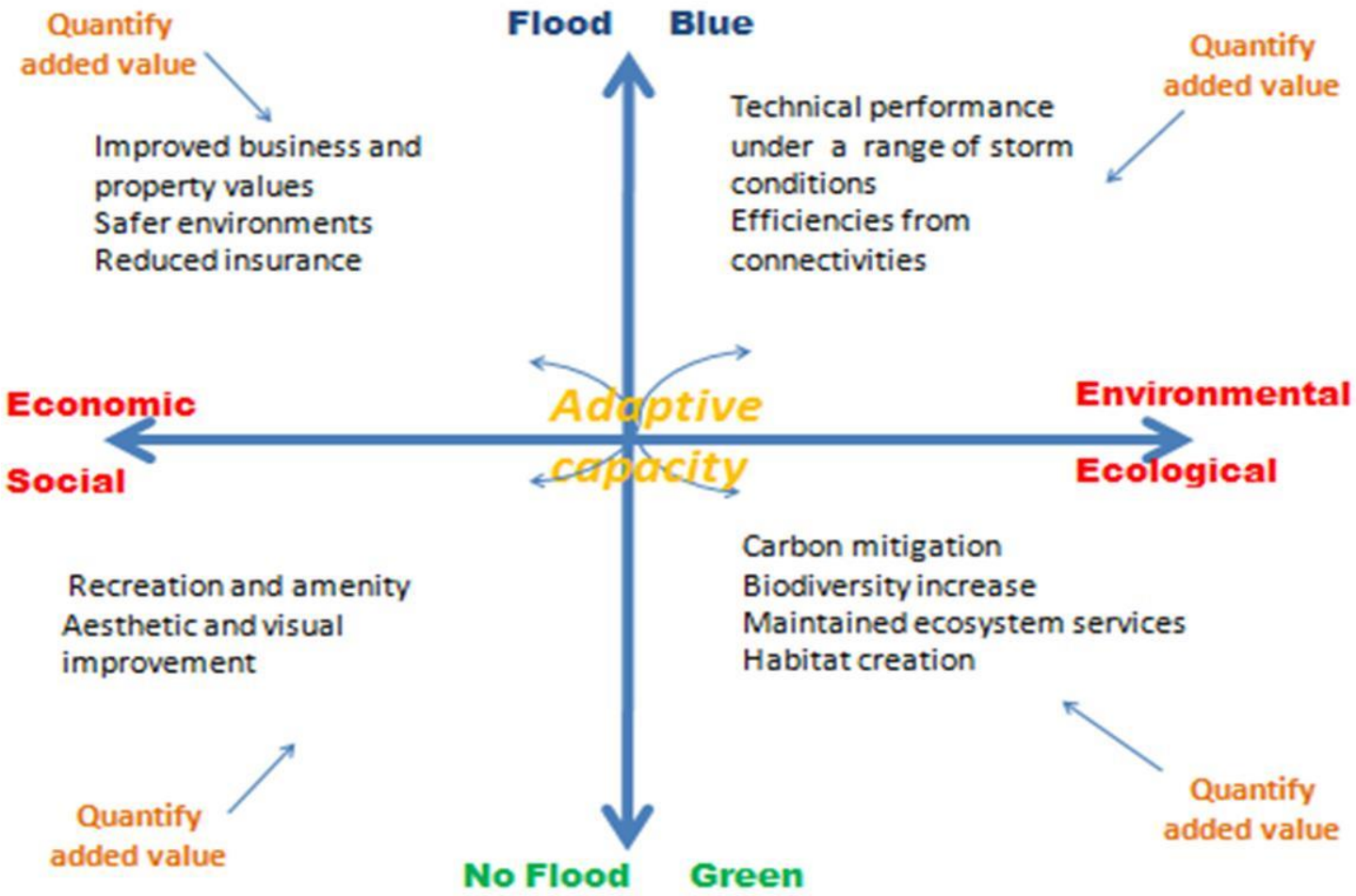


Figure 3. Research Space

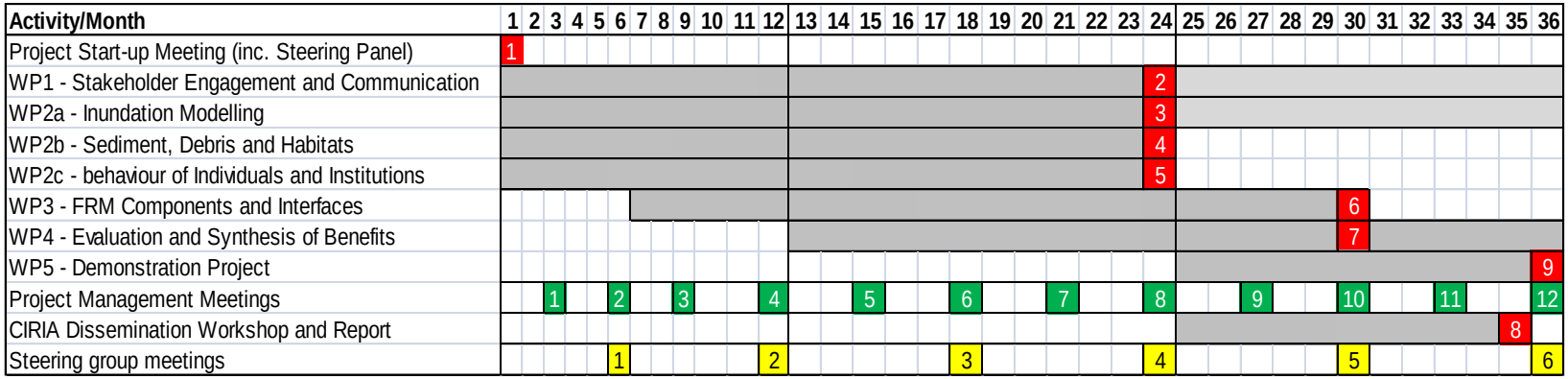


Figure 4. Consortium Time Chart
(WP activities = grey, Milestones = red, Quarterly Progress Meetings = green, Strategic Advisory Board Meetings = yellow)

Table 2. Project Milestones

Milestone	Comments
1	Project Initiation Report
2-7	Research Deliverables and Inputs to Demonstration Project
8	CIRIA Workshop and Launch of CIRIA Report
9	Demonstration City Workshop and Final Report

2.2 Work Packages

2.2.1 WP1: Communications between Scientists, Institutional Stakeholders and Communities

- **Aims and Objectives**

Communication between information providers and end-users (including relevant stakeholders and local communities) is often ineffective and one way. The aim of WP1 is to facilitate co-production of knowledge and increase two-way communication with respect to model processes, outputs and uncertainties between:

a) the Consortium research team;
b) academics, consultants and other technical specialists and UFRM practitioners/stakeholders who make decisions based at least in part on model outcomes, and;
c) communities at risk of flooding whose lives and livelihoods are affected by decisions that depend at least in part on the outcomes of urban flood inundation models.

It follows that WP1 will provide a mechanism for effective dissemination throughout the duration of the project.

Objectives

1. Developing communication strategies to cater to multiple perceptions and translate research into user applications.

This requires incorporation of decision-making needs into the research and development process to ensure that the information provided by the Consortium is driven by end-users requirements that are identified and highlighted at the start of the process. This links with the Engineering and Physical Sciences Research Council (EPSRC) Quota Studentship running parallel to the Blue-Green Cities Project (Annex II), which will explore the use of Bayesian networks to involve stakeholders and document information exchange in participatory modelling and UFRM. The starting premise is that effective communication of UFRM options and evaluation of the benefits of adopting a Blue-Green approach at the outset of project planning will help modelers and end users to negotiate model outcomes, especially in tailoring their relevance to the needs of the community and specific application in hand, so promoting end-user and community buy-in. WP1 will empower users to help guide model development and revision, and ensure that modellers take account of local knowledges and appreciate stakeholder needs, aspirations and efficiencies. Achieving this requires development of mutual trust via regular engagement and exchange of scientific and vernacular knowledge in a social context, including frank articulation of uncertainties using non-scientific language. Effective communication strategies with stakeholders in the Demonstration City selected for WP5 will be developed as part of the Learning and Action Alliance that will be initiated in the second year of the project.

2. Understand how information flows between stakeholders and 'publics' and the nature of the information that publics want in order to make decisions.

How/why various public bodies make decisions related to UFRM will be influenced by:

a) who makes the decisions (which could be mapped),
b) what uncertainties may influence practical applications, and

c) what uncertainties are inherent to the specific modelling process and limitations of the models chosen.

This co-production of knowledge will focus on the Demonstration City, with the additional objective to identify failure pathways, stemming from, for example, limited interest in the project by stakeholders approached at the onset. This will provide the opportunity to modify the communication strategy or even to identify the need to make contact with a different city.

3. Develop a framework for identifying the key uncertainties involved in planning and delivering Blue-Green infrastructure.

Policy makers, government and industry stakeholders frequently make decisions when faced with considerable uncertainty. WP1 aims to develop a framework to identify the Relevant Dominant Uncertainties (RDUs) in relation to: using Blue-Green infrastructure for UFRM; Blue-Green infrastructure/SuDS design and decision-making and; understanding which uncertainties represent barriers to uptake of Blue-Green infrastructure and SuDS for city-scale urban water and FRM under different (uncertain) future scenarios.

WP1 will also identify and rank the RDUs within each WP. The Blue-Green Cities project employs several models with different structures and types of data output, all associated with different types of uncertainty and knowledge of that uncertainty. WP1 aims to identify the sources of uncertainty to which the project is particularly vulnerable, the uncertainties that we are able to reduce, the uncertainties that we can track and propagate, and those we can only talk about. This will illustrate which uncertainties have the greatest influence on the Consortium's science and its take-home message; that Blue-Green infrastructure (when combined appropriately with piped drainage) out-performs grey infrastructure and provides multiple benefits that are robust given different possible climate and land-use futures. RDUs that impact significantly on the science and final outcome must be reflected upon in conjunction with wider stakeholders

- **Work Package Team**

WP1 will be led by Leonard Smith and assisted by Jessica Lamond, with support from Colin Thorne and Emily Lawson.

- **Study Approach and Methods**

Identifying and utilizing communication pathways and understanding the propagation of uncertainty within and between the WPs represents the first major challenge for the Blue-Green Cities project. Figure 5 shows the information flows and communication between WPs (and wider stakeholders via external communication and dissemination), and the push/pull of information between WP1 and the other WPs that will drive knowledge co-production and exchange.

1. Summarizing model structures

The first stage of WP1 will be to summarize the variety of model structures used across the project and the expected connections between those models (information flows), understand the uncertainty vulnerability of each group and ascertain the RDUs within each strand.

2. Integrated research

WP1 will develop a flow chart illustrating the data/information requirements for the main sub-tasks in each WP, colour-coded to show which WP is responsible for generating the data/information and passing this to other WPs. This diagram will be placed on the project intranet to be built upon and regularly updated by the project Research Associates (RAs) as

new data/knowledge transfers become apparent. WP1 will also develop a communal Gantt chart detailing key milestones within each WP and the dependencies on data/knowledge flow to meet these milestones. This will be another working document available on the intranet that will be developed during the project, and assessed at regular intervals to ensure deliverables can be produced on time. These documents will illustrate how the team will work together on sub-tasks and ensure a joined-up approach from the project onset.

3. Co-location working

Co-location working and regular meetings will represent an additional mechanism to aid understanding of how the WPs fit together and how uncertainty may propagate between strands. Communication between RAs and Co-Is will actively check for unannounced uncertainty at each stage of the model cascade and spot disconnects between models.

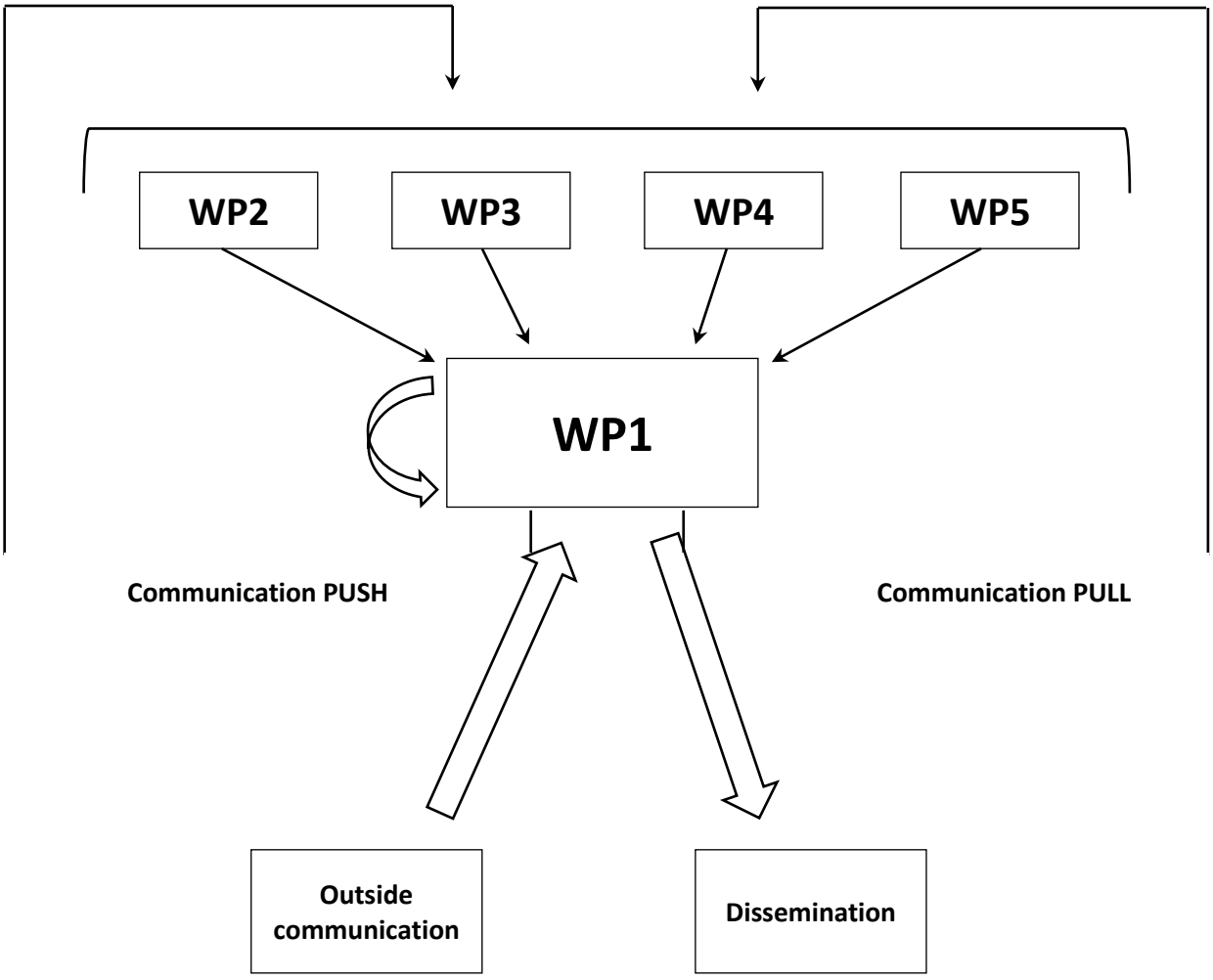


Figure 5. Information flows and communication between Work Packages and wider stakeholders.

4. Terminology and jargon busting

A further challenge will be to investigate the similarities and disparities in the terminology used in FRM, e.g. identifying where different dialects of uncertainty are used and why they may differ, and devise strategies to reduce miscommunication of knowledge (both internal and external). This will build on the EU Floodsite (Samuels et al., 2009; http://www.floodsite.net/) and be disseminated via Wikipedia, e.g. by creating an entry for "Blue-Green Cities".

5. Stakeholder communication and Learning and Action Alliance (LAA)

Parallel to internal discussions of uncertainty, WP1 will gain an appreciation of what stakeholders require from UFRM models and what is/is not important for practitioners and policy makers. This will influence how information and model uncertainty are communicated in both WP1 and wider aspects of the project. Stakeholder communication will build on best practice, as identified in the Implementation Strategies for Sustainable Urban Environment Systems (ISSUES) project (http://www.urbansustainabilityexchange.org.uk/) for knowledge transfer from the Sustainable Urban Environment (SUE) programme (http://www.urbansustainabilityexchange.org.uk/ISSUESSueProgramme.htm).

WP1 (linking with WP5) will form a Learning and Action Alliance (LAA) to develop a 21st Century vision for flood risk and surface water management and potential for Blue-Green infrastructure in the Demonstration City. This will begin in the second year of the project. LAAs are cooperative, horizontal forums where people can bring their expertise but talk freely outside of any organisational constraints in an atmosphere of mutual trust and ownership. LAAs have been trialed as a framework to establish, maintain and sustain partnerships tackling flooding and urban water management in light of the new challenges of urban societies, e.g. EU MARE project (http://www.mare-project.eu/).

6. Relevant Dominant Uncertainties (RDUs)

A programme of semi-structured interviews will be conducted with selected stakeholders in the Demonstration City to identify and rank the RDUs related to the design and implementation of Blue-Green infrastructure, and identify thresholds, tipping points and non-linearities in present and future urban water and flood risk management.

7. Masters Research Projects

Further value will be added through a coordinated programme of research conducted by Masters students at each of the institutions involved in the Blue-Green Cities project which will run in parallel to activities performed by members of the Consortium and focus on a selected deliverable related to the wider project, e.g. statistical projects could be run at LSE investigating the uncertainty in urban sediment transport dynamics and how this can be incorporated into model outputs. Masters Projects that to span across and overlap with the objectives of two or more WPs will aid internal communications.

- **Research Plan and Milestones**

Milestone 1: The RAs from each Work Package will attend an uncertainty workshop at LSE run by Leonard Smith (July 2013). The aim will be to discuss types of uncertainty in each of the models used in the Blue-Green Cities Project, being specific and adopting agreed terminology, e.g. ambiguity, indeterminism, imprecision, and intractability, and discussing how this can propagate within/between models, to aid with identification of the information flow across this project. In-house workshops on uncertainty will run every ~6 months. Internal communication of uncertainty flows will continue for the duration of the project via an internet forum hosted by LSE and run by the RAs.

Milestone 2: The opportunity for Masters Projects led by the PI/Co-Is at each institution will be discussed at the Quarterly Project Meeting (June 2013). A coordinated programme of potential Masters Research designed to meet specific aims of the Blue-Green Cities Project will be identified, proposed to future Masters students at each University, and finalised in March 2014. All the Masters projects will be completed by September 2014. If successful, the Masters Research programme may be repeated in 2015.

Milestone 3: A stakeholder map will be produced for the Demonstration City detailing who the stakeholders are and what are the links/flows of information between them (Jessica Lamond).

Milestone 4: A Learning and Action Alliance (LAA) will be formed in the Demonstration City with a start-up meeting in February 2014. Meetings will continue throughout 2014-15 to develop the Blue-Green Cities Vision, and continue after the lifetime of the Research Project.

Milestone 5: A framework will be developed to identify the RDUs in Blue-Green infrastructure design and planning, and will be trialed during interviews with key stakeholders in the Demonstration City (2015).

Milestone 6: The RDU identification framework will be used to select and rank the RDUs with each WP and determine which have the greatest influence on the Consortium deliverables.

- **Links to other WPs and Contribution to Consortium Outcomes**

Ensuring effective internal communications, promoting knowledge exchange and evaluating how different WPs fit together is an essential component of WP1 and will contribute to the Consortium's outcomes by ensuring connectivity and continuity of research and deliverables.

The deliverables from WP1 will also link with the other WPs more specifically. For instance, the flow of uncertainty throughout our analysis, from uncertainties within inputs (such as UKCP09), uncertainties introduced by our analyses (such as the fidelity of agent-based models), and those arising during interpretation of our outputs by decision makers, will be monitored and openly discussed by the team. This robust method of uncertainty evaluation will be communicated to key stakeholders involved in the project development to ensure transparent uncertainty evaluation throughout the cascade of models produced by the Consortium.

2.2.2 WP2a: Inundation simulation

WP2a addresses the question of how to use computer simulations to predict flooding and the response of stakeholders.

- **Aims and Objectives**

WP2a will work on four main areas which all have links to other WPs. The areas are:

- Modelling morphology and transport of sediment and debris in Blue-Green features. This will give us a greater understanding of the negative and positive impacts of sediment flows in the proposed features.

- Incorporation of agents into an inundation model. This will allow us to study how behavioural changes impact on flooding and vice versa. Further, we will be able to study how Blue-Green features may change these interactions.

- Representing Blue-Green features in a model of urban inundation. Existing inundation models focus mainly on the traditional measures for mitigating urban flooding. The inability to included Blue-Green features in the models and subsequent cost-benefit analysis (CBA) limits policy-makers, developers and designers confidence in more innovative designs.

- Developing probability maps of urban inundation to support resilient responses. Most inundation predictions are presented to the public as a map with binary information (flooded or not flooded). In reality there is a range of probabilities across an urban area due to different rainfall events, model and parameter uncertainty and spatial location. If we are to develop flood resilience methods more widely we need to use probabilistic outputs.

Each of the objectives are described below.

- **Work Package Team**

The WP2a team comprises Nigel Wright, Sangaralingam Ahilan & Andrew Sleigh (University of Leeds), and Chris Kilsby, Vassilis Glenis & Vedrana Kutija (Newcastle University).

- **Study Approach and Methods:**

Modelling morphology and transport of sediment and debris

Based on work at Heriot-Watt and Cranfield Universities on the sources, pathways and sinks of debris and sediment, we will incorporate the following into a model of urban inundation:

- The movement of sediments from catchment surfaces into and movement through Blue-Green features. This will identify source zones and sediment loads for input to models of urban areas. It will be used to study both water quantity and quality.
- Blockage of culverts and screens. This will involve a probabilistic (e.g. Monte Carlo) analysis based on the likely occurrence of blockage based on input from WP2b.

The inputs to the above will draw on work in the Flood Risk Management Research Consortium (FRMRC) (http://web.sbe.hw.ac.uk/frmrc/) such as the development of the Sediment Impact Assessment Model (SIAM) and the sediment toolbox. The outcomes of this analysis will also be used to inform the behavioural models from WP2c. The modelling will consider responses to possible future changes in drivers over a decadal timescale. The spatial scale will consider the catchment in terms of sediment inputs and individual Blue-Green features in modelling sediment movement.

- **Representing Blue-Green features in a model of urban inundation**

Existing capabilities with the City Catchment Analysis Tool (CityCAT) model include modelling the effects of permeable/impermeable ground surfaces and buildings/roofs to generate flood depth and velocity maps at 1 or 2m caused by design storm events. The following new capabilities will be developed and applied to pilot new Blue-Green technologies in the case-study area (at city scale):

- Inclusion of sub-surface drainage network (i.e. pipes) together with full 2-way dynamic coupling with the surface;
- Elaboration of the capacity of blue/green roofs for flood risk management;
- Simple SuDS features: water-butts, storage tanks, ponds & lakes, permeable surfaces, swales (as a special case of pipes);
- Simulation of more complex features such as swales will be investigated using 1-D approximations;

The outcomes of this development and analysis will support other parts of WP2a and will inform the behavioural models from WP2c.

- **Incorporation of agents into an inundation model**

The object-oriented nature of the CityCAT model facilitates incorporation of agent-based modelling which will be addressed in various stages:

Stage 1: in collaboration with a utility (Northumbrian Water Ltd, NWL) the impact of installing water butts at all domestic properties will be investigated. Surveys suggest the effectiveness of this measure reduces as owners abandon the water butts: this behaviour will be simulated so that the business case can be assessed.

Stage 2: socio-economic and demographic data will be added to the Stage 1 analysis, allowing variable behaviour in different wards. This type of approach will also be applied to simulation of blockages at culvert screens.

Stage 3: further higher level agents, representing local authorities and businesses, will be added to the CityCAT model using a hierarchical approach. This will first use a long term (100+years) updating model which will manage the agents' activities in UFRM (e.g. installation of features, developments and planning, insurance etc.). This model will in turn run CityCAT at intervals for significant storm events (e.g. 2 or 3 per year) to provide measures of inundation and damages, which in turn feedback on the economic state and attitudes of the agents.

This analysis will crucially depend on inputs from WP2c and, in turn, the outcomes will be used to inform the behavioural models from WP2c. Feedback will occur in several ways:

- Changing inundation patterns from urbanisation or climate change may lead to changes in resilience behaviour (installation of Blue-Green features, moving to other areas, etc.).
- Changes made in the urban environment to incorporate Blue-Green features may lead to people moving in or out of an area.

These changes will be studied by running the model with changed rules and boundary conditions for different time periods. If time allows, these changes will be incorporated as automatic rules in a longer term simulation.

- **Probability-based maps of inundation**

Current work on FRM tends to analyse a limited number of fixed return periods. In fact, this is often only one: usually 1-in-30 for urban drainage and 1-in-100 for fluvial inundation. To ensure an integrated analysis these return periods should be similar, and to properly value the benefits of flood resilience measures requires analysis across a range of return periods. Flood risk responses that work well for a return period of, for example, 1-20 years, may not offer much benefit for 1-in-100 years and conversely measures taken to address the 1-in-100 year event may not be beneficial for more frequent events. In view of this we will produce inundation predications across a range of events of different frequencies and events of different lengths. This will lead to a matrix of predictions which will be used to give a probability map for inundation in an urban area. It should be noted that only the lower frequency events will consider fluvial inundation.

The probability maps produced will include the usual maps of inundation, but also probability maps for particular depths and velocities (selected according to the usual depths and velocities considered for particular levels of damage). We will also be able to consider functions of depth and velocity that are used for damage assessment.

It must be realised that there is not a smooth linear transition between events of different frequencies. For example, a culvert will block at a particular level of flow or it may take a particular level of discharge for a surface flow to divert into an additional pathway. These step changes must be considered in the analysis and we will test the sensitivity of the results to these factors. In particular, we will consider the breach of defences, culvert blockage and pipe surcharging.

- **Links to other WPs and Contribution to Consortium Outcomes**

This work will have links to WPs 1 (uncertainty), 2b and 2c (multiple links detailed above), 3 (on the types of Blue-Green features) and 4 (in terms of synthesis). We will also ensure that this work ties in with the Environment Agency's (EA) National Surface Water Flood Mapping.

- **Research Plan and Schedule**

The research plan and schedule is detailed in Table 3.

	Task	Months
Blue-Green (BG) Features	Scope required BG features	1-9
	Design models for BG features	3-15
	Implement	6-24
Morphology and sediment	Catchment studies (WP2b)	9-18
	Morphological and sediment modelling of BG features	12-24
Agent modelling	Scope possible agent types and possible rules	6-18
	Incorporate agent types and rules developed in WP2c	18-30
Probabilistic outputs	Develop inputs for model based on future scenarios of climate, BG features and demographics	6-24
	Conduct simulations	18-30
	Produce graphical output based on probabilities	24-36

Table 3. Research Plan and Schedule for WP2a

2.2.3 WP2b: Sediment, Debris and Habitats

- **Work Package Overview**

There is potential, through informed integrated design and decision making, to achieve multiple flood risk benefits through the use of Blue-Green infrastructure. To achieve an effective water sensitive city design, the impacts and implications of incorporating Blue-Green stormwater management principles into the urban design form, beyond peak flood volume control, must be considered. This is hampered by the fact that sediment transport and debris dynamics in emerging vegetated and naturalized urban drainage design are not well understood. Implications of culvert replacement (daylighting) and designing surface water management measures within open public space require further research to support continued advances in safe and effective implementation.

This Work Package investigates SuDS, urban watercourses and floodplains, focusing on debris dynamics, sediment transport and blockage risks within the Blue-Green urban form. Flood conveyance, as affected by sediment and debris dynamics (including: entrainment, deposition, re-suspension, and blockage potential at choke and pinch points) are key flood risk and water quality considerations in surface stormwater management systems, especially those involving green infrastructure. SuDS, as part of the Blue-Green City, have the potential to reduce flood risk while improving water quality, public amenity and safety within the local urban environment. The connectivity, development and design of urban floodplains affect the function of this area as a sediment source or sink. Urban watercourse choke points, such as culverts and bridges, cause sediment and debris deposition increasing local flood risk. Evaluating the sediment connectivity and flux through the Blue-Green network is the primary purpose of WP2b.

- **Aims and Objectives**

The aim of the WP2b is to assess sediment transport and debris dynamics within Blue-Green urban drainage and watercourse networks to develop improved approaches to accounting for the risks and benefits associated with Blue-Green infrastructure.

To meet this aim, the following objectives have been set:

1. Undertake semi-quantitative assessments to characterize sediment transport and debris dynamics the urban drainage networks featuring Blue-Green infrastructure.
2. Provide analysis to support the identification and assessment of candidate options for adaptive stormwater management strategies that combine grey and green infrastructure to achieve Blue-Green outcomes which are capable of functioning as spatially-integrated, UFRM systems.
3. Synthesise existing and novel performance measures to identify risks and 'value added' benefits at a range of scales and under flood/non-flood conditions, in an ensemble of contrasting, possible flood futures. Through integrated design and modeling, establish how current designs for Blue-Green infrastructure can be enhanced to promote sediment and debris connectivity, reduce flood risk and provide multiple additional benefits as part of functionally-integrated Blue-Green systems that perform synergistically.

The key research questions which WP2b will address are:

1. How effective, in terms of sediment and debris connectivity, is Blue-Green infrastructure, both singly and as elements in integrated Blue-Green systems?
2. What are the urban land uses and environmental conditions that determine whether a catchment is a significant source or sink of sediment and debris?
3. What sediment characteristics are associated with key pollutants of concern (EU Water Framework Directive, WFD), how far does this sediment travel through a Blue-Green system before it is deposited and stored?
4. During the life cycle of a Blue-Green element, what is the potential for sediment re-suspension and deposition, particularity with regards to loss of flood storage functionality and blockage risk?
5. What benefits, other than those associated with flood conveyance and storage can be generated through enhanced Blue-Green design?
6. What is the potential for implementation of Blue-Green enhanced design to assist in achieving 'good ecological status' or 'good ecological potential' in urban watercourses, as required under the EU WFD?

- **Work Package Team**

The WP2b team comprises Scott Arthur, Deonie Allen, Heather Haynes, Jenny Mant and Ian Holman.

- **Study Approach and Methods**

The study approach is divided into four sections, appropriate to characterisation and analysis of sediment transport and debris dynamics within the urban drainage network. These are:

1. Review of literature and current research;
2. Sediment and debris source analysis;
3. Pathway – receptor field data collection and analysis, and;
4. FRM, water quality performance and evaluation of multiple benefits associated with enhanced Blue-Green design options.

1. Review of literature and current research

The initial stage will include a detailed review of literature and current research relating to debris and sediment source-pathway-receptor analysis within Blue-Green elements, urban surface watercourses and drainage infrastructure.

Significant research has been undertaken in SuDS and flood management peak and volume control across the UK. There are numerous design guidelines and best practice manuals for both green urban drainage design and daylighting culverted flow paths. The literature and research review will dissect the recent case studies to examine known benefits of specific Blue-Green elements. The design and implementation of these water management measures will be reviewed to gain insight into urban integration, placement and connectivity benefits.

Rural erosion and sediment transport mechanics may provide beneficial insight into the movement of sediment through vegetated urban stormwater and FRM systems. A review of sediment transport analysis, including natural and synthetic particulate tracing, will support the selection of sediment monitoring methodology. The literature review will include consideration of rural process, monitoring and modeling approaches to assist the appropriate knowledge transfer from rural field research to the urban environment.

Recent research in urban debris provision has highlighted the importance of socio-economic considerations alongside urban green space and natural area occurrence in an urban catchment (Wallerstein and Arthur 2012). The literature review will examine the current debris transport analysis, empirical modeling and conceptual simulation research findings.

2. Sediment and debris source analysis

The performance of existing Blue-Green assets will be analysed to fully understand the potential sediment/debris source loading and provision of material to the stormwater network or receiving waterbody. This will provide a debris and sediment source parameterized data set relevant to the existing and potential future use options.

3. Pathway – receptor field data collection and analysis

Limited field data is available for urban debris movement or sediment transport through Blue-Green drainage pathways. Therefore, to support comprehensive multiple benefit analysis of Blue-Green city design, further field data is required to better understand the transport and pathway connectivity of these drainage systems. The connectivity across the urban landscape, in the current urban form and through Blue-Green assets will be examined to establish effective linkages, and the design of continuous networks.

Using novel and innovative trace technology, debris and sediment transport monitoring will be undertaken across established Blue-Green elements and small urban watercourses within the urban drainage network. This, in conjunction with an understanding of sources of both urban sediment and debris, will provide source to receptor data specific for selected Blue-Green design elements. Data analysis will define the dynamics of Blue-Green sediment and debris transport, detention efficiency and connectivity to the receiving water bodies.

Debris transport

Passive Integrated Transponder (PIT) technology will be used to monitor small woody debris transport within small urban watercourses. Representative urban watercourses will be monitored over a range of flows to provide debris transport data relative to watercourse and flow characteristics. In conjunction with land use and catchment specific source information, analysis of this data will enable a debris delivery success and pinch point blockage risk analysis to be undertaken.

Sediment transport

Detailed SuDS assessment
Field data collection sites will be monitored to provide detailed analysis of sediment and debris source-pathway-receptor analysis. After discussion and agreement with the Project team, The SuDS system at the J4M8 business park near Heriot-Watt University (grid ref: NS968 664) been selected for detailed sediment transport analysis. This established SuDS treatment train services a small upstream catchment, provides multiple, connected Blue-Green stormwater management measures and is an example of current best practice in SuDS.

It is proposed that investigation at this key site will enable a greater level of detail in sediment transport monitoring and analysis, advancing the understanding of the sediment transport dynamics in specific Blue-Green pathways. Where possible, existing case study data from sediment transport, urban drainage pathway and SuDS, identified through literature and current research review, will be used to verify and validate the findings.

A novel and innovative sediment tracing approach is proposed to monitor sediment movement in the urban environment. In concurrence with rainfall and flow data, tagged sediment, will be released across representative urban surfaces and monitored over a prolonged period. The conveyance, deposition and re-suspension of the sediment, as it moves through the multi-element urban drainage network, will highlight the efficiency of these systems to detain or convey sediment and pollutants from the source (urban surfaces) to receptor (receiving water body). It will also highlight key elements of the SuDS network that require management and maintenance to support full efficiency. Monitoring will also emphasize choke points and preferential deposition locations, as well as areas of potential re-design for greater connectivity, flood risk or water quality improvement benefits.

Parameters of analysis
It is proposed that monitoring will occur over a sufficient period to enable seasonal changes to be considered. In conjunction with rainfall and runoff variations, the influence of vegetation growth and dye back on sediment transport, deposition and re-suspension will be monitored. Data will be collected as a time series, supported where possible by event analysis.

Key sediment aspects that may be monitored include:

- Trace type and concentration
- Particle size distribution (PSD)

- Sediment volume
- Particle density
- Organic content
- Settling velocity

In conjunction with:
- Depth-velocity (centre-line) for key elements of the system
- Locally specific rainfall time series

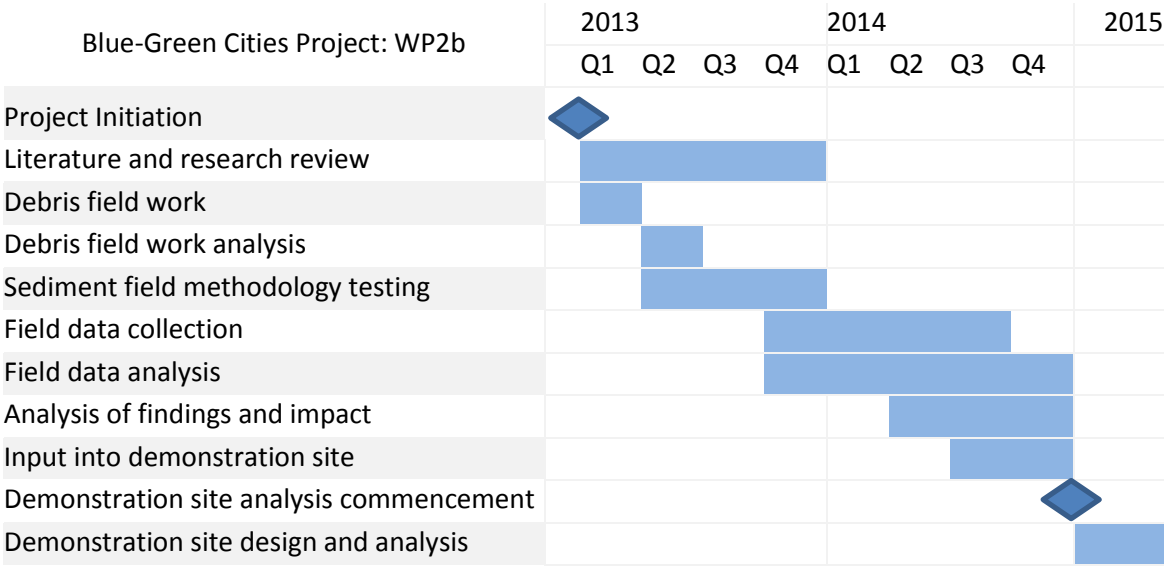
- **Flood risk management, water quality performance and multiple benefit evaluation of Blue-Green options**

Demonstration Site

Completed field data analysis and literature review findings will be used, in conjunction with a catchment assessment, to assess the consortium's Demonstration Site Blue-Green opportunities. The receiving waterway will be modeled using a simplified sediment transport tool, to enable impact assessment of Blue-Green design on the receiving watercourse sediment and water quality levels. Field work will be conducted to evaluate the performance of Blue-Green infrastructure and SuDS in the chosen sub-catchments, with respect to water and sediment management. In conjunction, the restoration potential of key urban waterways will be investigated using appropriate river habitat assessment methods applied to reaches in the case study areas

Identification, conceptual design and a review of Blue-Green options will be undertaken. Consideration will be given to the potential debris and sediment provision associated with the proposed land use and landscape. Indicative sediment and water quality analysis modeling of Blue-Green design options proposed within the Demonstration Site will be used to provide an indication of design benefits and opportunities. Recommendations on effective multiple benefit Blue-Green urban drainage design will be made, supported by research and field analysis.

- **Research Plan and Schedule**



2.2.4 WP2c: Behavioural responses of individuals and institutions

- **Aims and Objectives**

The aim of WP2c is to provide evidence-based rules about the behaviour of individuals and institutions for the agent based modelling that will be co-developed with WP2a. This will involve understanding thinking around the strengths and weaknesses of current flood measures, the state of the community and any need for or pressures for change; perspectives on different FRM approaches and the multiple potential benefits (and costs) of a more Blue-Green approach; possible reactions to a variety of changes that could occur over time, and possible outcomes from experiencing future flooding events.

Objective 1: Establish baseline data. WP2c will need to develop a good perspective on the situation as things stand, in order to understand more about possible reactions from all parties to the changes that the Blue-Green programme will suggest. This will include both the in/adequacies of current flood protection and FRM measures, the contemporary state of the communities people inhabit or interact with, and the related felt need for changes within these in any direction, or felt pressures for change. Only with a good understanding of the current situation can the Blue-Green Cities project hope to engage in constructive conversations towards proposing change.

Objective 2: Develop community stated preference models and perspectives on benefits with regard to different approaches to flood risk management. WP2c will research and discuss with communities and institutions their thinking around different approaches to FRM, in order to develop models of their preference and likely behaviour. The Blue-Green approach may be seen to have multiple potential benefits (social, economic and cultural), but may also be viewed as harbouring costs (reduced efficacy as compared with structural defences, reduced safety in green spaces), and a number of each of these may not have been calculated at the more theoretical level. All forms of FRM work will affect local environments in a number of ways, and a good number of the effects stemming from this will not be easily visible from the outside. Only through discussions with local participants will the potential multiple benefits (and costs) of a Blue-Green approach, and so stated preferences, be properly understood. It is important that discussions begin early with affected communities and institutions in order to understand local perspectives and learn from local knowledge; only in this way will *all* voices be heard and the models eventually developed be properly *co*-produced. This co-production is centrally necessary in order for communities and institutions to appreciate and value the works, and to appreciate both the services they provide and the behaviour that will be required in order to allow them to function correctly.

Objective 3: Develop models of behaviour over time. The FRM measures being discussed will be intended for the longer-term, and over this time communities – and their institutions – will inevitably experience a variety of changes (environmental, political and socio-economic-cultural). The WP2c team will therefore look to develop models based on sociological and behavioural theory that can approximate how public and institutional behaviours might shift over time as these changes are undergone. Discussions regarding need and pressures for change (mentioned above will) help in deliberating the more likely direction of these changes.

Objective 4: Develop models for behaviour in the event of flooding. Since no flood defences can provide 100% security, the possibility of flooding will always remain, and it is important to understand what effects both the presence of this possibility, and potential *actual* flooding, could have upon communities and institutions and their behaviour towards existing FRM strategies. WP2c will seek to explore, and to represent in the models that are developed, likelihoods for the ways in which communities might react to instances of flooding; for

example, installing further flood protection devices, strengthening or turning against the approaches adopted, or even deciding to abandon areas of currently occupied land because the risks and their associated costs are seen as too great. Again through discussions and using stated preference models with community members and institutional representatives WP2c will work to produce understanding of participants' perspectives in this area.

- **The specific objectives of WP2c in relation to the wider programme are therefore to:**

1. gain access to affected communities and associated institutions**,** and to thereby gain an understanding of community thinking, behaviour and choice preferences;
2. develop typologies of community and institutional actors**,** and to develop sociological and behavioral models to inform the development of WP2a and 2b;
3. work with communities and institutions to ensure they can contribute to the development of WP2c work, and to WP5, so that at the end of the programme they will feel some ownership of the outcomes and findings.

- **Work Package Team**

The WP2c team comprises Jessica Lamond and Glyn Everett, with assistance from Faith Chan.

- **Study Approach and Methods**

A full literature review is currently being conducted, exploring the work that has already been done upon flood-affected communities and their preferences and behaviours concerning approaches to FRM, development of community resilience and capacity and willingness to alter behaviour in order to mitigate the likelihood and effects of flooding. It is important to ensure that WP2c does not merely repeat work that has already been undertaken but instead adds to the existing body of knowledge.

Background studies from associated sub-projects being conducted during Year 1 (Wakefield, Liverpool, Bristol, Northampton, Cambridge, Portland (Oregon) and Belfast) will help in developing initial thinking around typologies of public and institutional behaviour and choice preferences. Similar projects running alongside Blue-Green over the next 3 years will continue to feed in to the development of WP2c project work.

Once a Demonstration City has been chosen, contact will be established with all relevant statutory bodies to locate any baseline data for the city on public attitudes to flooding, insurance, flood protection and FRM. The WP2c team will then begin mapping the city's demographic and socio-economic base in relations to areas of flood risk. Potentially affected communities will be identified for further study and contacts with all relevant institutions, stakeholders and stakeholder representatives will similarly be developed. Groups we hope to engage with are listed below;

1. Councils/Local Authorities, including Flood Risk Managers, Parks and Rivers Department, Drainage Engineers, Planners, and Community Engagement Officers
2. Environment Agency
3. Residents and Residents' Associations (both at risk and local but not at risk), "flood champions"
4. Local businesses and others with a local presence
5. Environmental groups
6. Industry/practitioners, e.g. planning, development and building industry representatives
7. Insurance industry
8. Water Companies

9. Local and regional media
10. Any additional groups in the chosen Demonstration City

We will develop a matrix of motivations, goals and relationships between all stakeholder groups outlined above to produce a mapping tool for the Demonstration City. This will form a living document that will be drafted prior to engagement and will then be developed in conjunction with stakeholders as engagement progresses.

In order for the WP2c team to more fully understand the thinking of different communities it will be necessary to work as closely as possible with them. Getting 'close' will require firstly gaining the trust and understanding of relevant 'community gatekeepers' (people who have some control over access to communities through a position they hold or the respect they are accorded within the community). This will enable the WP2c team to develop community contacts lists for later direct research and interaction.

Questionnaires will be developed to provide quantitative estimates for input to the agent based modeling (WP2a), assessing preference-values of households and businesses with regard to:

- Insurance;
- Responsibilities for FRM and installing household and community flood protection;
- Different types of FRM systems;
- Willingness to alter behaviour to affect the likely success of different FRM approaches;
- Access to green-spaces within communities;
- Perspectives on the benefits that might stem from improved access to green-spaces;
- Willingness to change behaviour in order to mitigate any contributions to environmental change.

The questionnaires will involve contingent valuation, or stated preference modelling, looking to explore people's preferences between a range of offered alternatives (for instance, between hard structural and more Blue-Green approaches to FRM). The questionnaires will then be followed up with focus groups with community respondents and other stakeholders, to deepen understanding of different community members' thinking and likely behavioural responses to environmental and other changes. This fieldwork will enable us to develop sets of rules relating to the likelihood of different publics' behavioural responses in light of different sets of barriers and incentives they might face.

The benefits from improved FRM could include shorter-term psychological and financial gains, were the FRM approach taken trusted, resulting in peace of mind that flooding were less likely, and reductions in insurance premiums. This is something that WP2c will seek to establish, but the main anticipated longer-term benefits will be avoided actual flooding; the time to feeling this benefit will depend on the flood return period. Further possible benefits from improved green infrastructure could take several years to come to full fruition. Our research will seek to establish whether, and if so, to what extent, these changes would be perceived as benefits, initially through exploratory studies of existing Blue-Green infrastructure and literature review and then through interactions in the Demonstration City. Perceived "risky" solutions will be fed back to other WPs as they become available from preliminary work.

- **Research Plan and Schedule**

Jan – Jun 2013:

- Conduct literature review, map out issues.

Jul – Dec 2013:

- Establish contact with statutory bodies, gather data and literature and analyse.
- Identify key communities of interest.
- Contact and conduct initial interviews with community gatekeepers and mapped key stakeholders to develop community contacts lists.
- Conduct two workshops, with community members and stakeholders.

Jan – Jun 2014:
- Analyse data gathered Jul-Dec 2013.
- Map stakeholders' and communities' perceptions and understanding of issues and options and baseline these through two focus groups.
- Develop conceptual models of range behaviours and options to explore in collaboration with WPs 2a, 2b and 4.
- Conduct research (interviews) in Portland, Oregon (see Clean Water for All inception report http://www.bluegreencities.ac.uk/bluegreencities/research/clean-water-for-all.aspx, regarding public perceptions of SuDS and Blue-Green infrastructure.

Jul – Dec 2014:
- Analyse Portland data.
- Develop two sets of questionnaires, one for households and one for businesses. Send these out to community and business contacts lists.
- Analyse data from questionnaire returns.
- Develop interview and focus group schedules for the two groups, send out invites to these.
- Begin conducting interviews and workshops.

Jan – Jun 2015:
- Conduct remaining interviews and workshops.
- Analyse data from interactions.
- Produce typologies and behavioural models.
- Contribute to the development of the Demonstration City work, interacting with stakeholders and community groups to discuss FRM options.
- Develop conversations and interactions towards a consensus upon the best ways forward for developing a more Blue-Green city.

Jul – Dec 2015:
- Continue to develop these interactions to ensure communities feel ownership of final outcomes.
- Continue with model and theoretical development.

- **Links to other WPs and Contribution to Consortium Outcomes:**

From the interaction with community members engaged with in WP2c, there will be an ongoing knowledge- and best practice-exchange developed with WP1 to ensure that all parties benefit from developments in understanding and that community participants are informed about our understanding of, and have the chance to contribute to our thinking around, the uncertainty inherent in any modelling.

The sociological models developed in WP2c are intended to feed into the development of the agent-based model (ABM) in WP2a, providing material for the development of the ABM and the coding of likelihoods of various behavioural changes under different circumstances. Thinking and findings from WP2c will also feed across and from WPs 2a and 2b in working towards the co-production of flood risk knowledge between scientists, engineers, publics and other

stakeholders. The exact nature of these interactions has yet to be finalised through discussions between projects.

The work conducted in WP3 will feed into thinking around the viable options that should be presented to community participants, and our understanding of the suggested level of efficacy of each of these, so that respondents can make more informed choices. These suggested levels of efficacy will be discussable in the focus groups and open to revision from local knowledge, not presented as unalterable fact.

Discussions with publics and other stakeholder in WP2c will also help with co-developing agreed local understandings re. WP3 around how different elements of different FRM models can interact and be integrated into a wider urban system; typologies of community demographics and choice preferences will help to develop the model.

Findings developed from WP2c will contribute towards understandings of the locally perceived socio-economic costs and benefits of Blue-Green approaches to FRM (WP4).

The WP2c work will come together with all other programme streams in contributing to the implementation and further development of WP5; contacts and networks established through WP2c will be engaged with in ensuring continuing community involvement and co-development of the city's flood-risk understanding and Blue-Green FRM approach.

2.2.5 WP3: Flood Risk Management Components and Interfaces

- **Aims and Objectives**

A key feature of this aspect of the research programme is to understand the effects of FRM strategies incorporating Blue-Green infrastructure at a range of spatial and temporal scales (from local through regional to global) and to appraise the potential for positive and negative interactions with wider urban infrastructure. In this respect, FRM components are part of a wider complex "system of systems" providing vital services for urban communities. The physical interfaces can be tracked by following flood pathways to features such as controlled storage in areas including car parks, recreational areas, minor roads, playing fields, parkland and hard standing in school playgrounds and industrial areas, as well as planned interactions between urban stormwater and green infrastructure facilities in the form of wetlands, bioswales and street planting. At times of extreme flood conditions other critical infrastructure can be impacted in the energy, transportation, water supply, wastewater treatment, and waste management sectors through a series of dependent inter-relationships (e.g. Figure 6).

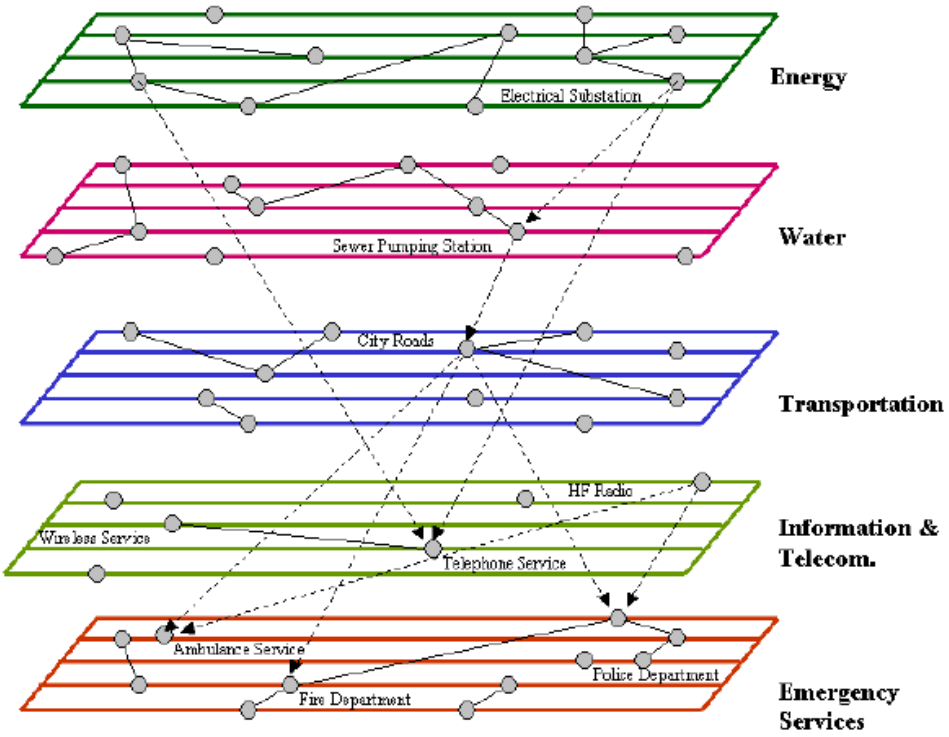


Figure 6. Infrastructure dependencies[1]

Disrupting these dependencies can have significant social, economic, supply chain and health consequences. The system interactions however extend beyond the physical to planning and governance structures and agency responsibilities for operating different forms of infrastructure. Key barriers to effective implementation of Blue-Green infrastructure can arise if planning processes and wider urban system design and urban renewal programmes are not fully integrated.

One of the key findings of the SWITCH Project[2] was that:
"the challenge for stormwater source control is not technical issues but decision making. Institutional change is therefore a fundamental need to upscale stormwater best management practices. Through the development of multi-objectives integrated planning processes, which can reconcile the often conflicting objectives that define urban form, significant opportunities exist to significantly enhance a city's landscape and environment".

A further system feature is manifest in the economic impacts of floods which can be felt across a range of spatial scales from local damage to the disruption of international supply chains, and can be represented by the concept of a flood footprint.

Potential barriers to the implementation of FRM strategies arise depending on where and to whom the benefits of Blue-Green infrastructure accrue during times of no flood and the extent to which

[1] Pedersona P., Dudenhoeffer D., Hartley S., Perman M. (2006) Critical Infrastructure Interdependency Modeling: A Survey of U.S. and International Research Idaho National Laboratory.
[2] SWITCH is an EU-funded research programme aimed at achieving more sustainable integrated urban water management in the 'City of the Future', it consists of a Consortium of 33 partner organizations working in 15 European and developing cities worldwide, with UNESCO-IHE as lead partner (http://www.switchurbanwater.eu/)

these act as incentives or disincentives to the adoption of innovative, radical and non-traditional solutions.

The **aim** of WP3 therefore is to analyse how different elements of UFRM interact and can be integrated into a wider urban system so that the change processes required can be identified and understood to provide support for city authorities and other stakeholders when seeking multi-functional land use.

- **The objectives that will be addressed are to:**

- develop tools and methodologies which can represent UFRM and Blue-Green networks within a single urban environment, with complex interactions and feedback loops established, and hence:
    - achieve an understanding of the unintended consequences of using Blue-Green infrastructure for UFRM, and
    - identify key intervention points in the physical and organisational structures to ensure rapid adoption, optimum functionality and to reduce risk in other infrastructure areas.
    - test the wider system responses at a range of spatial scales and densities for scenarios including high and low storm frequencies and extreme events (WP2).
    - use the conceptual model which emerges to test policies relating to the Demonstration Cities and so understand the effects of scaling up components (e.g. such as green roofs) to larger spatial scales, and to identify opportunities and constraints to achieving this (WP5).
    - Analyse costs and benefits from a micro-economic perspective to produce monetary values for every natural, engineering or planning measure in UFRM *(relocated from WP4)*.
    - Develop a *flood footprint* accounting tool to measure the cascading economic impact through multi-coupled economic systems, triggered by flooding adaptation measures, through to global and international scales *(relocated from WP4).*

- **Work Package Team**

WP3 will be led by Dick Fenner at Cambridge University, with support from Colin Thorne at the University of Nottingham. Supporting research will be carried out by Lan Hoang, based in Cambridge, with support from Emily Lawson based in Nottingham. Dabo Guan at the University of Leeds will develop the concept of a flood footprint to assess the economic impacts of flood events, comparing the relative extent of such footprints under grey and Blue-Green infrastructure.

- **Study Approach and Methods**

A system dynamics approach will be taken to the analysis of UFRM installations which initially will represent a hybridised set of common features as identified in cities already adopting water sensitive urban design principles. Data will be collated from a combination of published sources and reports, and interviews with key stakeholders (WP1 and WP2c).

Modelling will initially be carried out using Vensim and the use of more specific tools for integrated systems analysis will be reviewed. The scenarios used and the outputs produced from the hydrodynamic modelling and agent based responses in WP2 will be tested in the context of the wider urban system as represented here, and specifically in relation to the Demonstration Cities studied in WP5.

Assessments of the flooding impacts on cities have traditionally focused on the initial impact on people and assets. These initial estimates (so-called 'direct damage') are useful both in understanding the immediate implications of damage, and in marshalling the pools of capital and supplies required for re-building after an event.

However, since different economies as well as societies are coupled, especially under the current economic crisis, any small-scale damage may be multiplied and cascaded throughout wider economic systems and social networks. The direct and indirect damage is currently not evaluated well and could be captured by quantification of what we call the *flood footprint*. Flooding in one location can impact the whole UK economy. Neglecting these knock-on costs (i.e. the true footprint of the flood) means we might be ignoring the economic benefits and beneficiaries of flood risk management interventions. In 2007, for example, floods cost the economy about £3.2 bn directly, but the wider effect might actually have added another 50% to 250% to that figure.

A *flood footprint* is a measure of the exclusive total socio-economic impact that is directly and indirectly caused by a flood event to the flooding region and wider economic systems and social networks. The *flood footprint* accounting tool will be developed based on adaptive input-output models, and linked to the systems analysis in WP3 *(relocated from WP4)*.

- **Research Plan and Schedule**

Task 1 The work will review the many examples of best practice in cities in European, North America and Australia where concepts of water sensitive urban design are well developed. Common key features will be identified and used to develop a hybridised set of features for representation in the system analysis. (July 2013- September 2013).

Task 2 A systems dynamics model will be developed based on the development of a causal loop diagram of the hybridised features drawn from the schemes reviewed in Task 1. This will connect physical infrastructure performance with urban landscape features and services including transport corridors, Blue-Green spaces, recreation and habitat, buildings and other urban infrastructure as well as with issues such as waste management, resource recovery and water scarcity. (October 2013 - March 2014).

Task 3 The resilience and vulnerabilities of the wider urban environment to policies based on scaling up Blue-Green UFRM infrastructure to larger spatial scales will be tested using the model, based on a wide variety of UK and US contexts. (April 2014-September 2014).

Task 4 The model will be adapted to represent specific elements and features of the Demonstration City drawing on results from the other WPs (October 2014- March 2015).

Task 5 A policy analysis of options for alternative UFRM strategies in the Demonstration City will be conducted, and key impacts identified under a range of physical, planning, regulatory and socioeconomic scenarios. (April 2015-June 2015).

Task 6 Tertiary benefits to city and national economies will be measured resulting from Blue-Green infrastructure and enhanced UFRM measures (e.g. effects on industrial outputs and employment). From this the *flood footprint* accounting tool will be developed and applied to a range of case study regions as well as the Demonstration City (*relocated from WP4*). (July 2013 - September 2015).

- **Links to other WPs and Contribution to Consortium Outcomes**

Links to other WPs have been identified in the preceding sections, specifically to WPs 1, 2 and 5.

WP3 Outcomes will include:

- A methodological approach for evaluating the interaction of UFRM components with the wider urban system;
- Key and effective intervention points established with an assessment of critical physical and organisational dependencies;
- Recommendations for the integration of Blue-Green UFRM infrastructure with wider planning;
- Recommendations for the optimum spatial distribution of FRM components in a Blue-Green city;
- A wider understanding of economic impacts of floods at higher spatial scales through a flood footprint analysis (*relocated from WP4*).

2.2.6 WP4: Evaluation and Synthesis of Benefits

- **Aims and Objectives**

WP4 (Jan 14-Jan 16) will assess, quantify and value multiple benefits of adopting Blue-Green infrastructure in UFRM strategies. The Work Package will collaborate with - and extend - a parallel study by CIRIA: RP 993 "Demonstrating the multiple benefits of SUDS " (May 2013 – December 2014) whose principal aim is "to collate and evaluate potential methodologies for assessing the benefits of SuDS… and to develop an evidence base and detailed case studies that present an assessment of the benefits and costs". CIRIA will produce a spreadsheet based tool and methodology for the valuation of SuDS components based on a benefit transfer approach.

WP4 will focus on reviewing the science and modeling approaches by which primary benefit values can be quantified across of a range of flood control devices, including the wider use of green infrastructure in the urban environment. This will quantify, under non-flood conditions:

i) physical performance/capacity of vegetated and other surfaces to sequester carbon, mitigate the urban heat island effect, reduce noxious particulate matter, attenuate noise, etc.
ii) socio-economic and health benefits of creating urban green space
iii) ecosystem service benefits of habitat creation and biodiversity opportunities

Many attempts have been made in the literature to measure and value the multiple benefits of Blue-Green infrastructure but the results are often regionally specific (and not UK focused), relate to specific concerns (e.g. climate change), and are based on a disparate set of tools and methods. This background information needs assembling in ways which can provide practical advice to designers, planning authorities and other UFRM stakeholders, so it can be incorporated into formal decision making procedures.

The **aim** of WP4 is therefore to:

Develop/apply primary procedures for the robust evaluation of the multiple functionalities of Blue-Green infrastructure components within UFRM strategies and to assess the inherent uncertainties.

Develop methodologies for evaluating the relative significance of benefits in context specific locations, and from this, establish preference ratings linked to a multi criteria analysis for component selection. This is likely to be in a Q-GIS platform.

Review current design procedures and make recommendations to the design guidance to enhance the most significant non-flood benefits, as appropriate (e.g. to enhance water quality improvement, biodiversity connectivity etc.).

For each UFRM element, this involves both a performance appraisal against a set of diverse criteria and, where possible, monetisation of the benefits to allow:

a) direct comparison between alternative measures, and;
b) inclusion of multi-functionality advantages into cost: benefit calculations.

The following specific objectives will be addressed:

- Review the effectiveness and scope of option appraisal tools including cost: benefit analysis, ecosystem services valuation, and multi-criteria analysis in UFRM.
- Apply these methods, and other existing tools, to the UFRM components and systems as identified in WP2 and WP3 and represented in WP5.
- Produce protocols for the robust evaluation of the wider benefits achievable by specific UFRM components under non-flood conditions which incorporate Blue-Green infrastructure in relation to carbon sequestration, urban heat island reduction, biodiversity and habitat enhancement, etc. and assess their relative (context specific) significance. This will be based on an Ecosystem Services approach.
- Create "***benefit layers***" within the Q-GIS platform adopting a three-step approach: 1) benefit evaluation: physical-socioeconomic-ecological, 2) benefit significance: incremental values added in a location-specific context; and 3) benefit preference: taking up the outcomes of WP2c.
- Create a "***benefit profile"*** for each installation/installation type and map the benefit intensity (based on the cumulative spatial distribution of benefits) in the case study area under each scenario and condition (e.g. Blue-Green future and design rainfall).
- Synthesise the multiple attributes using multi-criteria analyses which derive weightings from a relative comparison of the performance metrics established, views of the UFRM professionals (engineering, planning and regulatory) and wider stakeholder concerns.
- Understand the uncertainties and non-linearities involved in scaling up solutions and in estimating benefit values.
- Propose modified design approaches that serve to enhance and optimize the significant benefits which Blue-Green infrastructure flood management solutions can provide.

- **Work Package team**

WP4 will be jointly led by Dick Fenner at Cambridge University. The research will be carried out by Lan Hoang, based in Cambridge, with support from Emily Lawson based in Nottingham.

- **Study Approach and Methods**

The work will be informed by the recent Green Infrastructure Valuation Tools Assessment (Natural England, September 2013) and apply published methodologies for the fundamental calculation of physical, socio-economic and ecological benefits.

The performance of unit UFRM components (e.g. restored urban streams and floodplains, green and grey infiltration systems, surface ponds, constructed wetlands, urban tree planting, green roofs, etc.) will be calculated for their contribution to specific benefits including carbon sequestration, urban heat island reduction, biodiversity and habitat enhancement etc.

Procedures will be provided to allow these values to be scaled up to evaluate a unique design and aggregated at lager scales across multiple installations, whilst allowing for regional (UK) variations and site specific factors. Blue-Green benefit evaluations will be benchmarked against grey infrastructure alternatives.

Having established the magnitude of the contribution of the UFRM component in each benefit category, economic tools will be applied to monetise each benefit using a range of valuation techniques, (hedonic pricing, contingent valuation, ecosystem services valuation etc.). A multi-criteria analysis (using either Multi Attribute Utility Theory (MAUT) or Analytic Hierarchy Process (AHP) techniques) will use this (weighted) information to aid comparison, ranking and selection of alternative UFRM options based on:

i) ensuring appropriate FRM performance (WP2),
ii) optimising multiple benefits under non-flood conditions.

- **Research Plan and Schedule**

Task 1: Defining components and benefits
A list of Blue-Green infrastructure features which are commonly incorporated in source control UFRM strategies will be identified as the basis of study (as listed above) and standard unit designs selected and developed as appropriate. A set of expected benefits will be defined including (but not limited to) carbon sequestration, urban heat island reduction, biodiversity and habitat enhancement, as well as considering other effects including energy savings in buildings (from shading and insulation), air quality improvements, scope for water re-use, reduced road salt use, traffic noise reduction, water quality improvements etc. (Jan 2014 – Mar 2014).

Task 2: Applying models and analysis frameworks
Existing methodological approaches for assessing multiple benefits will be reviewed and published data on the performance and quantified benefits of Blue-Green infrastructure and FRM components collated. Performance principles from the SWITCH[3] project will be incorporated into the benefit assessment framework (e.g. water sensitivity, aesthetics, functionality, usability, public perception, integrative planning). (Feb 2014 – April 2014).

Task 3: Determining benefit significance
The potential to accrue a range of benefits for each type of infrastructure (including grey infrastructure) will be established under context specific conditions and possible scenarios. The relative significance of each of these benefits will be assessed for specific example locations. This will determine whether the benefit is unique to the flood infrastructure component ad provide a service where not previously existed, or provide an incremental benefit increase to a service already existing in allocation. The benefit significance will also be measured as a range of preferences determined by appropriate stakeholder groups. (May 2014 – Dec 2014).

Task 4: Considering uncertainties and non-linearities
Protocols for scaling these values to reflect full site specific designs and aggregating across multiple installations will be developed, and the uncertainties and non-linearities of such scaling will be considered. Similarly the uncertainty associated with each benefit category and any monetized values determined will be evaluated, and the effects of high or low economic growth and high or low climate change possibilities assessed. (Oct 2014 –Dec 2014).

[3] SWITCH is an EU-funded research programme UNESCO-IHE as lead partner) (http://www.switchurbanwater.eu/

Task 5 MCDA for component selection/specification
Based on stakeholder feedback and preferences identified in WPs 1 and 2c (including investigating public views on the long term cost and societal and well-being benefits of Blue-Green infrastructure features in UFRM), use of multi-criteria analysis will be explored for component selection, and strategic prioritisation. Existing uses of MAUT and AHP in flood management in Germany and America will be assessed, and example methodologies produced demonstrating how the inclusion of multiple benefits can enhance the selection of optimal design, planning and operational aspects of Blue-Green infrastructure in urban environments. (Jan 2015-Jun 2015).

Task 6: Re-evaluation/modification of design procedures
A re-evaluation of current design procedures will be undertaken to address enhanced ways of achieving the most significant benefits. This will consider, for example, specifying levels of water quality improvement which can be achieved by different types of bioswales and retention ponds. (Mar – Dec 2015).

Task 7: Application to Demonstration City
The procedures developed will be tested and validated in the Demonstration City (WP5), allowing alternative designs and UFRM policies to be evaluated. (Jan 2015 – Sep 2015).

Task 8: Compilation of final report
Compilation of final report and recommendations (from WP3 and WP4). Knowledge transfer to end users. (Oct 2015 – Dec 2015).

- **Links to other WPs and Contribution to Consortium Outcomes**

Links to other WPs have been identified in the preceding sections, specifically to WPs 1, 2, 3 and 5.

WP4 Outcomes include:

1. An understanding of the nature, potential and significance of a range of benefits which can accrue from Blue-Green infrastructure and other flood management interventions under non-flood conditions.
2. Recognition of the compound uncertainties involved in achieving multiple benefits at scale.
3. Enhanced design procedures to optimize potential multiple benefits of flood risk management strategies and installations.

2.2.7 WP5: Demonstration Study

- **Aims and Objectives**

The overarching aim of WP5 is to illustrate how the approach adopted in this project, for the development of new strategies for managing urban flood risk and utilization of Blue-Green infrastructure, can be used to support learning from multiple feedback loops at every stage of UFRM appraisal, decision making, implementation, evaluation and adaptation.

Specifically, the objective of WP5 is to:

Deploy and demonstrate the applicability of the methods, measures and evaluations developed in WPs 1-4 in an urban location with hydrological, topographic, urban density, and socio-economic

conditions that are representative of those found more widely in UK cities.

The Demonstration Study will endeavour to incorporate the understanding and interest of a wide range of stakeholders in UFRM and connect this with the potential impact of adopting the Blue-Green vision in a practical, real-life setting.

WP5 will also investigate policy and legislation in the Demonstration City and in a wider UK context to consider the impact (positive/negative) of the Blue-Green Cities Project on the current governance system with respect to UFRM and surface water management. UK policy disincentives and blockages are almost certainly a reason why the adoption of Blue-Green approaches and infrastructure is lagging other countries. WP5 will communicate progress to stakeholders involved in policy making and generate usable outputs which may support future UFRM plans.

In addition, WP5 will consider the wider focus of Blue-Green Cities, e.g. Blue-Green communities, looking beyond cities to smaller urban or semi-urban locations where the same ideals and principals apply.

- **Work Package Team**

WP5 will be led by The University of Nottingham and Colin Thorne. Emily Lawson (Nottingham RA) will work full time WP5 for 12 months during year 3. Heather Haynes, Scott Arthur, Jenny Mant, Jessica Lamond, Dick Fenner and Dabo Guan (and their PDRAs) will switch their personal research time and resources to WP5 in year 3, as the Work Packages they have been leading or involved in reach completion. Leonard Smith, Nigel Wright and Chris Kilsby will continue with WPs 1 and 2a throughout year 3, facilitating stakeholder engagement, uncertainty communication and inundation modelling (incorporating methods for accounting for sediments, debris and stakeholder response developed in WPs 2b and c) in the context of the Demonstration City (WP5). The whole project team will be involved in preparation of the Demonstration City Workshop and Final Report at the end of year 3 (month 36).

- **Study Approach and Methods**

The research involves several, largely sequential tasks. To encourage communication between researchers, end-users and stakeholders, the project will be promoted by social media (Twitter, LinkedIn, project website with discussion forums) as part of WP1. In year 3, these methods of communication will be specifically targeted towards end-users and relevant, interested stakeholder groups, including academics, Local Authorities, consultant, planners and developers, and citizens of the Demonstration City. Web-based tools will be used to facilitate discussion and engagement with relevant local parties regarding the development of new UFRM strategies and utilization of Blue-Green infrastructure. Insights will be fed back to the research Consortium team and to encourage methodological evolution to support stakeholder and end-user requirements, and to promote learning from multiple feedbacks loops in UFRM research and development.

The Demonstration City will be chosen during Year 1 of the project, and will be a focus for the deliverable outputs. Demonstration City selection will build on UFRM research performed by the FRMRC by selecting one of the cities studied intensively recently as part of co-location and case study research. Candidate cities include Derby, Glasgow, Leeds, and Newcastle. The most attractive site will satisfy all/most of the following criteria;

- availability of a comprehensive database on urban flood infrastructure, inundation modelling, flood damages, social and cultural dimensions of flooding and public attitudes and expectations;
- an active and well-informed group of stakeholder organisations including the City Council, EA/Scottish Environment Protection Agency (SEPA), private water companies and other competent authorities;
- willingness of key stakeholders to engage with academics and the project.

These elements are essential to ensure that the Demonstration City can fully support the research and is in a position to actively uptake its outcomes and user-focused deliverables.

In addition, other cities may be selected by the team as sites for secondary case studies designed to demonstrate the applicability of specific new methods and strategies for managing urban flood risk developed within or between Work Packages. The aim will be to test these Work Package outcomes within the context of wider planning to achieve environmental enhancement and urban renewal in which multiple benefits of adopting the Blue-Green approach can be rigorously evaluated.

Active dissemination of Case Study results will be assisted by CIRIA (Construction Industry Research and Information Association) and will include publication of a CIRIA Report as well as one domestic and one international stakeholder workshop. The project team will draw heavily on and make best use of experience gained from FRMRC in all aspects of project dissemination.

- **Choice of Demonstration City**

In June 2013 the Research Consortium selected Newcastle as the Demonstration City. Newcastle experienced major flooding events in June (Toon Monsoon) and August 2012, both ~100 year return period, and is vulnerable to flash floods as 92% of the city centre surface is impermeable. Local drainage systems are often unable to cope with high volumes of rain over short periods leading to sewer incapacity and surcharge. New strategies for removing surface water from combined sewers are required to free up capacity and enable the drainage system to cope with future expansion. There is interest in Blue-Green strategies for flood risk management from key stakeholder groups (Newcastle City Council, Northumbrian Water, Newcastle University, Environment Agency, architects, land owners and consultants), and an active stakeholder community and buy-in to the Project.

The NewcastleGateshead Surface Water Management Plan; Identifying Areas at Risk report (http://goo.gl/wx73uF) has identified 37 hotspots in Newcastle at risk of surface water flooding. The Blue-Green Cities team will choose several of these as sub-catchments, including those with an open watercourse and/or culverted watercourse, based on team discussion and consultation with the key stakeholders during the Learning and Action Alliance meetings (WP1).

- **Research Plan and Schedule**

WP5 (Demonstration City) represents the final component of the project and is fundamental to its goal of putting stakeholders at the centre of UFRM modelling and decision making, and hence, will not begin until the third year of the project. In year 1, the team will discuss potential Demonstration Cities and agree on one flagship city as the focus of WP5, plus other cities (including a sub-watershed in the City of Portland) designed to act as secondary case studies. Emily Lawson will establish personal connections (via social media) throughout years 1 and 2, to gather interest in the project which will be beneficial for communicating the Consortium outcomes from the Demonstration Study in year 3.

On completion of WP5 (month 36) a Demonstration City workshop will be held and a Final Report produced evaluating the multiple flood risk benefits of blue green infrastructure in the chosen city. This will incorporate deliverables from WPs 1-4 but will be specific to the Demonstration City.

- **Links to other WPs and Contribution to Consortium Outcomes**

WP5 will build on research developed in WPs 1-4 throughout the first two years of the project to test and apply the models and performance evaluation methods to the Demonstration City. Illustrating the applicability of the research to a specific urban catchment with distinctive flood risk management issues, environmental and regulatory constraints, and identifiable goals (environmental, social, and economical) will be the key Consortium outcome from WP5.

3. PROJECT MANAGEMENT

3.1 Management Structure

The project is coordinated and managed at The University of Nottingham by Colin Thorne, with assistance from Nigel Wright, Dick Fenner and Emily Lawson, and administrative support from Lindsey Air.

Progress Meetings are held at three monthly intervals, alternating between virtual and round-the table formats.

The Strategic Advisory Board (SAB) provides oversight, with the SAB inter-acting formally with the Consortium Research Team at bi-annual, strategic review and feedback meetings.

Active dissemination will be assisted by CIRIA, who have been contracted to organize one Project Dissemination Workshop and to publish one CIRIA Report.

It is also planned to organize additional stakeholder workshops on selected topics in urban flood risk management, some of which will be held in Northern Ireland, Scotland and Wales. In all aspects of project management and dissemination, the project team will draw heavily on and make best use of experience gained from the FRMRC.

3.2 Financial Management

The grant is administered by The University of Nottingham under the terms of the Award Letter (Annex VII) and the Consortium Agreement (Annex VIII).

The Consortium Administrator (Lindsey Air) will work with the Finance Officer in the School of Geography at The University of Nottingham (Jonathan Walton) to produce Quarterly Budget Reports, listing project expenditure to date compared to the project budget according to the categories listed in the University's AGRESSO accounting system. The budget reports will be issued in advance of each Quarterly Progress Meeting and review of the budget reports will be an agenda item at all meetings.

Any issues that arise concerning the budget report will be discussed at the meeting with appropriate actions being agreed at that meeting. Where actions are agreed, these will be completed and reported back to the Consortium Administrator in advance of the next Quarterly Progress Meeting.

3.3 Dissemination

Dissemination will be led by the Consortium Management Committee (Colin Thorne, Nigel Wright, Dick Fenner, and Emily Lawson), supported by the Consortium Administrator and with the assistance of Paul Shaffer of CIRIA, who are contracted to provide such support.

3.4 Strategic Advisory Board (SAB)

The membership of the SAB is listed in Table 4. The Terms of Reference of the SAB may be found in Annex III. Responses from the Research Consortium to SAB feedback after the June 2013, December 2013, and June 2014 Quarterly Progress Meetings are detailed in Annexes IV, V and VI.

Table 4. Membership of the SAB

Name	Organisation	Contact Details
Mark Fletcher	Arup	Rose Wharf, 78 East Street, Leeds LS98EE t. 0113 242 8498, m 07880 785627 Mark.Fletcher@arup.com
Michael Henderson	AECOM	Mid City Place, 71 High Holborn, London WC1V 6QS t 020 7465 2000 michael.henderson@aecom.com
Adam Baylis	Environment Agency	Adam.baylis@environment-agency.gov.uk
Cameron Sked	Environment Agency	Cameron.sked@environment-agency.gov.uk
Fola Ogunyoye	Haskoning	Rightwell House, Bretton, Peterborough, PE3 8DW T.01733 336506 M. 07920 016148 fola.ogunyoye@rhdhv.com
Kit England	Newcastle City Council	Civic Centre, Barras Bridge, Newcastle upon Tyne, Tyne and Wear NE1 8QH kit.england@newcastle.gov.uk
Dave Gowans	Moray Council	Council Offices, Academy Street, ELGIN, IV30 1LL Tel. 01343 543451 David.Gowans@moray.gov.uk
Maggie Skenderian	City of Portland	Bureau of Environmental Services, 1120 SW Fifth Ave., Portland, Oregon 97204, USA Phone : (503) 823-5334 fax : (503) 823-6995 maggie.skenderian@portlandoregon.gov www.portlandoregon.gov/bes
Bruce Roll	Clean Water Services	16060 SW 85th Ave, Tigard, OR 97224, USA RollB@CleanWaterServices.org http://www.cleanwaterservices.org/
David Porter	Rivers Agency	Hydebank, 4 Hospital Road, Ballydollaghan, Belfast BT8 8JP . T: 028 90 253 227 (53227) M: 077 177 32 456 David.Porter@dardni.gov.uk
Hans Jensen	UKWIR	UK Water Industry Research Ltd, 1 Queen Anne's Gate London SW1H 9BT, T: 0207 344 1868 Hans.Jensen@ukwir.org.uk

3.5 Research Collaboration (National)

The Consortium's primary vehicle for national collaboration will be the EPSRC Flood Risk Management Network, which is being organized by Garry Pender at Heriot-Watt University and will be funded by a network grant recently awarded by the EPSRC.

The Network's core academic members will be drawn from the three research consortia funded at the April 2012 'Sand Pit', which include this Consortium plus ones led by Chris Kilsby at Newcastle University and Graham Coates at Durham University.

Chris Kilsby's Consortium - Flood MEMORY: Multi-Event Modelling Of Risk & recoverY (http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/K013513/1) concerns the most

critical flood scenarios caused by sequences or clusters of extreme weather events striking vulnerable systems of flood defences, urban areas, communities and businesses. The research will assess the risk of situations where a second flood may strike before coastal or river defences have been reinstated after damage, or householders and small businesses are in a vulnerable condition recovering from the first flood. By examining such events and identifying the worst case scenarios, the researchers hope their findings will lead to enhanced flood resilience and better allocation of resources for protection and recovery. Ultimately the processes developed could be used worldwide.

Research led by Graham Coates at Durham University - Organisational Operational Response and Strategic Decision Making for Long Term Flood Preparedness in Urban Areas, known as SESAME (http://gtr.rcuk.ac.uk/project/B75839B5-9C3E-430A-B86E-BF319CAFFB64) will develop cutting-edge computer modelling to look at how emergency planners, the emergency services, local authorities, businesses and other key players interact in the aftermath of a flood. The research will lead to the creation of the first unified framework which integrates and evaluates organisations' changed behaviours in the face of flood events and how these impact on business continuity management and future preparedness. The findings will go towards better planning and response in the future as well as mitigating economic losses.

The EPSRC FCERM Network (http://www.fcerm.net/) will also include academics from selected flood risk management research projects in the UK funded by other organisations, plus a wide variety of stakeholders and professionals from the flood risk management community.

3.6 Research Collaboration (International)

Cities in Europe (e.g. Copenhagen, Rotterdam, Lodz, Graz, Berlin) North America (e.g. Portland, Philadelphia, New York) and Australia (e.g. Melbourne, Adelaide) are addressing the challenges raised in this research programme.

Links will be developed with the authorities in these locations to identify and share best practice as well as with bodies such as the International Water Association (IWA, Cities of the Future Programme), and European Programmes (e.g. MARE – Managing Adaptive Responses to changing Flood Risk).

Academic Institutions with whom dialogue will be established include Monash University's Centre for Water Sensitive Cities**,** UNESCO-IHE Flood Resilience Group, and the MIT Department of Urban Studies and Planning (Co-LAB).

Between April 21 and 28, the Consortium undertook a mission to Portland, Oregon to initiate an important international collaboration with the City of Portland. The programme for the mission is included as Annex IX.

The outcomes of the mission are currently being worked up and are underpinning a bid to the EPSRC for supplemental funding under the 'Clean Water for All' programme to substantive, support collaborative research in 2014.

Update: April 2014. The 'Clean Water for All' (CWFA) bid was successful and forms a stand-alone project to be completed in 2014. This builds on the collaborative partnerships with American colleagues engaged in National Science Foundation funded research that complements, without duplicating, that of Blue-Green Cities. More information can be found on the webpage (http://www.bluegreencities.ac.uk/bluegreencities/research/clean-water-for-all.aspx) and in the CWFA inception report (http://www.bluegreencities.ac.uk/bluegreencities/documents/inceptionreportv5.pdf).

3.6. Engagement with related projects

There will be a two-way exchange between the Blue-Green Cities Research Project and similar research at national and international levels. In addition to the specific projects that each WP will engage with (listed in Section 2), a larger list will be added to the Blue-Green Cities website for reference by the Consortium. This will be regularly updated as new research, reports and blogs of interested are created.

4. REPORTING

1.1. Internal Monitoring and Reporting

Internal monitoring and reporting will be handled through Quarterly Progress Meetings, with the minutes (including copies of power point presentations and supporting documents) being posted on the Consortium website.

4.1.1 Scientific Progress Reporting

Copies of all scientific and technical outputs will be submitted to the Consortium Administrator for recording and posting on the Consortium web site. Scientific progress will be reported to and reviewed by the SAB at bi-annual meetings and reported to the EPSRC in line with the terms and conditions of the award Letter (Annex VII).

4.1.2 Financial Reporting

Financial reports will be prepared by the Principal Investigator with assistance from the Consortium Administrator in accordance with the terms of the Award Letter (Annex VII). When necessary, financial information required to produce these reports will be supplied by the Co-Investigators in accordance with the Consortium Agreement (Annex VIII).

4.1.3 Strategic Advisory Board

The Strategic Advisory Board (SAB) will report their comments and advice in a short written report submitted to the Consortium Administrator following each of its six formal meetings. In addition, the SAB will (with assistance from the Consortium Management Committee) assess the practical relevance of the Consortium's research in an applications-oriented science audit at the end of Years 1, 2 and 3.

4.1.4 Reporting to EPSRC

Reports to the EPSRC will be prepared and submitted as required under the terms and conditions of the Award Letter (Annex VII).

5. ANTICIPATED OUTPUTS AND THEIR DISSEMINATION

5.1 WP1: Communications between Scientists, Institutional Stakeholders & Communities

Outputs to other Work Packages

The main output of WP1 will be the establishment of effective communication routes between the WPs and encouragement of discussions by the team to aid the progression of the individual WPs.

Specifically, WP1 will identify communication gaps early in the research and development process (years 1 and 2) and within the model components prior to presentation to the Consortium for use in the Demonstration City case studies in year 3. The communication and engagement routes explored as part of WP1 will ensure impact through dissemination of the project as part of WP5. External communication with stakeholders will complement the participatory methods developed as part of the EPSRC Quota Studentship (Annex II).

WP1 will also produce a framework for identifying and ranking the Relevant Dominant Uncertainties (RDUs) involved in planning and delivering Blue-Green infrastructure.

In addition, WP1 will facilitate the discussion of uncertainty (and effective communication of uncertainty) throughout all WPs and aid model development by the designation of Failure Pathways.

Academic Outputs

Academic outputs from WP1 will include the presentation of work at national and international conferences and publication in appropriate, peer-reviewed international journals, to be identified as the Work Package progresses. Long-range goals will be to publish a paper(s) in a special issue of The Journal of Flood Risk Management, and present to a different academic audience, such as Urban Design and Planning.

Practitioner Outputs

The primary deliverable of WP1 to practitioners is co-production of more robust knowledge and understanding of uncertainty flows in flood risk modelling and RDUs surrounding Blue-Green infrastructure: a prerequisite for practitioner confidence in model results and the decisions based on them. To demonstrate and exchange new knowledge, we will engage with professional associations such as the IWA, internationally, and CIRIA, nationally.

Public Outputs

The co-production and exchange of more robust knowledge will also be the primary public output of the project, and delivered through workshops and dialogue with stakeholder groups. The Learning and Action Alliance is also intended to run beyond the time scale of the project.

Other Outputs

Masters projects associated with the Blue-Green Cities project will provide research training and enhancement of knowledge for postgraduate students and help build a network of future

scientists working on flood risk management. Guidance of Masters Projects by the RAs will allow the development of leadership and mentoring skills. We will also have an active blog on the Blue-Green Cities website to encourage wider engagement with the project (http://blogs.nottingham.ac.uk/blue-greencities/).

5.2. WP2a: Inundation Simulation

Outputs to other Work Packages

WP1: descriptions of uncertainty.
WP3: predictions of the impact of Blue-Green features.
WP5: models of the Demonstration City.

Academic Outputs

Conference papers at Hydroinformatics 2014, International Conference on Fluid Mechanics (ICFM) 2014, International Association for Hydro-Environment Engineering and Engineering and Research (IAHR 2015), and Hydroinformatics 2016. WP2a will produce one journal paper in each of the above areas, i.e. 4 in total.

Public Outputs

Public engagement events and ongoing media work.

Other Outputs

MSc and MEng projects.

5.3 WP2b: Sediment, Debris and Habitats

Outputs to other Work Packages

The key outputs from WP2b to WPs 2a and 3 are:

1. analysis of sediment and debris dynamics through the Blue-Green urban drainage system to support hydraulic flood risk modelling, inundation mapping and enhanced urban flood risk assessment, and;
2. sediment and debris source – sink analysis of the urban form and Blue-Green network elements,
3. continuity analysis of Blue-Green elements as a network to support effective Blue-Green design,
4. multi-benefit analysis of Blue-Green infrastructure and urban drainage source-pathway-receptor design elements with respect to morphology and habitats. Specifically, sediment and debris related benefits, consideration of the impact and influence on flood risk.

These outputs, in conjunction with WPs 1 to 4, will inform and provide the inter-related set of outputs needed to support the Demonstration Study in WP5.

Academic Outputs

Academic papers

- Preparation and submission of three academic journal papers

- Preparation and presentation of two conference papers (including the 35th IAHR World Congress and the International Conference on Urban Drainage, ICUD)

Workshop and collaborative publication activities

- Interurba – Modelling the urban water cycle as part of the city, attendance and input into academic workshop and outcome publications

Practitioner Outputs

A greater, and more detailed, understanding of Blue-Green infrastructure sediment transport dynamics. This will support advancement and improvement in design, both of individual elements, but also the composite systems, their location within the urban landscape, their management and maintenance.

Deliverables

- CIRIA guidance publication (relevant chapter and collaborative input)
- Local authority (West Lothian Council/SEPA) guidance and support on Almond Basin river health (EU WFD) improvement opportunities

Public Outputs

Presentation through local public engagement activities, as appropriate and opportune.

5.4 WP2c: Behavioural responses of Individuals and Institutions

Outputs to other Work Packages

- Ongoing knowledge-exchange with WP1 to ensure community participants have chance to contribute to thinking around inherent uncertainties in modelling.
- Sociological models developed in WP2c feed into development of an agent-based model in WP2a (typologies of community actors).
- Discussions in WP2c will help with co-developing local understandings re: WP3.
- WP2c findings will help develop understandings of locally perceived socio-economic costs and benefits of Blue-Green approaches to flood risk management in WP4.
- WP2c findings and community engagement will contribute to implementation of WP5.

Academic Outputs

- We will produce at least three publications from the Work Package (these may include refereed journal articles, book chapters and/or conference-related publications).
- We will produce one book contribution in this Work Package.
- We will make four conference presentations based on our work on the project.

Practitioner Outputs

- We will produce outputs for a range of practitioners, their format depending to some extent on feedback from the concerned parties as to what would be of most use to them. First thoughts on this include:
- An *Advice on Community Engagement* document for the Environment Agency;
- Guidance notes on *Blue-Green Approaches and Communities* for Local Councils;
- A *Workshop Toolbox* for all interested external parties;

- A *Recommended/Best Practice* papers for the National Flood Forum.

The content of these outputs will depend upon the outcome of discussions with all the above-named groups, and will be tailored according to their stated preferences.

Public Outputs

- One public feedback session on the WP2c work with participants.
- A public-facing summaries of the work conducted & findings from the Demonstration City.

5.5 WP3: Flood Risk Management Components and Interfaces

Outputs to other Work Packages

WP2b	Impact of corridors for sediment management on wider urban infrastructure and services.
WP4:	A system analysis of infrastructure dependencies around relating to green infrastructure components in UFRM strategies at different spatial scales (for flood footprint analysis)
WP5:	A policy analysis of options for alternative UFRM strategies in the Demonstration Cities.

Academic Outputs

Conference presentations (e.g. 8th International Conference on Water Sensitive Urban Design, Gold Coast Australia, October 2013 and subsequent events; 13th International Conference on Urban Drainage, Sarawak, Malaysian Borneo 7-11th September 2014, The International Conference on Sustainable Development of Critical Infrastructure (IC-SDCI 2014), Shanghai , May 16-18 2014 or subsequent events).

Journal papers: Proceedings of the Institution of Civil Engineers (Water Management; Flood Risk Management); Water and Environment Journal, Chartered Institution of Water and Environmental Management (CIWEM); American Society of Civil Engineers (ASCE) Journal of Environmental Engineering.

Output will inform other research groups working in related e.g. at Sheffield University (Pennine Water Group), Exeter University (Centre for Water Systems), Imperial College (Department of Civil and Environmental Engineering – Blue Green Dream); UNESCO-IHE Flood Resilience Group; Monash University's Center for Water Sensitive Cities, and elsewhere.

Practitioner Outputs

- Recommendations for the integration of Blue-Green FRM measures with wider planning.
- Recommendations for the optimum spatial distribution of FRM components in a Blue-Green city.
- Interaction with CIRIA through Advisory Panel for Exceedance of Urban Drainage Systems Manual, and with the Institution of Civil Engineers (ICE).
- A flood footprint analysis for economic impacts of floods at the global scale.

Public Outputs

Workshop with planners and regulators to explore opportunities for intervention and integration.

5.6 WP4: Evaluation and Synthesis of Benefits

Outputs to other Work Packages

WP5: evaluation of alternative designs and policies in the Demonstration City.

Academic Outputs

Conference presentations (e.g. 8th International Conference on Water Sensitive Urban Design, Gold Coast Australia, October 2013 and subsequent events; 13th International Conference on Urban Drainage, Sarawak, Malaysian Borneo 7-11th September 2014).

Journal papers: Proceedings of the Institution of Civil Engineers (Water Management; Engineering Sustainability); Water and Environment Journal (CIWEM); ASCE Journal of Environmental Engineering.

Output will inform other research groups working in related e.g. at Sheffield University (Pennine Water Group), Exeter University (Centre for Water Systems), Imperial College (Department of Civil and Environmental Engineering – Blue Green Dream); UNESCO-IHE Flood Resilience Group; Monash University's Center for Water Sensitive Cities, and elsewhere. Specifically, there will be collaboration with CIRIA in the production of RP 993: "Multiple benefits of SuDS systems" through the development and testing of a planned online benefit valuation tool.

Practitioner Outputs

- Evaluation and valuation of benefits from individual components of Blue-Green infrastructure installations within FRM strategies and the uncertainties involved in their quantification and scaling, and proposals on how to assess the significance of benefits in specific contexts and locations.
- A decision support tool (in Q-GIS) for option of appraisal of appropriate infrastructure and FRM strategies within a Blue-Green approach to integrated urban planning and urban renewal.
- Appraisal of current design methods for SuDS and recommendations (where appropriate) for ways in which design can enhance/optimize the most significant benefits.

Public Outputs

Dialogue with stakeholder groups about priorities, preferences and payment for Blue-Green design strategies

Other Outputs

Possible Software package for a benefit evaluation tool.

5.7 WP5: Demonstration Study

Outputs to other Work Packages

WP5 will build on outputs from WPs 1-4 and the facilitation of stakeholder engagement, uncertainty communication and inundation modelling (including sediments, debris and stakeholder response) in the context of the Demonstration City. Equally, outputs from stakeholder engagement during WP5 will feed in to WPs 1, 2a, 3 and 4 (which continue during year 3) by presenting additional, user-friendly methods of UFRM and decision making. WP5 will serve as a means of knowledge exchange between researchers in the WPs and stakeholders/end-users.

Academic Outputs

We will present work at national and international conferences such as the biennial International Conference on Water Sensitive Urban Design. In the later stages of the project we will publish in appropriate, peer-reviewed international journals, such as the Journal of Flood Risk Management.

Practitioner Outputs

Research in the project will start by drawing on the procedures already adopted by practitioners in designing urban fabrics, spaces and green corridors including, amongst others, the SuDS Manual, the River Restoration Centre (RRC) Manual, and relevant CIRIA Reports. This means that the project's outputs will be set in a framework that is readily usable by practitioners.

The main deliverables to practitioners will be a guide to developing new strategies for managing urban flood risk and incorporating Blue-Green infrastructure in the design. We also aim to produce a benchmark for successful stakeholder engagement throughout the project planning, application and evaluation stages, for active implementation by practitioners. The project team will participate in a CIRIA workshop (organized by Paul Shaffer) towards the end of year 3 to aid with disseminate of the project deliverables to UK stakeholders and interested practitioners. CIRIA have agreed to Report based on our research outcomes.

Public Outputs

Details of the research leading to, and comprising, WP5, will be communicated regularly with the public through internet-based tools (project website, twitter feed and LinkedIn). Community members/end-users will have the opportunity to be involved with model development and evaluation during year 3 when the Demonstration City, and smaller, potential case study sites, has been identified and work on an effective FRM plan incorporating Blue-Green infrastructure is being developed. Public output in the form of workshops and events will occur throughout year 3.

A Demonstration City workshop will be held at the end of year 3 to illustrate how the project has evaluated the multiple flood risk benefits in Blue-Green cities and demonstrate the advantages of Blue-Green infrastructure in the context of the respective city community. The main deliverable from this will be a guide to flood risk management and environmental enhancement utilising Blue-Green methods that ideally, could influence local stakeholder and policy makers. The multi-functionality of Blue-Green infrastructure allows numerous development plan policies to support the implementation, e.g. landscape, flood risk, open space planning, sustainable transport policies.

Other Outputs

A final output from this project relates to the experience and knowledge that will be gained by all researchers involved. The novel engagement with and involvement of end-users throughout the project, and particularly during the Demonstration Project, will lead to the PDRA's gaining experience in ensuring impact at the early stages of their research careers that they will carry through to future projects, perpetuating pathways to impact established herein.

5.8 Dissemination Plan

Managing the risks of urban flooding to individuals, communities, businesses, property, infrastructure, commerce and the environment in cities, lies at the heart of this project. The project objectives include studies of the impact on, and feedback from stakeholders including not only FRM planners and decision-makers, but also individual citizens, community leaders, businesses, etc. In this respect, co-production of knowledge is integral to the research and the dissemination of our findings will begin on day 1. For example, the objectives of the project include to:

"Put competent authorities, businesses and communities at the centre of the research by establishing feedback pathways between them and the UFRM modellers, planners and decision makers to ensure co-production of knowledge."

And,

"Illustrate how this approach can be used to support learning from multiple feedback loops at every stage of UFRM appraisal, decision making, implementation, evaluation and adaptation."

Further, WP1 is focused on communication throughout the project. This will ensure that stakeholders are engaged in the modelling, UFRM options selection and evaluation of UFRM benefits in Blue-Green Cities from start to finish, in order to negotiate project outcomes, enhance their reliability and ensure buy-in from end users and uptake of the project's user-focused deliverables.

In addition to engaging with end-users in co-production of knowledge and outcomes through WP1, further steps to ensuring impact through dissemination include:

1. Engagement with key stakeholders beyond those involved directly in the project through fieldwork (especially questionnaires and focus groups in WP3), meetings and workshops that will include:
    a. Statutory authorities such as the DEFRA, EA for England and Wales, SEPA, and the Northern Ireland Rivers Authority, based on links that already exist between the Investigators and these bodies (especially those forged during the FRMRC) and as well as new contacts;
    b. Built environment professionals such as architects, civil engineers, urban planners, transport and highways bodies and their professional institutions.
    c. Local councils in the research study and Demonstration Cities. Glasgow is a strong candidate Demonstration Study because of the existing engagement of the Local Authority in developing a Blue-Green city. Derby, Leeds and Newcastle are also possibilities for similar reasons.
    d. Citizens through engagement with Non-Governmental Organisations (NGOs) such as the Rivers Trusts, National Flood Forum and appropriate local social enterprises.

2. Research in the project has started by drawing on the procedures already adopted by practitioners in designing urban fabrics, spaces and green corridors including, amongst others, the SuDS Manual, the RRC Manual, FRA Channel Design Options, Foundation for Water Research FR/R0014, Defra FD2619 and relevant CIRIA Reports. This means that the project's outputs will be set in a framework that is readily usable by practitioners. For example, CIRIA (Paul Shaffer) have agreed to organise a dissemination workshop for UK stakeholders and to publish a CIRIA Report based on our research outcomes. They will also serve on the SAB during the second half of the project.

3. We have put in place a SAB made up of senior professionals in UFRM including representatives of the Environment Agency, Department of Agriculture and Rural Development (DARD), the insurance sector, consultants, the City of Portland and UKWIR.

4. We will engage with professional associations such as the IWA internationally and CIRIA nationally. IWA already have a "Cities of the Future" initiative with which we will interact.

5. We will present work at national and international conferences such as the biennial International Conference on Water Sensitive Urban Design. In the later stages of the project we will publish in appropriate, peer-reviewed international journals, such as the Journal of Flood Risk Management.

6. Internationally, we are engaging with other projects such as the Delft Flood Resilience Group (www.floodresiliencegroup.org) and the highly regarded, "2008 Grey to Green" initiative in Portland, Oregon.

7. We will communicate the research on an on-going basis through internet-based tools including a project website, Twitter feed and LinkedIn group maintained by Emily Lawson.

The Investigators all have prior experience of working with end-users in other projects. In particular Colin Thorne and Nigel Wright have been involved in generating user-focused research outputs in FRMRC. In this context, Colin Thorne was deputy Chair (Dissemination) for the FRMRC and he chaired FRMRC's Dissemination Committee. The University of Nottingham were responsible for the two User-focused Deliverables produced during FRMRC 1 and have been involved in producing 3 of 4 CIRIA Reports coming out of FRMRC 2. In this respect, the professional and stakeholder networks already developed under FRMRC will bring a large group of end-users to this project.

Other co-investigators are involved in a variety of related, funded projects (EU, Research Councils, etc.) both in the UK and internationally that will ensure two-way engagement with this project.

Finally, the novel engagement with and involvement of end-users throughout the project will lead to the RA's gaining experience in ensuring impact at the early stages of their research careers that they will carry through to future projects, perpetuating pathways to impact established herein.

5.9 Key Performance Indicators (KPIs)

The performance of the Consortium will be monitored by the management team in relation to key performance indicators. Each of the Project's WPs have their own time line, milestones and

outputs, which will be used to gauge and assess the successful and timely completion of each element of the research programme. Comparison between research progress and the agreed timelines will alert the Management Committee if any tasks are late so that timely corrective action can be taken. The need for and, when necessary, the nature of changes to the work programme will be identified and fully documented. Indicators of progress and success within the WPs that may be used by the management committee include:

- Manuscripts submitted to peer reviewed journals
- Conference papers
- Technical reports
- New collaborations
- Interactions with stakeholders and users
- Interactions with elected representatives and other decision makers
- Interactions with the international research community
- Generation of additional, related research funding
- Outreach activities

Additional KPIs to be monitored by the Management Committee include:

- interest in the Consortium website (e.g. number of hits and queries/contacts).
- interest expressed in urban flooding and Blue-Green Cities more generally, for example through interest in other websites (number of hits; of queries, etc.).
- highlights on wider societal and/or ethical components of the Project, such as public outreach activities.
- collaboration and data exchanges with groups and organisations outside of the UK.
- overall quality and efficiency of the "external" communication strategy of the Consortium and level of European and International recognition of the Project's research, as evidenced by co-citation, referencing, requests for information received by Project Administrator, invitations received by the Partners, etc.
- management of intellectual property and commercialisation of research output: as evidenced by management reporting.
- capacity of the Consortium to meet financial targets and to deliver results on time and on budget: as formally reported to the EPSRC and DARD Rivers Agency.
- progress towards delivering the stated outputs and outcomes.

5.10 EPSRC Science Audit

The quality of the science being developed by the Consortium within the project will be assessed using the normal EPSRC peer review procedures. The practical relevance of the work will be assessed with the help of the SAB which will conduct an applications oriented science audit at the end of Years 1, 2 and 3.

6. MANAGEMENT OF RESULTS AND PROTECTION OF INTELLECTUAL PROPERTY RIGHTS (IPR)

The obligations resulting from the Award Letter (Annex VII) are binding for The University of Nottingham as the organisation to which the grant has been awarded and extend to the other universities participating in the Consortium through the operation of the Consortium Agreement.

The EPSRC can request access to information held by any of the universities in the Consortium and the EPSRC requires them to comply with the Freedom of Information Act 2000 and the Environmental Information regulations.

The EPSRC must be informed of any major changes to the research project including in particular any failure to gain access to planned research facilities and services which will affect the deliverables. The EPSRC can request revised proposals and can decide to issue a new grant.

The ownership of intellectual property and responsibility for its exploitation rests with the research institutions. The research institutions have granted EPSRC licence to use the Results and Foreground IPR and the EPSRC may sub-licence each of the Funders.

Consortium universities and their researchers must ensure that all valuable results are protected and exploited and that they produce a suitable return. If the researchers do not intend to protect or exploit the results, the Funders have the option to have the IPR assigned to them at no charge. At their own expense a Funder(s) may protect or exploit those results. In such cases the researchers will not be entitled to a share of any income generated.

The Consortium universities must ensure that all those associated with the research are aware of, and have accepted the arrangements for exploitation of research findings and this is set out in the Consortium Agreement.

All results from the project (information and intellectual property rights resulting from the performance of the project) are the property of the university that has generated them. Ownership of information and intellectual property rights which pre-date the Consortium and/or are generated independently of the Consortium is not affected by the Consortium.

Each university owns the results it has generated or conceived. Commercial exploitation of the Results is required in accordance with the EPSRC Award Letter and universities should share the revenues resulting from the exploitation of joint results in proportion to their respective contributions and effort.

All decisions concerning the protection of IP should be made by the university(s) generating the results and they should pay the resulting costs (in the case of joint results in proportion to their share of the ownership). The universities undertake to provide reasonable assistance in connection with proceedings involving any patent filed in connection with any results from the project.

The universities are entitled to publish and to present papers based on Consortium research, but are requested to provide copies to the Consortium Administrator for recording and archiving. In cases were IP protection is being pursued, publication may be delayed to allow IP protection to be put in place.

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8. ANNEXES

Annex I. Bio sketches of the Consortium Team

I.1 Management Committee

Colin Thorne is the Principal Investigator for the Consortium. He is the Chair of Physical Geography at The University of Nottingham. His BSc and PhD are in Environmental Sciences (UEA) and he has held appointments at UEA, US National Sedimentation Laboratory, US Army Waterways Experiment Station, Colorado State University, Queen Mary University London and, since 1990, Nottingham. He has 30+ years' experience in basic and applied environmental science that encompasses multiple aspects of fluvial geomorphology and river management and extends from site-scale, fundamental research on bank stability, fluvial hydraulics and sedimentation to basin-scale, strategic and policy-related research on very large rivers. For the last decade it has centred on flooding and flood risk management. He was a WP leader in the Flood Foresight Project, a co-I in Phase 1 of the FRMRC, PI on the Pitt Flood Foresight Update, and PI on the China-UK Taihu Basin Flood Study. He was Deputy Director of FRMRC II, which ended in March 2012. He will apply his experience in helping lead research consortia in acting as PI for this project. The other members of the Consortium Management Team are Nigel Wright and Richard Fenner.

Nigel Wright has been Professor of Water and Environmental Engineering at the University of Leeds since 2009 and prior to this was Professor of Hydraulic Engineering at UNESCO-IHE/TU Delft. His work has focused on the application of computer methods to fluid flow in the natural and built environment. Whilst at The University of Nottingham until 2006 he developed a particular focus on modelling for flood risk management and was involved in the establishment of the UK Flood Risk Management Research Consortium. Within the Consortium, Nigel will provide technical expertise and leadership in modelling flood inundation in urban areas, algorithm development, model selection, model speed-up, uncertainty on flood risk management, primarily in Work Packages 2a and 5. He will also bring experience in the management and formal reporting of UKRC-funded projects as well as important links to related projects nationally and internationally.

Dick Fenner is a Chartered Civil Engineer and a Senior Lecturer in the Department of Engineering at Cambridge University. He has research experience on the maintenance and rehabilitation of urban drainage infrastructure, risk analysis of failure of non-critical sewers (GR/K5158/01) and the development of knowledge based systems for the performance assessment of sewer networks. He was a member of the Project Neptune Consortium for optimising sustainable water distribution systems (EP/E003192/1) and is currently a co-I on Sustainability and Proliferation Resistance Assessment of Open Cycle Thorium-Fuelled Nuclear Energy (EP/E 003192/1). He is also working with an industrially funded multi-disciplinary team on future resource pathways, involving modelling of integrated water use at various scales. He will provide technical expertise and leadership in urban drainage and multi-criteria analysis in Work Packages 3 and 4, while also assisting with day-to-day management, formal reporting to the EPSRC, networking and dissemination.

I.2 Co-Investigators

Scott Arthur is recognised internationally as an expert in drainage and the hydraulic performance of culverts. He has over 40 publications in international journals, 40 papers in peer reviewed conferences and has authored two book chapters, a CIRIA design guide and contributed to standards development in the UK, EU and USA. Additionally, he is an invited member of the international organising committees of conferences central to his fields of research. His research has been supported by EPSRC, the European Union and the Scottish

Government. Using internationally leading work studying the formation of blockages in sewers as a starting point, recent research undertaken as part of research Consortium activities (FRMRC II & EU-SAWA) has resulted in Heriot-Watt being regarded as leaders in understanding the flood risk associated with debris in rivers. Most recently, based on his SuDS and river debris work, Dr Arthur was asked to review SEPA's research strategy and the methodology used to prioritise flood risk management investment. Within the Consortium, Scott will lead research conducted as part of WP2b, on debris dynamics and related blockage risks in urban watercourses.

Dabo Guan is a Senior Lecturer in Environmental Economics at the University of Leeds. He has been working on several interdisciplinary projects in assessing socioeconomic impacts of climatic changes in those poor and vulnerable rural regions in developing countries (e.g. Eastern Himalayan, funded by Sida, Sweden) and rich with good adaptive capacities cities in developed countries (EPSRC funded ARCADIA). He has expertise in modelling the propagated effects of physical damage through economic supply chains. Dabo is an appointee of water@leeds, which is an interdisciplinary hub of 150 researchers including a number of cross-faculty, academic-industrial partnership fellowships. Dabo has strong collaborations with WWF, Yorkshire Water and Arup. He is also a Lead Author for the IPCC AR5. His work on embodied emissions in trade have been broadcast by various media such as Guidance, BBC Radio 4, and CNN. Within the Consortium, Dabo will lead research conducted in Work Package 4, on environmental economics and developing the concept of the Urban Flood Footprint.

Heather Haynes was appointed to Senior Lecturer in Sediment Processes at Heriot-Watt University in 2011. Her PI experience covers urban flood inundation modelling with integrated urban drainage (EPSRC CASE/CAN/06/05), flow-sediment measurements in gravel filter SuDS (Carnegie Trust) and physical modelling of sediment transport relating to flood history (EP/E030467/1). She is a Chartered Geomorphologist with strategic stakeholder partnerships with Scottish Environmental Protection Agency and engineering consultancies, whilst maintaining Learned Society outreach as a Fellow of the Royal Geographical Society (FRGS), sitting on the British Society of Geomorphology's Research Committee and as an invited member of the Royal Society of Edinburgh's Young Academy. Within the Consortium, Heather will lead research in Work Package 2b, on geomorphology and habitats in the urban watercourses.

Ian Holman is a Senior Lecturer in the Cranfield Water Science Institute, whose research focusses on the role of catchment characteristics in runoff generation, erosion and sediment delivery in predominantly rural catchments. Ian was also the lead author of reports to the Environment Agency on the extent and contribution of degraded soil conditions to the 2000 and 2007 floods, land use impacts WP Leader in DEFRA Project FD2120 and flood risk WP leader on Defra Project BD2304. In addition, he has extensive experience in the use of the Soil and Water Assessment Tool (SWAT) model for modelling catchment hydrological response and water quality.

Chris Kilsby is Professor of Hydrology and Climate Change in the School of Civil Engineering and Geosciences at Newcastle University. He has worked on hydrological risk in urban and catchment settings for over 20-years using a variety of physically based and statistical approaches. This work has increasingly been in the context of climate change impacts and sustainable adaptation responses. Recent work includes leading the Weather Generator component of the UKCP09 national climate scenarios and the development and use of extreme rainfall scenarios for urban drainage assessment at city scale. Within the Consortium, Chris will apply his expertise in stochastic processes and high resolution urban modelling to research in Work Package 2a.

Jessica Lamond is a senior research fellow in flood risk management at the University of the West of England. Her main research interests are in managing the consequences of flooding through buildings and behavioural adaptation and flood insurance. With a background of ten years decision support for Export Credit Guarantees Department and Unilever in interest rate hedging, consumer behaviour and market analysis Jessica gained her PhD in 2008, where she developed a new method to measure flood effect in property and insurance markets. Following this she has collaborated on projects for industry, government, national and international funders, for example the preparation of an integrated urban flood handbook for the World Bank in which she led a team of experts in climate, urban planning, health, drainage and solid waste. She has over 50 publications on flooding and the urban environment including "flood hazards, impacts and responses for the built environment" with Taylor Francis; journal articles, conference papers and practitioners' workshops. Within the Consortium, Jessica will participate in research on stakeholder communications in Work Package 1 and lead research on citizens' behaviours and responses in Work Package 2c.

Jenny Mant has experience in river restoration and management principles and processes including those associated with urban river systems. She has worked with a range of strategic stakeholders, consultants and public agencies across the UK in the context of delivering best practice catchment management. Her experience also spans the impacts of flood alleviation capital works on sediment and habitats by providing advice and input into the Defra/EA project (FD1920/TR) and follow-on Work Packages and the assessment of large wood in the context of modelling the impact in flood-risk prone areas. In addition she has experience in the assessments of the interactions between sediment, vegetation and hydrology in river systems. Within the Consortium, Jenny will be involved in Work Package 2b, taking the lead in research concerning sustainable management and restoration of urban watercourses.

Leonard Smith is a Fellow of Pembroke College, Oxford and Director LSE's Centre for the Analysis of Time Series (CATS). He has a longstanding interest in the interface of dynamical systems theory and meteorology, along with disentangling the effects of observational uncertainty and model error. He is a member of the WMO's Expert Team on Forecast Verification, has been a consultant to the European Centre for Medium-range Weather Forecasts for several years, and works closely with forecast development at the Naval Research Laboratory, home of the US Navy's operational model. He served as original co-chair of the Societal Impacts component of THORPEX (www.wmo.int/thorpex) and is a co-author of the THORPEX science plan. Professor Smith is also a key player within other major climate change institutes including the Grantham Research Institute on Climate Change and the Environment, the ESRC funded Centre for Climate Change Economics and Policy with the University of Leeds, and the related Munich Re Programme on "Evaluating the Economics of Climate Risks and Opportunities in the Insurance Sector" for which he is the PI. He is also currently PI of the NERC End-to-End Quantification of Uncertainty for Impacts Prediction (EQUIP) project. In 2003 he was awarded the Fitzroy Prize of the Royal Meteorological Society. Within the Consortium, Leonard will lead research on communicating risk and uncertainty to stakeholders, communities and citizens.

I.3 Research Associates

Emily Lawson Emily trained as a glacial water chemist at the University of Bristol and was awarded her PhD, 'Investigating Carbon Sourcing and Cycling in Subglacial Environments', in November 2012. This included designing novel incubation experiments to monitor CH4 and CO2 production in sub-ice environments, as part of a NERC-funded project ('biogenic production of climatic amplifiers under ice') at the University of Bristol. She then completed three months post-doctoral research investigating the impact of glacial nutrient export on ecosystem productivity in downstream, near-coastal marine environments. Emily then worked as a lecturer in Physical Geography at the University of Bristol, teaching Cryosphere units and

Physical Geography Research Methods (7 months) before joining The University of Nottingham as a Research Fellow in the School of Geography. She now works full time on the Blue-Green Cities project. Emily will assist the PI and Co-Is in integrating research across the Work Packages, with particular emphasis in WPs 1 and 5.

Deonie Allen is a qualified Environmental Scientist, having completed BSc and MSc degrees in environmental science and sustainable development. Her professional experience lies in hydrology and flood risk management, urban drainage and water sensitive urban design. She has been fortunate to work on design and impact assessment projects both across the UK and Australia, ranging from site specific design to strategic level planning. She has professional work experience in both private and public agencies, providing a rounded understanding of the challenges of sustainable urban drainage implementation. She is currently undertaking PhD research at Heriot-Watt University. Within the Consortium, Deonie will assist Heather, Scott, Jenny and Ian with the research performed in WP2b.

Glyn Everett is a Research Fellow within the Centre for Floods, Communities & Resilience (CFCR) at the University of the West of England (UWE). He has a background in conducting inclusive social research around education, public engagement with the environment and public understanding of science. He most recently worked on a Big Lottery Fund project investigating different publics' capacities for and interests in engaging with natural history, researching attitudes towards the environment and climate change using a Public Engagement with Science and Technology (PEST) approach. He has strong experience of conducting inclusive participatory research with hard-to-reach groups and feeding back to participants and lay co-researchers. Within the Consortium, Glyn will assist Jessica with the research performed in WP2c.

Lan Hoang obtained her BSc in Geography and Environmental Science at Melbourne University and Monash University (Australia). From 2007 to 2009, she took an Erasmus Mundus MSc in Hydroinformatics and Water Management. Lan has worked on various topics, focusing on decision making under deep uncertainty, hydrology and environmental modeling within the context of water management. Lan's PhD project at the Sustainability Research Institute, Leeds University revolves around the concept of robust decision making, which tests policy/engineering options under multiple scenarios and satisficing criteria. This project was a case study under the ARCC Water Project, a collaboration among various universities, engineering consultancy firms and the water industry. Her project analyses water system robustness using Multi-criteria Decision Analysis for an area in North Sussex, England. Major aims of the project were to identify significant uncertainties in the decision making process, packages of adaptive and sustainable measures to retain the region's resilience and robustness to water supply deficits. In this project, Lan explored the cascade of uncertainty triggered by using different sources of climate information such as different UKCP09 products and the downscaled RCM projections from the Future Flows project. Other past work experiences include university projects and various internships at HR Wallingford Ltd. (Oxfordshire, UK), the International Institute of Applied System Analysis (Laxenburg, Austria) and the Hanoi office of the World Agroforestry Centre. Within the Consortium, Lan will assist Dick Fenner and Dabo Guan with the research performed in WPs 3 and 4.

Vassilis Glenis is a Researcher in Water Resources in the School of Civil Engineering and Geosciences, University of Newcastle. Within the Consortium, Vassilis will assist Chris and Nigel with the research performed in WP2a.

Sangaralingam Ahilan has a research interest in statistical and numerical modelling in water engineering application and specialized in areas relating to stochastic hydrology and river

hydraulics. Within the Consortium, Sangaralingam Ahilan will assist Nigel and Chris with the research performed in WP2a.

Faith Ka Shun Chan is an assistant professor at the University of Nottingham, Ningbo campus, China. He currently conducts research on the international water management practices, particularly focus on flood risk management in East Asian mega-deltas and coastal megacities. He has worked as a teaching assistant in the School of Geography from University of Leeds, was a chair of water@leeds postgraduate forum and was a part time PhD researcher in the University. He has a strong research and teaching interest on inter-disciplinary aspects of environmental management, in particular, on sustainable development of water and soil management issues. He has worked with the United Nations and University of Bonn in the sustainable dryland environmental management project in Uzbekistan, funded by UNSECO, during his Master Research degree. Currently, he is based in Ningbo, China and aims to further look at research projects on flood risk management, water resources management, soil management and climate change adaptations in Asia and Pacific region.

Annex II. Bayesian networks as a tool for involving stakeholders in the participatory modelling and management of flood risk

EPSRC Quota Studentship awarded to: Shaun Maskrey
Supervised by: Nick Mount and Colin Thorne, University of Nottingham

1. Background

Decisions about the most appropriate solution for managing flood risk must be informed by, understood by, communicated to and embraced by a wide range of stakeholders and policy makers if limitations associated with 'top-down', 'technical fix' solutions are to be avoided (Brown and Damery, 2002; Collins and Evans, 2002). As a result, statutory European legislation underpinning the Water Framework Directive (WFD) (EC, 2000) now requires an increasingly integrated decision making process that is informed by the active involvement of stakeholders and inter-disciplinary learning (Orr *et al.* 2007) rather than solely expert opinion. Regulators in the UK (DEFRA/EA, 2006) also recognise that this should include a focus on the whole range of system behaviours, temporal and spatial interactions rather than discrete 'design events'. The outcome is a complex flood risk management decision-making processes (Figure II.1) that should seek to:

1. incorporate and integrate a much broader evidence base – including quantitative and qualitative information and evidence derived from stakeholders with different system perspectives and expertise;
2. enable evaluation of the evidence by the stakeholders and policy makers in a manner that communicates the potential benefits and limitations of different management options clearly and supports an improved understanding of the uncertainties surrounding them;
3. and direct stakeholders and policy makers towards a consensus about the preferred management decision, if this is achievable.

Modelling this process will be an essential element in delivering transferrable tools to practitioners tasked with directing the decision making process. This will require the development of participatory modelling methods specifically focussed on modelling flood risk management decisions that:

1. document the different stakeholder and policy evidence bases and the relationships and influences that exist between them;
2. formalise the relations and influences in a manner that supports multi-directional exploration of the impacts of management decisions – i.e. what might be the impact of a decisions for a given stakeholder, and what impact might a stakeholder have over the effectiveness of a management decision?;
3. present the outcomes of different management decisions in an accessible and auditable manner that can be effectively communicated to, and understood by all stakeholders and policy makers.

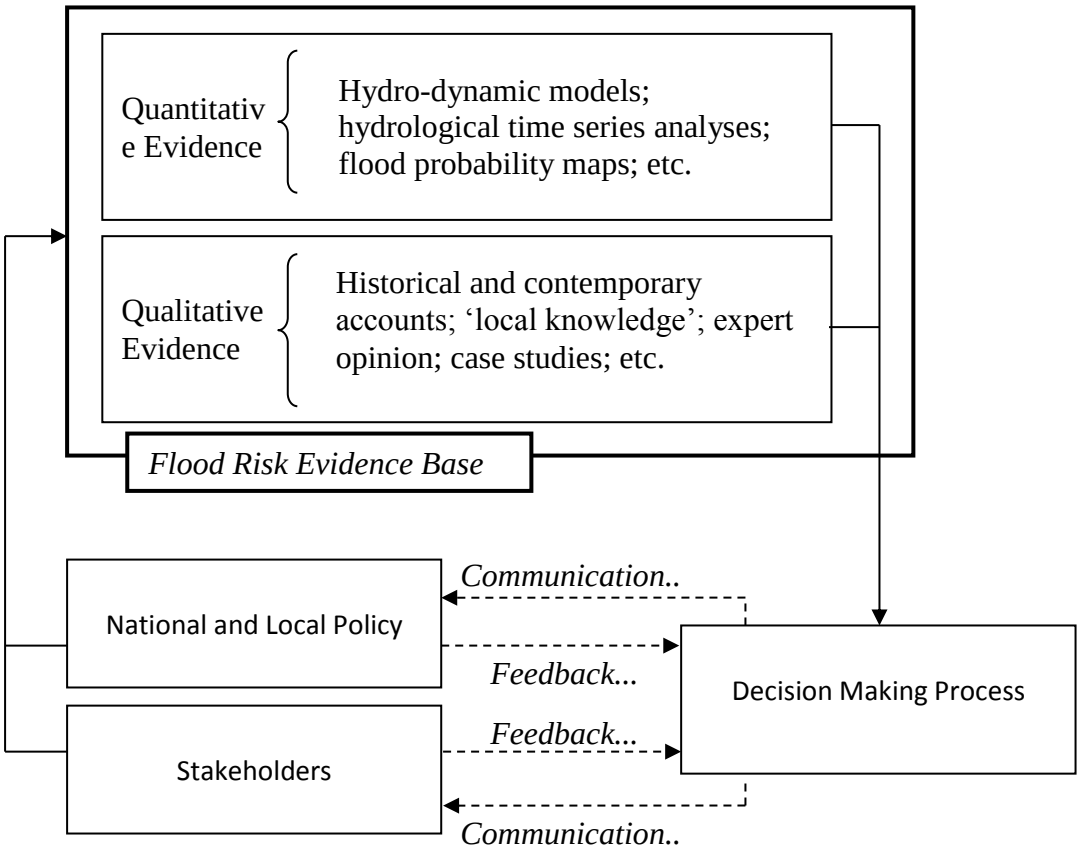


Figure II.1: The decision making process in flood risk management.

The use of such participatory modelling methods are currently in their infancy in flood risk management with few published studies to guide practitioners in their use of participatory methods and little in the way of tools to apply. Perhaps the most influential recent study is that of Lane *et al.* (2010), which does directly address the purpose of scientific contributions to flood risk by focussing on knowledge produced by academics and local people working together. The work recognises the need for simplified participatory modelling tools that are tailored to the best available local data, but it falls short of providing a general method for working with stakeholders in the management of flood risk. Indeed, there remains a clear and pressing need for participatory modelling methods and tools that can better support practitioners engaged in flood risk management decision making.

2. Project Outcomes

By developing a method that incorporates the three core methodological aspects presented above, this project will:

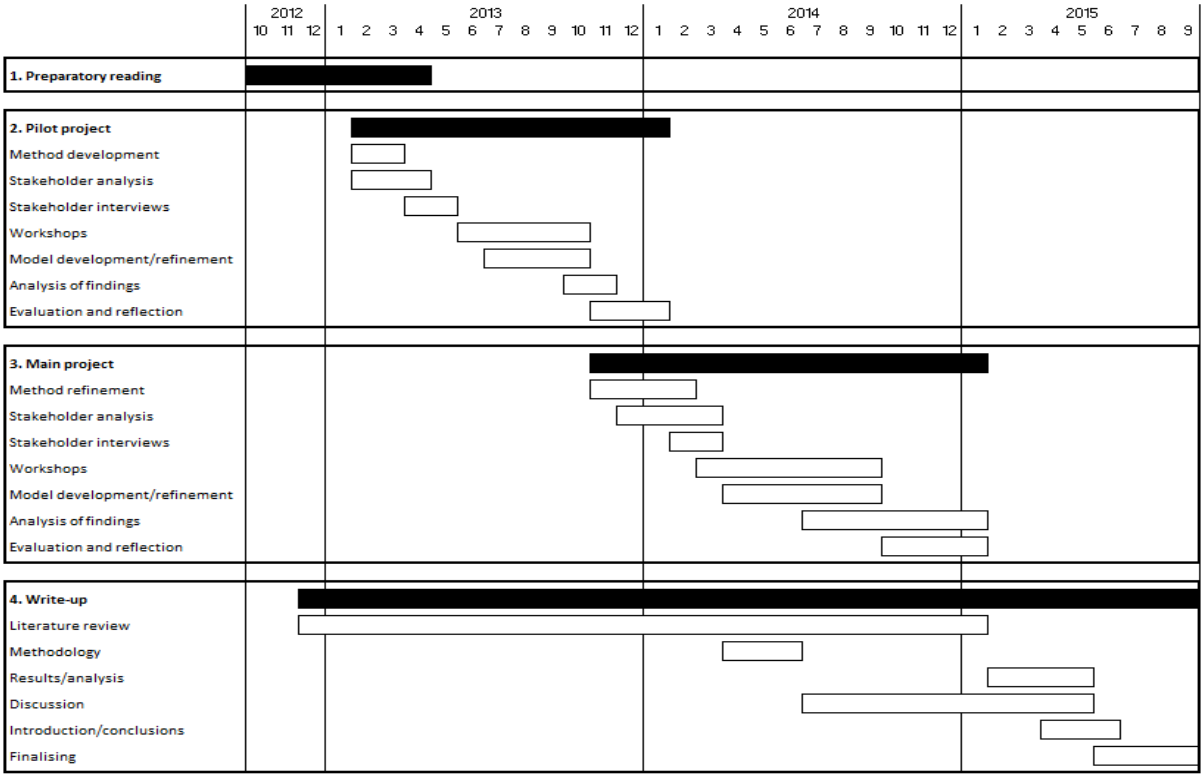
1. establish the human element as a critical factor in flood risk decision-making by involving stakeholders in all stages of the decision-making process, and recognising the influences that stakeholders may have on the physical outcomes of the solution and vice versa;
2. develop a transferrable methodology for a comprehensive decision-making process where innovative flood-risk solutions arise from utilising the widest possible range of quantitative and qualitative information sources;
3. use Bayesian networks to present the methodology as a formalised and interactive graphical network of nodes (quantitative and qualitative data and views) and dependencies (influences) developed and subsequently used by stakeholders and policy makers;

4. explore how the outcomes of a range of innovative flood-risk solutions will be impacted upon by changes in physical, stakeholder and policy scenarios;
5. exemplify the utility and evaluate the benefits of the method in two real-world examples (the Blue-Green Cities Demonstration Project and flood risk management decision making in Hebden Bridge), which demonstrate how innovative flood-risk solutions can be developed and evaluated using the participatory modelling approach.

3. Approach and Links to Blue-Green Cities Work Packages

The PhD has been structured to run alongside the Blue-Green Cities project – benefitting from and contributing to specific Work Packages in the project but not functioning as a core component of it. Participatory modelling methods will originally be developed and piloted outside of the Blue-Green Cities project; using the case study of flood risk management in Hebden Bridge, West Yorkshire. The participatory methods developed in the pilot will then be transferred to the Blue-Green Cities Demonstration Project (Work Package 5) to explore and compare their effectiveness in this alternative management context, and to determine their value as a means for enhancing communication (Work Package 1). This transfer will necessitate access to the information sources and stakeholder / policy makers engaged across the scope of the Blue-Green Cities project, as well Work Package 5. To facilitate their engagement, Shaun Maskrey (the PhD student) and/or Nick Mount (the primary supervisor) benefit from access to Blue-Green Cities project meetings and events.

4. Timetable



5. References

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Collins, H. M. and Evans, R. (2002). The third wave of science studies: studies of expertise and experience. *Social Studies of Science.* 32:2, 235-296

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Annex III. Terms of Reference for Strategic Advisory Board (SAB)

EPSRC Project EP/K013661/1 (Blue-Green Cities) SAB

TERMS OF REFERENCE

1. To provide independent advice to the Blue-Green Cities Research Team on the quality of the science undertaken by the Consortium and the extent that it fulfils the objectives as set out in the Implementation Report.

2. To perform a science audit of each of the Work Packages and report findings and recommendations to the Project Team.

3. To provide an independent source of informed advice to the Project Team and EPSRC as the need arises.

4. To meet as an Advisory Board in June and December, these meetings to coincide with quarterly project progress meetings.

5. To receive and comment upon annual progress reports produced by the Consortium and provide a critical oversight of the dissemination activities it conducts.

6. To advise the PI on leading the project to a successful outcome that maximises its potential for impact on urban flood risk management practices nationally and internationally.

7. No fees or stipend are payable to members of the SAB, but reasonable travel and accommodation costs will be refunded against receipts and registration fees for Consortium dissemination events will be waived.

CRT/NGW, March 2013

Annex IV. Responses to SAB feedback (June 2013)

SAB feedback is given in italics, Consortium responses are below each item.

1. *We would like to see a more detailed breakdown of how teams are working together on sub-tasks to ensure you have a joined up approach from day one of the project. This should illustrate the integration of the individual research elements to produce a homogeneous process leading to a beneficial output across all aspects of FRM covered in the consortium.*

Ensuring internal communication within and between the Work Packages (WP) is a key objective of WP1. We will employ several strategies to illustrate how the teams will work together on certain tasks and produce the deliverables within the specified timescale. We have a working flow chart that details the data/information requirements for the main sub-tasks for each of the WPs, colour-coded to show which WP is responsible for generating the data/information and passing this to other WPs. This diagram will be placed on the project intranet to be built upon when new data/knowledge transfers become apparent. WP1 may develop this flow chart into an information fountain. We also have a communal Gantt chart that details the key milestones within each WP and the dependencies on data/knowledge flow to meet these milestones. This is another working document for the intranet that will be developed during the project, and assessed at regular intervals to ensure deliverables can be produced on time.

2. *Please clarify the intended audience for the Blue-Green Cities project and share your stakeholder engagement plan with us as soon as it is ready. We want to help you engage with the <u>full</u> range of stakeholders (from institutional to community based).*

    a. *Include Insurance Industry as an institutional stakeholder - a key barrier to uptake of Blue-Green options.*

    b. *Include Water Companies – many are currently investigating the possibility of stormwater separation from their combined sewers*

The intended audience for the Blue-Green Cities project includes some degree of representation from all those affected by the installation of Blue-Green infrastructure, whether or not they are directly at risk of flooding. At a local level, we feel that neighbouring communities should still have an investment in the improvement of Blue-Green infrastructure and the reduced disturbances from incidences of flooding. Groups we hope to engage with are listed below;

i. Councils/Local Authorities, including Flood Risk Managers, Parks and Rivers Department, Drainage Engineers, Planners, and Community Engagement Officers
ii. Environment Agency
iii. Residents and Residents' Associations (both at risk and local but not at risk), "flood champions"
iv. Local businesses and others with a local presence
v. Environmental groups
vi. Industry/practitioners, e.g. planning, development and building industry representatives
vii. Insurance industry
viii. Water Companies

ix. Local and regional media
x. Any additional groups in the chosen Demonstration City

We are very happy to follow up any examples of best practice and use these as a basis for the evaluation of any specific initiatives, perhaps as a series of mini case-studies. For instance, links with Linda Dobson (Manager, Sustainable Stormwater Division, City of Portland, Bureau of Environmental Services) would give insight on US Water Company projects and may be the basis of a follow on visit to Portland when the timing is right (as previously discussed).

A stakeholder engagement plan will be developed in throughout 2013 and will be shared with the SAB as soon as it is ready.

3. *In your stakeholder engagement plan you should identify the key motivations for each stakeholder group in delivering Blue-Green Cities and discuss how you will communicate information across academic/decision makers/community audiences.*

We will create a matrix to lay out relationships, goals and outcomes of engaging with specific stakeholders which will help determine the key motivations for each group in delivering Blue-Green Cities. This will be added to the stakeholder engagement plan in due course. We will also develop a similar mapping tool for engaging with stakeholders in the Demonstration City. This will define how we plan to communicate information from academic to public spheres.

4. *Consider updating Wikipedia with your 'jargon buster' to ensure the outputs are available to all.*

A Wikipedia entry has been written for "Blue-Green Cities" (https://en.wikipedia.org/wiki/Blue-Green_Cities), and the "jargon-busting" will continue on a forum hosted by the Centre for the Analysis of Time Series (CATS) at the London School of Economics (LSE). We will begin by defining common terminology used in the analysis of quantitative and qualitative uncertainty in flood risk management. This may later be added to Wikipedia or compiled into a glossary.

5. *Consider adding a mapping of systems to your engagement plan. This may help identify potential conflicts.*

The stakeholder engagement plan will be developed in WP2c, with contributions from WP1 (see point 3 above). WP2c and WP3 will work together to add a mapping of systems to the engagement plan.

The mapping of systems is a core component of WP3 and we have already made progress on this aspect of the Work Package by developing a series of helpful diagrams. Our intention is to have at least a conceptual causal loop diagram ready for presentation at the Sept 2013 Quarterly Review meeting, to be iterated and refined following discussion in the team. This "map" will overlay aspects of functional complexity (the technical system and its physical interconnections) and relational complexity (at the organisational and operator responsibility level). The intention is to qualitatively identify at an early stage where the effective intervention points (and barriers) lie for the adoption and implementation of Blue-Green infrastructure.

6. *One system interaction we are particularly interested in is the feedback between sediment and flooding. Please highlight any findings in this area in your outputs.*

    a. *Get a better understanding of lifecycle within SuDS design, systems and water course maintenance.*

Using time stepped extended monitoring we will be able to consider multiple event sediment movement through the studied SuDS and urban watercourse network. Collection of rainfall, flow (depth and velocity), sediment mass, particle size distribution, and tracer concentration data consistently over this extended period will support the time stepped sediment movement analysis. This will enable the analysis of the concentration flux, transport rates, resuspension due to increased rainfall, and flow and source-transport interaction. Field work will be conducted in Scotland and in the Demonstration City.

Field sediment data and analysis will be supported by a review of existing case studies (SuDS elements and treatment trains) to help determine life cycle lengths, sediment movement and deposition/pollutant retention changes over time.

We will also conduct debris and sediment pinch point analysis to help inform design and system/watercourse maintenance needs. This work will show;

i. the interaction between land use, debris and sediment source(s), Blue-Green network design and management (including maintenance), and
ii. the multiple event and long term deposition impact on water quality, flood risk and Blue-Green benefits.

There is also potential for monitoring a SuDS scheme on Ribblesdale Road, Nottingham, via a Masters project (University of Nottingham and Nottingham City Council).

7. *Consideration, identification and quantification of multiple benefits*

We will produce a clear indication that consideration has been given to when benefits will become visible from the research and from Blue-Green thinking. This will include the perceived benefits that stakeholders believe Blue-Green infrastructure can offer and perceptions of the timescale for benefits to come to full fruition (as part of WP2c stakeholder engagement).

Key research output will be focussed around the application of conceptual frameworks currently being developed for the Demonstration City. As this has yet to be finalised timings are uncertain.

A wider issue is the time base along which the benefits accrue, and this is a key focus of our thinking in terms of number of years to maximum (mature) performance (which for vegetation could be up to 25 years).

    a. *For your pilot please produce a mapping of costs and benefits showing: what, how much, when and to whom (e.g. a look up table of costs and benefits covering the range of tools available in SuDS and Blue/Green thinking).*

This is a planned output of WP4. We currently have a Masters student looking at the feasibility of such an approach (as applied to Chicago). Progress is not expected here for 12 months (WP4 does not nominally start until January 2014). Development of this will be done with awareness of similar work being concurrently developed by CIRIA, HR Wallingford etc.

b. *Establishing a monetised system of accounting for multiple benefits - latch onto other drivers by other people at times where most of the benefits are no flood related*

Good suggestion, again monetisation is planned for the later stages of the work after the physical quantification of benefits. Many uncertainties will need to be addressed, and the value will lie in the protocols for doing this. One example of non-flood related drivers may be water scarcity is some regions where capturing stormwater is critical (e.g. through rainwater harvesting).

c. *Identification and analysis of benefit together with the development of a flood footprint for probability periods (1 in 5, 10, 25, 50, 75 & 100 for example)*

WP3 and 4 are initially focussing on three system condition states as defined in the 3 point approach of (Fratini et al., 2012): no flood; at design capacity, extreme inundation. It is not our intention to focus (initially at least) on the frequency or probability of these states occurring in any given location. However, it is possible that the research strategy for WP3 and 4 may evolve later in the project and look at quantifying the flooding footprint for different probability periods.

8. *In your pilot consider implementing some unproven (risky) blue green solutions. Calculate the 'risk cost' associated with these options and demonstrate how the risk can be managed at a project level.*

A risk based approach follows current consensus on drainage design. The intention is to review and evaluate a comprehensive set of Blue-Green components, and identify the practicalities and risks of their adoption, as affecting a range of stakeholder groups (beyond just the asset owner /operator). The risk management at project level will relate specifically to how these would work in the Demonstration City, where this point can be more sharply focussed.

The SuDS field work (WP2b) and literature review will examine the current understanding of risk specifically related to sediment, debris, water quality, ecosystem services, and flooding. This information, supported by information available on the frequency of occurrence, will be provided to WP3 and WP4 so help define what 'physically risky solutions' are and the potential sediment/debris focused impacts of these risks.

Ideas of perceived *risky solutions* will be fed back to other WPs as they become available from preliminary stakeholder engagement work (WP2c).

9. *For your pilot, benefits should not be described in isolation. You need to explain how much impact they have compared to traditional options and compared to the size of risks we face.*

Although not explicitly stated previously, we have already decided to make comparison of benefits with those from conventional grey infrastructure alternatives to address this point. Several papers have done similar exercises (e.g. for New York). This may feed into the multi-criteria data analysis (MCDA) aspects of the work in Year 3.

10. *If possible, try to estimate the impact of your work if scaled up to the city scale, or even national scale.*
    a. *Justify the up scaling process from minor individual schemes / theories to city / national scale costs & benefits*.

Part of the output will be to make recommendations on the optimum density of Blue-Green infrastructure in context specific circumstances; e.g. the extent to which individual components such as green roofs can be scaled up will be addressed with the expectation that in doing so some of the benefits may be non-linear (e.g. biodiversity and habitat benefits that may achieve a multiplier effect at larger a scale through the connectivity of Blue-Green corridors). However, the benefits of upscaling are likely to be location specific and may vary significantly across different meteorological, hydrological and socio-economic regions of the UK. There may be a trade-off (possibly analogous to the economic level of leakage on water supply networks) that can be identified subject to site specific constraints, through optimisation procedures, and linked to MCDA (input on preference information from different stakeholder groups will be required from WP1/WP2c).

The transferability of the procedures developed will be relevant to any location and have the ability to be widely applied, and hence, we aim to scale up the coats and benefits of Blue-Green infrastructure to both the city scale, and national level.

11. *It would be useful to have a brief note describing, in simple terms, the current state of the art for Blue-Green cities. Then at the end of the project we can use this benchmark to describe to others how and where progress has been made.*

The definition of ideal Blue-Green city design will vary in specifics according to location, climate, socio-economic status, flood risk, political and social values, community and economic needs etc. For instance, the current design best practice for Blue-Green cities and SuDS in Scotland has moved from regional or catchment treatment to source control supported by downstream sub-catchment treatment (i.e. pond or basin) (the 3 levels of treatment required by SEPA).

The current state of the art for Blue-Green Cities has been partially documented in our Wikipedia entry (https://en.wikipedia.org/wiki/Blue-Green_Cities), and will be added to over the course of year 1. A discussion topic for "state of art Blue-Green Cities" will be set up on the CATS forum. An international review of current best practice in network design and implementation could be completed to assist with our planned UK review.

12. *Related projects, e.g. encouraging a two-way exchange between the Blue-Green Cities project and what is happening elsewhere.*

The Blue-Green Cities team will investigate the list of related project provided by the SAB (an extended version is also located on the Blue-Green Cities website (www.bluegreencities.ac.uk/bluegreencities/research/relatedprojectsandreports.aspx)) and aim to engage with other relevant work. Many members of the team are involved in other research that may link with Blue-Green Cities, e.g.

i. Jessica and Glyn (WP2c) are working with Liverpool City Council (analysing community flood resilience)
ii. Several members are involved in the other EPSRC projects funded at the 2012 'Sandpit';
    a. Flood MEMORY: Multi-Event Modelling Of Risk & recoverY, involving Chris Kilsby (WP2a), Heather Haynes (WP2b), Jessica Lamond (WP2c)
    b. Organisational Operational Response and Strategic Decision Making for Long Term Flood Preparedness in Urban Areas, involving Nigel Wright (WP2a) and Dabo Guan (WP4)

Related University projects are also in process at several of the institutions involved in Blue-Green Cities, for example;

- 1st year PhD, Cambridge University: The impacts and benefits of the UK canal system and associated infrastructure (Funded by Canals and Rivers trust- essentially examining the role of canals (and their multiple benefits) in the context of Blue Green cities).
- 2 on-going Masters Dissertations, Cambridge University, investigating aspects of Blue-Green Infrastructure (proof of concept studies).
- Ongoing Masters and PhD project at Newcastle University, investigating green roofs and flow hydraulic through green infrastructure

Additional feedback from individual members' of the SAB

13. *Consideration of the impact of the project on the current governance system in respect of flood risk management & surface water management, whether positive or negative. Communicate progress and get useable outputs into action to support FRM plans for 2015/16.*

WP5 could investigate policy in the case study city and wider UK. Policy disincentives and blockages are almost certainly a reason adoption of Blue-Green approaches and infrastructure is lagging other countries.

14. *Inundation simulation – a cost/benefit aspect to the research as it is finally presented which should be included as part of the modelling package/process*.

We agree that a flood risk approach is the way to proceed, with the risks of Blue-Green solutions to be evaluated and quantified in ways that will be practical and useful to designers, again through an MCDA approach.

15. *Add to the introduction section in the Inception Report, e.g. look at Envision tool (ranking system for civic infrastructure), try to say more about why Blue-Green Cities effort is unique and different to other ecosystem services tools, what niche will this research fill (Section 1.3. in report).*

The project's starting point is FRM and the focus will be on delivering that prime function, whilst maximising a range of other functionalities: so it is strongly focussed around service delivery (protection from flooding) with an attempt to rank the overall benefit potentials such that the research can inform design and operational practice to enhance these co-benefits in the most effective manner. This feedback loop to FRM decision making is a key novel element of the work/research niche.

16. *Consortium to contact DARD if have interest in Northern Ireland for case study city*

WP2c are very keen to conduct research around the Connswater Community Greenway and are investigating funding sources at present. Further ideas from the team regarding work in Northern Ireland will be developed as the Blue-Green Cities project progresses.

17. *Wider focus of Blue-Green Cities - beyond cities to smaller urban or semi-urban locations where the same ideals and principles apply, possible "blue/green communities" spin on it.*

The project team will investigate the potential for applying key findings from modelling the benefits of Blue-Green infrastructure for flood risk management at the city/sub-catchment scale to larger urban locations. The plan for investigating "Blue-Green communities" will be developed during the first two years of the project (and after the Demonstration City has been chosen).

18. *Look at the USGS Flood Inundation Mapping Tool http://water.usgs.gov/osw/flood_inundation/, and new FEMA flood maps (based on LiDAR and a big step forward in the USA).*

WP2a will investigate the use of these tools and potential application for flood inundation mapping in the Demonstration City.

19. *It is essential that the designated city is data rich (in terms of historical flood events with clear understanding around the flood source/s), stakeholder hunger for solutions which may require a move away from traditional methods. Consider Glasgow.*

Extensive research has been undertaken into the four short-listed locations for the Demonstration City, e.g. detailing existing data the Consortium has access to, data requirements, existing and planned Blue-Green infrastructure, and potential for engagement with a wide range of stakeholders. One branch of stakeholders (Local Authorities, Environment Agency and project managers involved in FRM/Blue-Green infrastructure development) have been contacted in each of the cities and their interest in the project has been gauged. WP5 will present the four shortlisted candidate cities to the Consortium at the September 2013 Quarterly Progress Meeting and a decision will be made.

20. *Change logo from yin/yang symbol.*

Shaun Maskrey has designed a new logo.

Annex IV References

Fratini, C., Geldof, G. D., Kluck, J., and Mikkelsen, P. S., 2012, Three Points Approach (3PA) for urban flood risk management: A tool to support climate change adaptation through transdisciplinarity and multifunctionality: Urban Water Journal, v. 9, no. 5, p. 317-331.

Annex V. Responses to SAB feedback (Dec 2013)

SAB feedback is given in italics, Consortium responses are below each item.

1. *Start focussing on how emerging research will eventually lead to useful outputs for practitioners.*

The Project aims to deliver both novel research and outputs that can be directly utilised by industry and inform engineering practice in managing flood risk. As the Project enters its second year we will remain vigilant regarding this balance and focus discussions on how the emerging work will lead to outputs for practitioners. The ability to synthesise all elements of the disparate Work Packages (WP) around the Demonstration City in Newcastle will be a key first step to meeting this objective.

Each WP had already addressed how their specific research might generate practitioner outputs and this is available in the Inception Report, Section 5 Anticipated Outputs and their Dissemination. This includes the planned CIRIA report and we hope that Paul Shaffer will be engaged in future Quarterly Progress Meetings. We will ensure this is generated as a minimum and further practitioner outputs will be discussed at the upcoming. We would appreciate any input from the SAB regarding the current needs of practitioners.

2. *Further investigation into the funding incentives for uptake of Blue-Green infrastructure (BGI). Consider analysing the incentives recommended in the Green Building Council's Retrofit Incentives report as alternative strategies for encouraging uptake of measures.*

Investigating the barriers and incentives for uptake of Blue-Green infrastructure (BGI) will be of key importance in the Demonstration Case Study (WP5, Newcastle) in illustrating the applicability of potential implementation of BGI into local policy and practice. Funding incentives may also affect the perceptions of BGI that are held by individuals and institutions, which is of interest to WP2c (behavioural responses) and WP1 (communications and uncertainty). WP1 will investigate whether the incentives in the GBC Retrofit Incentives report could be alternative strategies to encourage uptake and will discuss this with key stakeholders during the Learning and Action Alliance (LAA) meetings in Newcastle (to begin in February 2014). WP2c will also discuss these funding incentives when they meet with community groups in the Demonstration City as part of their work investigating the perceptions and behaviours of people towards flood risk and management strategies. Several of the incentives may be directly transferrable to implementation of BGI, e.g. variable council tax and rebates for homes with BGI, or the energy (or water) efficiency feed-in-tariff which may reward households for installing measures to reduce their surface runoff to the sewer network, rainwater harvesting, or creation of additional green space (e.g. green roof, de-paving driveways).

3. *Quantification of benefits of the Blue-Green (BG) approach is essential for unlocking conversations on who benefits/pays and potentially engaging the private sector and health groups for funding such work. We recommend that the key outputs from this work package should be practical and with direct application to industry.*

We agree that a robust quantification of multiple benefits is a precursor to determining the value these represent to a wider stakeholder group. This is the remit of WP4. The practical nature of WP4's deliverables is summarised as follows: to provide an evaluation framework by which the magnitude AND significance of each benefit can be judged and related to location and

context specific circumstances, for example by understanding whether the benefits are new in a location or incremental improvements on what already existed. This improved understanding of what SuDS/GI can deliver (in addition to a drainage function) will allow designs to be refined to ensure the co-optimisation of the most significant benefits.

WP4 will thus provide evidence (qualitative and quantitative) that BG infrastructure can provide a range of benefits, including those related to health and improved quality of life. This evidence will enable debate between funding bodies (public and private) and help make the case for BG infrastructure is a cost effective strategy that can generate multiple benefits to a range of stakeholders. Identifying where the benefits may accrue will progress the debate on who benefits/pays.

We are keen to discuss with the SAB how to create the balance between academic outputs and those that could be directly used by industry, and propose further discussion at the June Quarterly Progress Meeting.

4. *The SAB have identified that the assessment of BG solutions does not fit well in the current methodology to assess flood risk in economic terms at a national level. How might Blue-Green Cities (BGC) make a difference? For example, recommending how BGI should be modelled in national products such as the Flood Map for Surface Water or the National Flood Risk Assessment.*

We plan to make such recommendations as part of WP2a and WP2b research, but the exact form for these will depend on those adopted across the Consortium and will be discussed in due course. Recommendations for effective modelling of BGI will be made via publications in academic journals.

5. *The project deliverables need to move beyond just modelling flood risk. There needs to be a concerted focus on the end product and the SAB would like the team to explain how they intend to stay focussed on benefit assessment and business case development of BG concepts.*

We strongly agree the project deliverables need to move beyond just modelling flood risk and hope to achieve this by focussing on a set of deliverables for both academia and industry (end-user focussed). These have been defined for each of the work packages (detailed in the Inception Report) and will be updated as the project progresses, particularly in relation to the demonstration study (Newcastle, WP5) which is not due to start in full until 2015. The Consortium, and specifically WP4, aims to provide the scientific evidence and reasoning necessary to inform the business case development of BG concepts. WP2c will also provide a framework for evaluating the preferences of communities and individuals with respect to specific BG strategies which again, can provide the background information to the business case development for BG concepts (this time from the social perspective).

The focus of WP4 is primarily to develop and apply methodologies which can foremost **quantify** the **potential extent** and scope of a range of benefits from SuDS/GI (when principally in the green condition), and to weight these according to locally governed significance. This will naturally lead later in the project to determining the relative value of these benefits, and this information may be useful to others if incorporated into a cost-benefit calculation to help justify their adoption. Such improved knowledge may also be helpful in a multi-criteria approach to component selection to meet the specific needs in a local context, and in a similar approach may be useful for comparison with alternative grey infrastructure.

In addition, a specific end-user focussed business case for the development of BG concepts may be an output of the CIRIA RP 993 (Multiple benefits of SUDS) project, which we are engaged with, and hope to build on as part of WP4 and the determination of benefit significance.

6. *Consider 'Designing for Exceedance'. BGC should provide better information on how to account for the added benefits of BG concepts in terms of flexibility and resilience for managing exceedance events compared to more traditional single benefit piped drainage approaches. This will add to the current limited knowledge on the performance of BG and grey infrastructure during flood events.*

This comment relates to a better understanding of complex system interactions under a variety of conditions states, exceedance being one of those, and normal green conditions and flood inundation being the others. This is the domain of WP3 and an academic journal paper (currently under review) has been produced examining system interactions when using SUDS/GI.

7. *Consider the new approach (and legislation) to flood insurance, e.g. how this may influence people's behaviour and their acceptance of a change away from grey infrastructure towards BG.*

The new approach and legislation to flood insurance will be discussed during the Newcastle LAA meetings to highlight the views of key stakeholders involved in water management (City Council, Environment Agency, local interest groups and critical infrastructure, e.g. transportation, communications and health). Additionally, WP2c will discuss insurance with community groups when generating the data to identify perceptions of BGI.

8. *Further research into proprietary Blue-Green products; provide insight into how to make best use of these in a Blue-Green City, highlighting the importance of focussing on system performance and less on individual products.*

While we plan to look at how different proprietary products perform as part of the urban system, it is beyond the scope of this research to assess the effectiveness of particular products. From the work conducted in WP4, we hope to gain understanding of the relative significance of certain benefits in different location contexts. This will inform the discussion on whether standard, "off the shelf" SuDS/BGI products, e.g. water butts, standard green roofs, household-scale rain gardens, could provide the maximum benefits, or whether the locational context is a more significant factor in determining the success of SuDS/BGI and solutions need to be designed for the specific environment where the infrastructure will be implemented. This could advise the debate on the effectiveness of proprietary products and discussions on how these could be supported by the industry.

To complement the on-going parallel work of CIRIA (RP 993 Demonstrating the Multiple Benefits for SUDS - a business case) which has direct funding support from the industry, we hope to scrutinise some of the fundamental science which underpins these assessments and guidance. This will include a range of Blue-Green responses, and the framework by the Consortium will allow others to evaluate proprietary products. We agree the emphasis should be on system performance and these interactions are being covered in WP3. It may also be beneficial to discuss this at the June Quarterly Progress Meeting.

9. *Start promoting the project to a wider audience* including;*

- the CIWEM Urban Drainage (UDG) and rivers and coastal group's LinkedIn pages
- FlowNet (part of the LGA's knowledge hub)
- Institution of Civil Engineers (ICE)
- Institute of Water
- CIRIA Susdrain

*Please let SAB know when this is done so they can promote posts/blogs/comments etc.

Contact with this wider audience will be coordinated by WP1 but include contributions from multiple sources (WPs). This is consistent with our intended dissemination routes, and several journal and conference papers are either under review or in active preparation. A link with Susdrain will be of particular benefit to achieve this. The project is already interacting with stakeholders in Newcastle and Portland and we expect to reach academics as well as local councils, NGOs and local authorities both nationally and internationally. Further engagement will follow as part of the production of a CIRIA report towards the end of the project. Additionally, several members of the team are presenting at events organised by the institutions the SAB suggest, e.g. Colin Thorne at the CIWEM Rives and Coast Group, and Emily Lawson and Chris Kilsby at the Institute of Water (Northern Ireland area).

All team members who are members of LinkedIn are encouraged to join the CIWEM UDG and Rivers and Coastal Groups, ICE and the Institute of Water groups, and contribute to discussions and make direct reference to their work as part of Blue-Green Cities. A topic titled "Three research projects that may be of interest (Blue-Green Cities, Flood Memory and SESAME)" has already been posted in the CIWEM UDG group and will be followed up with posts on the specific research different WPs are doing. WP3 and 4 will consider posting in the ICE LinkedIn group.

WP2 will also consider writing case studies for Susdrain and the team are encouraged to join FlowNet and contribute to the forum. Blue-Green Cities are now following and have made contact with ICE (@ICE_engineers) and the Institute of Water (@InstWater) on Twitter.

We posted on a link to the article on UK flood risk management that Colin Thorne wrote for the Guardian (10.2.14) on FlowNet, and introduced Blue-Green Cities and the other two research projects that were funded at the 2012 sandpit.

10. *Several cities besides Newcastle have expressed an interest in the project and their engagement should be encourage where appropriate. One option is to add a section to the website that explains how they can get involved. It could include options ranging from signing up for the twitter feed, to being able to re-use models with their own data.*

It is a good idea to share best practice and the drivers and barriers experienced with as many cities as possible, and whilst focussing our pro-active work on Newcastle, other cities who express an interest in the project should be welcomed. The project also has to comply with EPSRC data management requirements which ensure that data is available after publication in academic journals.

11. *Further investigation into the possibility of a research project in Northern Ireland given the financial commitment from there.*

The Consortium will review whether their current research could include a case study in Northern Ireland as part of the ongoing flood alleviation and Community Greenway project in

East Belfast. This will be follow up by Jessica Lamond. This will be communicated to the PI (Colin Thorne) who will discuss and finalise plans for research or engagement in Northern Ireland with David Porter. Another possibility is to look at the relational complexity in the province and track how SUDS/GI decisions are taken and influenced.

Chris Kilsby and Emily Lawson will present an overview of the Blue-Green Cities Research at the Institute of Water Northern Ireland Area Conference in April 2014.

12. *Allow time at the next SAB meeting (June 2014) to discuss 'shopping list' of practical outputs from BGC that could make a real difference to industry, e.g. key facts, insight into current practice, or user focussed tools. In the meantime, the SAB believe CIRIA's role in developing practitioner focussed outputs from project deliverables should be commenced early to avoid a repeat of the challenges of similar outputs from FRMRC2.*

Also allow time to discuss performance standards for the design, testing and assessment of the outputs from the research. These must align with industry or be used to identify where changes to current practice is necessary.

Both items will be added to the agenda for the June SAB Meeting. Colin Thorne will contact Paul Shaffer and discuss CIRIA's involvement in BGC and invite Paul to the June meeting. We are interested in what practical outputs could be of use to the industry and how this aligns with our research.

For instance, WP4 has moved away from developing a user tool, in the form of look up tables to determine the values of multiple benefits as this would replicate the CIRIA work now underway. A practical output could be in advice on the design procedures for SUDS/GI, a) to allow better integration between these and b) to co-optimise benefits in the initial design.

Other practical outputs include a consideration of the non-linearity and uncertainty factors of the benefits, which may inform decision makers of the scale needed to realise the benefits and how to integrate SuDS/GI components within the urban domain, including insights into critical spatial density of installations to achieve desirable benefits.

13. Use information gained from literature reviews and research to develop good practice guides (or information fact sheets) that may be used by practitioners. This could be made widely available through CIRIA.

The Consortium will endeavour to develop good practice guides or factsheets that may be used by practitioners although it is not the explicit aim of the research work packages to spend significant resource in this kind of documentation. We plan to follow the route to practice that the ISSUES (Implementation Strategies for Sustainable Urban Environment Systems) project followed.

In addition, WP1 has already produced a BGC leaflet (A4, double-sided, folded twice) for distribution at conferences, workshops, meetings and other public engagement events. We aim to produce a factsheet on research in WP2 (water, sediment, debris and human interaction modelling), WP3 (interactions in urban infrastructure systems and the flood footprint), and WP4 (benefit evaluation). This could include guides/information on methods, protocols, or case studies where specific goals have been achieved. There may be a delay in producing the factsheets (especially for WP4 which began in January 2014) if work has been submitted for publication and not yet accepted.

14. *How will the outputs from BGC research be understood by the public at flood risk and those charged with engaging them as well as technical specialists?*

WP1 will include this as part of the communication strategy building on knowledge gained from the LAA with input from WP2c on how publics interpret BGC research objectives and outputs (and wider issues regarding BGI for FRM in general).

15. *Update the current Wikipedia definition. At present this is too flood centric, omitting water resources, water demand and the interplay between floods and droughts. These need to be included as one of the key benefits of Blue Green cities is an integrated approach that considers the whole water cycle.*

Update current BGC components listed on Wiki (too similar to SuDS plus river meanders). Include concepts like green outfalls/infrastructures, green erosion protection, green/blue corridors, green defences and growing / natural defences.

We agree with this observation. Much the work of WP3 and WP4 is to evaluate interaction and benefits in the non-flood condition, in ways which enhance the concept of a Blue-Green City, which uses multi-functional infrastructure across a range of diverse uses mostly under the non –flood condition. The definition has been subsequently revised.

16. *Share details of the stakeholders we will engage with in Newcastle to ensure appropriate contacts can be made to enable efficient access to data and a strong LAA.*

WP1 will regularly update the intranet with the list of stakeholders invited to LAA meetings after consent has been given at the first workshop (Feb 14th 2014). We would be very appreciative of any contacts the SAB may be able to provide to help make the LAA a success. Data access will be a theme for future LAA meetings and will also be discussed by the Consortium at the March Quarterly Progress Meeting.

17. *Define scenarios that will be addressed to evaluate benefits of BG and grey infrastructure under different futures. Where possible, scenarios used should try to account for some long term changes which will frame the case study, such as ONS population projections through to 2030, land use allocations in Local Plans, and uplift in severity/frequency of weather events due to Climate Change.*

This is an important suggestion and it is necessary that these scenarios are commonly agreed and owned across all the Work Packages. Whilst developing scenarios relevant to Newcastle they need to be widely generic in ways which could generate future constraints/opportunities elsewhere from a set of universally agreed possible futures.

At present the Consortium are considering a set of six scenarios (detailed in the table below and on the project intranet) and within these, three condition states will be examined; green (no-flood), design standard and blue (flood exceeding level of defense). We agree with the SAB that the scenarios should adequately frame the case study (Newcastle) and include future projections that are relevant to this specific UK location. To enable this, the socio-economic futures in all scenarios will be based on ONS population projections through to 2030 and land use and employment plans/projections from Newcastle City Council and related sources, e.g. the Core Strategy and Urban Core Plan. We will use three different physical scenarios; high climate change (SRES A1F1, UK CIP 09), low (SRES B1) and the Newcastle projection for climate

change based on UK CIP 09 forecasts for the Tyne and local information. We will run each physical/economic scenario under the business as usual and BG future.

Exact scenarios are still under discussion and will be an agenda item at the June meeting.

18. *Linked projects and initiatives.*

We thank the SAB for introducing the Consortium to these linked projects and initiatives. The Consortium will see if they are applicable to their WP and wider research interest and contact the relevant person.

- A new flood alleviation scheme in Newcastle on the River Ouseburn at Brunton Park, being delivered as a partnership between the EA and Newcastle city council, with support from Arup. There is a history of flooding to properties from surface water flooding, and various combinations of high fluvial flows and consequential restriction for the free discharge of the drains. Instead of traditional defences and pumping solutions, the scheme design allows for a more integrated approach. It uses attenuation ponds at lower capital cost and with habitat and amenity benefits.

  We have emailed David Wilkes for more information and will encourage engagement with this project, possibly via "wider membership" of the LAA (discussions and contact via a new Newcastle LAA LinkedIn group).

- The ongoing flood alleviation and Community Greenway project in East Belfast which is an ideal study area for this research.

  This has been addressed in point 11 and will be a key consideration over the coming months.

- The polyscape tool. Developed originally at Bangor University as a stakeholder engagement tool to identify opportunities and conflicts for land use management. Since it was originally developed Neil McIntyre (formerly of Imperial) received funding to add confidence that each measure will have the intended benefits.

  The team will investigate whether the polyscape tool could be used for application in benefit evaluation exercises and multifunctionality of landuse (see Jackson et al., 2013).

- Designing for exceedance. Current CIRIA project of which Dick Fenner is part of the project team.

  We have formal links with CIRIA RP 991 (Design for Exceedance) and CIRIA RP 993 (Multiple benefits of SUDS) through Dick Fenner, who will keep the Consortium updated with the ongoing work. The former demonstrates best practice in managing exceedance through 12 case studies, the latter is developing a valuation tool to monetise multiple SUDS benefits. Opportunities will be taken to test a beta version of this tool (in Newcastle?), providing critical feedback to CIRIA.

- Work at a European level by 'Working Group F', which includes representation from all Member States involved in the delivery of the EU Floods Directive.

  This will be investigated by the Consortium via the EU WFD website and Work Programme 2013-2015. We will also look at the wealth of information provided in the associated

thematic documents (CIRCABC) (although these seem to have been produced before 2010 so possibly lacking in recent developments).

- Work by the Cabinet Officer's Behavioural Insights Team into how to design policy which influences behaviours across a wide range of areas, underpinned by behavioural science.

  The applicability of this work to Blue-Green Cities research will be investigated by the Consortium via the Behavioural Insights Team website and blog.

- The Government Office for Science Foresight Team is running a Future of Cities programme looking at urban systems and metabolism which may be worth linking with for scenario planning.

  This will be investigated by WP5 via the Future of Cities website and blog. This programme reports in 2015 so there may be scope for utilising their outputs in the Demonstration Project (WP5).

- Royal HaskoningDHV is just commencing a Defra funded research to develop a method for mapping potential of areas for SuDS retrofit. This project has a short window (complete and of March 2014).

  Emily emailed the Consortium about this project (10.1.14) and interested members of the team, e.g. WP2a, have been in dialogue with Fola directly.

Other projects

- The Clean Water for All Project (collaboration between Blue-Green Cities and the NSF funded Portland-Vancouver ULTRA (Urban Long-term Research Area) Project) helps expand the international dimension of the work.

- There is also a PhD project at the Centre for Sustainable Development (Cambridge University) investigating multiple benefits of UK canals in urban areas, supported by the Canal and Rivers Trust.

Annex VI. Responses to SAB feedback (June 2014)

SAB feedback is given in italics, Consortium responses are below each item.

SAB summary
The SAB were pleased to hear about the progress made on this project and in its sister project Clean Water for All. We are continually impressed by the dedication of the team, who are making this project stand out against other similar academic projects. The project is now half way through and ***we look forward to seeing some more concrete outputs in the comings months.*** *We would prefer to see several iterations rather than a final draft. Early versions will help us provide more useful feedback while there is still time to make any changes.*

The Blue-Green Cities Research Consortium has produced a range of outputs throughout 2014 including conference papers, academic journal publications and book chapters. These are listed below and many have hyperlinks to the published document.

2014 outputs from the Blue-Green Cities (BGC) team

Academic journal publications (published)

Allen, D., Arthur, S., Wallis, S. G., Haynes, H. and Wallerstein, N., Influences and drivers of woody debris movement in urban watercourses. Science China Technological Sciences, August 2014, 57 (8) 1512-1521.

Thorne C. Geographies of UK flooding in 2013/14. The Geographical Journal, December 2014, 180(4), 297-309.

Smith, L., Petersen, A., Variations on reliability: connecting climate predictions to climate policy, in Boumans, M., Hon, G., Petersen, A., (eds.) Error and Uncertainty in Scientific Practice.

Academic journal publications (in review)

Allen, D., Arthur, S., Wallerstein, N., and Haynes, H., Provision, transport and deposition of debris in urban waterways, International Journal of Sediment Research, (2014 in review).

Everett, G., Lamond, J., Morzillo, A., Chan, F., Matsler, A.M., Can Sustainable Drainage Systems Help People Live With Water? Proceedings of the ICE - Water Management, (2014 in review).

Guan, D., et al., Flooding footprint analysis for 2012 flood in Yorkshire. Environmental Research Letters., (2014 in review).

Hoang, L., Fenner, R., System interactions of stormwater management using Sustainable Urban Drainage Systems and Green Infrastructure. Urban Water Journal (2014, in review).

Lamond, J., Water supply and the risk of flooding. In: Barton, H., Thompson, S., Grant, M., and Burgess, S., (eds.). Planning for Health and Wellbeing. Routledge (2014 forthcoming).

Lamond, J., Rose, C., Booth, C., Evidence for improved urban flood resilience by SUDS retrofit. ICE Urban Design and Planning Journal (2014, accepted).

Lamond, J., Wilkinson, S., Rose, C., Proverbs, D., Sustainable Urban Drainage - Retrofitting for Improved Flood Mitigation in City Centres. RICS research report. London: Royal Institution of Chartered Surveyors (2014 forthcoming).

Book chapters (in press)

Everett, G., Lawson, E. and Lamond, J. Green infrastructure and urban water management. In: Sinnett, D., Burgess, S. & Smith, N. (eds.) Handbook on Green Infrastructure: Planning, design and implementation. Edward Elgar, (2015 in press).

Conference Proceedings (mostly open access)

Ahilan, S., Wright, N., Sleigh, A., Too, S., Glenis, V., Kilsby, C., Kutija, V. Flood Risk Management in Small Urban River Using a Sustainable Urban Drainage System: Wortley Beck, Leeds, UK. International Conference on Hydroinformatics (HIC 2014), August 2014.

Allen, D., Arthur, S., Haynes, H., Ellam, R., Olive, V., Black, K., Mant, J. Sediment transport through sustainable urban drainage systems: monitoring for long term multiple event analysis, Proceedings of the 3rd IAHR Europe Congress, Porto, Portugal, April 2014.

Allen, D., Arthur, S., Olive, V., Ellam, R., Haynes, H. A detailed examination of fine sediment transport through a vegetated swale over multiple events, 13th International Conference on Urban Drainage, Sarawak, Malaysia, September 2014.

Everett, G., Lamond, J., A Conceptual Framework for Understanding Behaviours and Attitudes Around 'Blue-Green' Approaches to Flood-Risk Management. Flood Recovery Innovation and Responses, June 2014 Poznan, Poland. WIT Press.

Guan, D., et al., Flooding footprint analysis for 2007 flood in Yorkshire. ISEE (International Society of Ecological Economics) 2014: Wellbeing and Equity within Planetary Boundaries, August 2014.
Galatioto, F., Glenis, V., Roberts, R., Kilsby, C., Exploring and Modelling the Impacts of Rainfall and Flooding on Transport Network. The case study of Newcastle upon Tyne. In: 2nd International Conference on Urban Sustainability and Resilience, 2014.

Hoang, L., Fenner, R., System Interactions of Green Roofs in Blue-Green Cities. 13th International Conference on Urban Drainage, Sarawak, Malaysia, September 2014.

Kutija, V., Bertsch, R., Glenis, V., Alderson, D., Parkin, G., Walsh, C., Robinson, J., Kilsby, C., Model Validation Using Crowd-Sourced Data from a Large Pluvial Flood. International Conference on Hydroinformatics (HIC 2014), August 2014.

Lamond, J., Wilkinson, S., Rose, C., Conceptualising the benefits of green roof technology for commercial real estate owners and occupiers. Pacific Rim Real Estate Conference, Jan 2014.

Lawson, E., et al., Delivering and evaluating the multiple flood risk benefits in Blue-Green Cities; an interdisciplinary approach. Flood Recovery Innovation and Responses, June 2014 Poznan, Poland. WIT Press.

Lawson, E., Kilsby, C., Delivering and Evaluating Multiple Flood Risk Benefits in Blue-Green Cities, Institute of Water (IWA) Northern Ireland Area Conference: Flushed Away! Sewerage - The Poor Relation? April 2014.

Mant J, Allen D, Arthur S, Terrell R, Morse J, Yeakley. A. Urban river and riparian restoration make urban rivers more resilient to contaminated sediment, European River Restoration Conference (ERRC), October 2014.

Thorne, C., et al. Delivering Sustainable Urban Flood Risk Management in Blue Green Cities. Surface Water Management 2014, CIWEM, June 2014.

Wilkinson, S., Rose, C., Glenis, V., Lamond, J., Modelling green roof retrofit in the Melbourne Central Business District. Flood Recovery Innovation and Responses, June 2014 Poznan, Poland. WIT Press.

Wright, N., Thorne, C., Lawson, E., Delivering and Evaluating Multiple Flood Risk Benefits in Blue-Green Cities. International Conference on Hydroinformatics (HIC 2014), August 2014.

Wright, N., Thorne, C., Delivering and Evaluating Multiple Flood Risk Benefits in Blue-Green Cities. 6th International Conference on Flood Management (ICFM6 2014) September 2014.

BGC working documents
Work Package 5: Demonstration Case Study – Newcastle 2015 (available on the BGC website soon).

Factsheets

Using Bayesian networks to involve stakeholders in flood risk decision making in Hebden Bridge (Shaun Maskrey, 2014).

SAB Feedback - detailed points

1. *The project team are ideally placed to develop some of the key facts that could help us as practitioners promote blue green concepts. By the end of the project, please try to answer the questions below and provide your findings in a similar style to the FRMRC fact sheets. We know that it might not be possible to answer all of these questions in this project.*

The Blue-Green Cities team accept this suggestion from the SAB and will endeavour to address the questions that are listed below and present the findings as factsheets. Indeed, we have already started to produce factsheets, e.g. "Bayesian networks to involve stakeholders in flood risk decision making in Hebden Bridge", and agree that it is an effective means of disseminating our research outputs. Each of the Work Package (WP) teams will provide information in their field of expertise to create, or co-create with another WP team, the factsheets, which will be coordinated by Emily Lawson over the final year of the project. The WP teams that could potentially address some of the questions are listed below.

Scale of implementation

- *What proportion of Newcastle is suitable for Blue Green infrastructure (BGI)?*
- *As you increase the amount of Blue Green infrastructure in Newcastle, do you reach any tipping points at which the costs, benefits or funding available suddenly changes?*
- *What proportion of the predicted increase in flood risk due to climate change, urban creep and/or population growth could be mitigated by transforming Newcastle in to a Blue Green city?*

These are all interesting questions and of key importance to policy makers in Newcastle and similar cities. It is important to note that the Blue-Green Cities team will be concentrating on two case study areas in Newcastle (upper/middle Ouseburn near the Newcastle Great Park development, and the urban core, extending up to the Town Moor). It simply isn't feasible to

address the whole of the administrative area (which covers 225 km^2) within the resources allocated to the consortium by the EPSRC. Therefore, we will endeavour to address them as they pertain to the case study areas. Our goal in Newcastle is to develop the science, methods and concepts to illustrate the benefits of using BGI; this may allow us to develop the tools that could be used to answer these questions. It is also beyond our remit to discuss funding for Blue-Green infrastructure (which is more of a regulatory/policy question); instead, we aim to generate an evidence base that demonstrates the physical performance of Blue-Green infrastructure that is relevant at a local context.

Costs and benefits

- *How much would it cost, and how quickly, could Newcastle be transformed into a Blue Green city?*

WP1 will explore this with the LAA; however, this may be beyond the scope of our research (see comment above).

- *Who benefits and who pays for a Blue Green Newcastle?*

WP4 will determine the multiple benefit profiles (and beneficiaries) for BGI strategies in Newcastle and illustrate how the benefits extend over different spatial scales and can add incrementally to an area. WP2c will provide information on perceived benefits of BGI to local communities/residents. WP4 has moved away from investigating who pays, however, this could be discussed with the LAA, which includes major stakeholders such as the City Council, Northumbrian Water, Natural England and the Freemen of Newcastle upon Tyne.

- *When do the costs and benefits accrue in Newcastle?*

This may be a difficult question to address, particularly as the ongoing maintenance costs of BGI in Newcastle (and the rest of England) are unclear. We can attempt to answer this question by determining the benefit profile and lag time to maximum benefit following implementation for a range of environmental, ecological and social benefits (WP4), e.g. noise attenuation will not peak until trees have reached a certain level of growth, and discuss the costs with Newcastle stakeholders such as the City Council and Northumbrian Water (WP1).

- *What are the costs of maintaining Blue Green infrastructure? Does Blue Green infrastructure require more or less maintenance than traditional approaches?*

Again, this may be a difficult question to address in a one-year case study (see comment above), and determining the maintenance strategies (and associated costs) of BGI is somewhat beyond the scope of the project as our objective is to evaluate different approaches to urban water management based on flood risk reduction and the accrual of other, multiple benefits. The maintenance costs of both Blue-Green and grey infrastructure will be dependent on the exact type of infrastructure, whether this is a discrete entity or in a treatment train, the level of maintenance that is provided (e.g. to maintain function and/or aesthetics) and how often this will be done, e.g. simply removing trash from SuDS ponds or removing contaminated sediment, and the time period over which the maintenance costs are calculated (the lifetime of the infrastructure may also differ). WP1 could discuss maintenance costs with Newcastle stakeholders and the LAA but some of this information may be protected. We may be able to write a more qualitative piece on the types of maintenance required for Blue-Green vs. grey and which requires greater maintenance over a 30 year period.

- *What proportion of the flood risk benefits from Blue Green infrastructure are due to keeping sediment out of the drainage system versus simply reducing runoff?*

Through fieldwork and modelling, WP2a and WP2b will work together to determine the retention of sediment in certain types of BGI during different storm events and over different time periods, and investigate the extent to which the retention of sediment in BGI reduces the flood risk. This could then be compared with the flood risk reduction based on reduced surface water runoff only.

Encouraging uptake

- *How can you make local communities 'enthusiastic' about Blue green cities and their role in making it happen?*

This could happen by advocating a solution driven by flood risk management but able to provide a range of other benefits that are appealing to local communities. This will required knowledge of what communities prefer. The WP2c team will develop questionnaires for distribution in affected communities in Newcastle, based on stated preference modelling, to generate quantitative data on behaviours, attitudes and preference values of households and businesses, e.g. their thoughts on different types of BG systems and willingness to alter their behaviour, which may affect the likely success of different flood risk management approaches. They will also investigate the perceived benefits of BGI and anticipated long-term benefits. This may give some indication of how communities view their role in sustainable water management. Communication strategies that could be used to raise community enthusiasm for such schemes could be discussed with the LAA.

- *What is the best way to incentivise uptake of Blue Green approaches by householders?*

Please see answer above. WP2c may also develop focus groups with Newcastle communities to explore the communities' reaction to specific proposals and schemes (as modelled by WP2a and discussed with the Newcastle LAA stakeholders). This may give insight into how to incentivise households. This will also be developed as part of the Agent Based Modelling (WP2a and 2c).

- *Should proprietary products be encouraged as a way of delivering Blue Green cities? On one hand it could bring innovative marketing and funding. On the other, it could simply cause us to focus on the most profitable methods rather than those that deliver the best outcomes for local communities.*

The Blue-Green Cities team will work together to try and address this question, with input from the Newcastle LAA (which includes practitioners who have an informed view on this matter). The team are predominantly looking at Blue-Green infrastructure rather than proprietary products, but understand that they may be part of the larger picture.

Risk and uncertainty

- *Is there really more risk associated with implementing Blue Green infrastructure compared to implementing traditional approaches?*

This is a difficult question and depends somewhat on the risk appetite of the policy makers. This will be investigated by WP1 when identifying the Relevant Dominant Uncertainties (RDUs) that stakeholders are faced with when designing, selecting and using BGI for urban flood risk management. There is a perception that grey is safer than Blue-Green due to sophisticated modelling of the former and less evidence to support the latter. Grey is perceived as a safer method due to more experience of this infrastructure type and greater understanding of the limitations. However, there are also real uncertainties and assumptions in modelling piped

infrastructure which contribute to the risk, but these may be more accepted by the industry. Grey infrastructure may also lead us down a route to technical lock-in whereas Blue-Green may be more adaptable to changing future conditions, and thus, posing lower risk. WP1 hopes to understand which uncertainties represent barriers to uptake of BGI for urban water and flood risk management under different (uncertain) future scenarios, and risk, compared with the risk of traditional methods, could be a key factor.

Stakeholders

- *Is it more difficult to get approval, from all stakeholders, for Blue Green infrastructure than it is to get approval for traditional flood defences?*

Recent flood defence and risk management programmes in the UK have illustrated that the public and many policy makers are more familiar with, and thus favour, traditional grey infrastructure as this is deemed safer and there is more confidence in its functioning. We expect that it is more difficult to get approval from all stakeholders for BGI, and will discuss this with the LAA, which includes a range of stakeholders from different industry and public spheres. WP2c may also discuss Blue-Green vs. grey solutions with Newcastle communities to include the voice of the local resident in this debate.

- *How did communities in Newcastle respond to the Blue Green concept?*

WP2c will discuss the Blue-Green concept with local communities during their community surveys (note that this will be in small section of Newcastle that aligns with the case study areas). WP1 will get feedback from LAA stakeholder regarding community responses to past BG initiatives in wider Newcastle.

- *What are the main motivations for each of the key stakeholder groups to deliver Blue Green cities? For example, it could be saving money or increased house prices rather than reduced flood risk.*

WP1 and WP2c have a preliminary matrix of stakeholder motivations and drivers for delivering BGI. The motivations are varied and span the regulatory, economic, socio-cultural and environmental sphere. In addition to flood risk management, these include; responding to policy and regulations, climate change adaptation targets, delivery of multiple benefits, managing water as part of spatial planning, reducing the input of surface water into combined sewers to thus reduce capacity, risk of sewer overflow and treatment of surface water at treatment plants (cost saving), reputation and corporate social responsibility, green space provision for recreation and amenity, and improvement in water quality and wildlife/habitat. This could be discussed further with the Newcastle LAA and a factsheet produced.

General project

These questions will be addressed by the Blue-Green Cities team in the later stages of the project. However, we can make some comments at present (detailed below).

- *What difference has your work made to the city and residents of Newcastle?*

One key difference will be the outputs of the LAA in 2015. Indeed, creation of the LAA has brought a range of stakeholders together (who would not otherwise meet as a group and on a regular basis) in an informal setting and encouraged discussion and debate. We have found that objectives of different stakeholder groups often align and hope that this has set a platform for these groups to work together in the future.

- *How transferable are your findings to other UK cities?*

Our findings should be very transferrable as we are using Newcastle to demonstrate the methods and science that we are developing. Our evidence base for Blue-Green will be able to be transferred to other cities and local data will make the outputs location-specific and relevant to the city in question.

- *What are the key advances this project has delivered?*

These range from an advancement of subsurface-surface flow routing (including free and pressurised flow) to the development of a new method for assessing the cumulative benefits of BGI, optimising the benefits and determining the benefit trade-offs, and more that will be determined in 2015.

- *How did your work on social media benefit the project?*

This is discussed in point 5 (below).

- What are the most likely routes to implementation for your findings besides the CIRIA project? (This question is best answered jointly with the SAB)

This will be added to the agenda for the January 2015 QPM. The team plan a UK dissemination event at the end of 2015/early 2016.

2. *The discussions about the level of detail required to understand costs, benefits and uncertainty was very interesting. Our advice is to focus on main premise of this project, which is to put stakeholders at the heart of everything you do. The right level of detail is as much as a stakeholder needs to make their decision, and no more. There are a range of stakeholders and decisions. So it may be appropriate to consider using a tiered approach, similar to the one used in the CIRIA project on the multiple benefits of SuDS.*

We agree that the stakeholders must be at the heart of the Blue-Green Cities Project; one objective is to "put competent authorities, businesses and communities at the centre of the research by establishing feedback pathways between them and the urban flood risk management modellers, planners and decision makers to ensure co-production of knowledge." WP4 will investigate the tiered approach and provide feedback and guidance to WP1 and WP2c regarding the communication of information on costs, benefits and uncertainty.

3. *In much of our discussions on BGI with you, we've all still been in the mindsets of grey infrastructure engineers - focussing on performance standards and maintenance regimes.* ***With the much of Blue Green infrastructure being above ground, we should focus on form as well as function****. Sue Illman, president of the landscape institute, talks about making landscapes beautiful, and would be a good person to speak to in industry, you may also have contacts within your own universities. For the next SAB meeting please provide feedback on which projects you have identified and whether any opportunities have been identified to work together.*

The team have been tasked with engaging landscape architect contacts/colleagues about BGC research and the importance of form as well as function, and investigating projects that may be synergistic. As suggested, feedback will be provided at the next SAB meeting (Jan 2015). Another idea is to host an event in Spring 2015, such as a half-day seminar, and invite landscape architects (in academia and practice) to discuss objectives for implementing BGI, challenges and barriers to implementation, and best practice examples to achieve form as well as function.

Jeremy Purseglove, recently retired from Mott Macdonald as their Chief Environmentalist and a trained landscape architect, is well known in the industry and has cautiously agreed to get involved with the BGC project next year (Dick Fenner has more information).

We have also engaged with BACA Architects who we tried unsuccessfully to get onto the SAB.

4. *All of the SAB are enthusiastic about this project, but a few members have commented that they are not always able to attend in person. So it can be difficult to stay up to date. Before each SAB meeting we would like to have a short project update that briefly describes:*

    - *Progress so far against the main tasks.*
    - *Main achievements since the last SAB meeting.*
    - *Key tasks you will be working on over the next six months.*
    - *Any input you need from the SAB.*

The Blue-Green Cities team will produce a short project update and send this to the SAB one week prior to each SAB meeting. This will be coordinated by Emily Lawson with input from each WP and despatched by Lindsey Air along with any other papers and logistical information.

5. *The feedback on the success of your social media work was very positive, and you should be congratulated for your efforts. Taking it one step further, we would be interested to know what difference social media has made to the project. For example, are there new connections you have made that you wouldn't otherwise have had? Has it helped you communicate more easily within the team? Have you been able to disseminate to a bigger audience?*

The Blue-Green Cities team have used social media to meet several objectives, including;

- dissemination of research, such as the promotion of publications and written outputs;
- stimulation of thinking about Blue-Green concepts;
- notification of conferences (both those of interest to the flood risk management field and those where the BGC team are presenting), and the:
- discussion of "hot topics".

The website provides a platform to showcase BGC research in one easy-to-access location that is often promoted by our social media. It is difficult at present to quantitatively show that social media has increased the number of people interested in BGC research; however, a key advantage has been the ability to communicate with those overseas working on similar projects. Social media encourages the rapid, informal communication without the delays imposed by formal publishing in journals or the peer-review process. It has allowed the project team to have fast access to new, relevant information, and has been a valuable tool for publicising the project, e.g. if the team tweet about a conference that they are attending then others may see this and further investigate the BGC project. We have had numerous requests for information on different WPs based on comments written in social media. Social media can help us see the direction that research is moving in and provide feedback during the research process, in addition to assisting with the dissemination of published research.

We have not specifically used social media to help communication within the BGC team, but rather with external academics, practitioners, and the public, e.g. a public science lecture that Emily Lawson will give in December was advertised on twitter and picked up by academics from Loughborough University who plan to attend. Social media has thus greatly improved

project networking and has widened our dissemination audience beyond the typical academic and practitioner circles.

6. *Some of the SAB members have struggled to get access to the intranet site. Please could you resend the log in details to all SAB members and also re-invite all SAB members to the LinkedIn group.*

The SAB have been emailed instructions for receiving passwords and logging on to the intranet and also LinkedIn group invitations have also been resent. Please get in touch with Emily Lawson if a further invitation is required.

Annex VII. EPSRC Award Letter

EPSRC
Pioneering research and skills

Head of Department
Research Innovation Services
University of Nottingham
King's Meadow Campus
Nottingham United Kingdom
NG7 2NR

Grant Ref: EP/K013661/1

Date: 26 June 2012

Dear Head of Department

GRANT OFFER: Research Grant, IDEAS Factory Sandpits
GRANT TITLE: Delivering and evaluating multiple flood risk benefits

The EPSRC is offering a grant towards the cost of the above project, subject to the terms and conditions set out below.

Return of the 'Offer Acceptance' will be taken as acceptance of the grant on the terms stated. If you are unable to accept the grant you should return a 'Decline' confirmation as soon as possible. Upon receipt of the 'Offer Acceptance' a 'Start Confirmation' request will be issued.

Grants are cash limited and expenditure against the grant must not exceed the value awarded apart for reasons stated in the standard terms and conditions.

Please note copies of this letter have not been sent to the grant holder and co-investigators (as appropriate); it is your responsibility to distribute copies as is necessary.

Yours faithfully

Grants Pre Award Team
RCUK Shared Services Centre Ltd
A service provided on behalf of EPSRC

Organisation: University of Nottingham
Grant Holder: Professor C Thorne
Grant Title: Delivering and evaluating multiple flood risk benefits
Starts: 1 January 2013 **Ends:** 31 December 2015 **Duration:** 36

GRANT VALUE

Funds Awarded

Authorised FEC
(£)
RC Contribution
(£)

	net	Indexation	Total	net	Indexation	Total %	FEC
DI - Staff	578,043	8,077	586,120	462,434	6,462	468,896	80
DI - T&S	100,000	1,425	101,425	80,000	1,140	81,140	80
DI - Other Costs	85,200	1,214	86,414	68,160	971	69,131	80
DA - Investigators	227,434	3,240	230,674	181,947	2,592	184,540	80
DA - Estate Costs	144,818	2,063	146,881	115,854	1,650	117,505	80
DA - Other Directly Allocated	13,788	196	13,984	11,030	157	11,188	80
Indirect - Indirect Costs 5	558,205	7,952	566,157	446,564	6,362	452,926	80
Total Value of Award	**1,707, 488**	**24, 168**	**1 731,656**	**1,365,991**	**19,334**	**1,385,325**	

Cost of Access to Facilities
(Funds not awarded to Grant Holding Organisation)
0

STAFF

Staff Summary

Authorised FEC
net
RC Contribution
net
Number Of Staff
Months
Investigator 241,925 193,540 32
Other 19,459 15,567 7
Researcher 544,093 435,274 162

Staff and DI Investigator Details

Start Date End Date Duration
FTE
Percent
Name or Post Identifier
Summary Fund
Heading
Authorised
Cost (Excluding Indexation)
1 January 2013 31 December 2015 36 10 Dr J Lamond Directly Incurred 14491.00
1 January 2013 31 December 2015 36 66 UWE RA Directly Incurred 66940.00
1 January 2013 31 December 2015 36 67 Leeds RA Directly Incurred 88389.00
1 January 2013 31 December 2015 36 100 Nottingham RA Directly Incurred 123828.00
1 July 2013 31 December 2015 30 100 Cambridge RA Directly Incurred 103036.00
1 January 2013 31 December 2014 24 100 Heriot Watt RA Directly Incurred 89722.00
1 January 2013 31 December 2015 36 10 Newcastle clerical Directly Incurred 7556.00
1 January 2013 31 December 2015 36 10
Nottingham admin
support
Directly Incurred 11903.00
1 January 2013 31 December 2015 36 67 Newcastle RA Directly Incurred 72178.00

Staff Details (Directly Allocated)

Average
Hours/week
Name or Post Identifier
3.8 Dr R Fenner
1.9 Dr D Guan
1.9 Dr H Haynes
3.8 Professor C Kilsby
7.5 Professor LA Smith
5.6 Professor C Thorne

1.9 Professor S White
3.8 Professor N Wright

EQUIPMENT DETAILS

Description Delivery Date Country Of Origin Total Value

FACILITY AND SERVICE DETAILS

Facility Cost of Access
Number of
Units

PROJECT PARTNERS

Organisation Department Last Name First Name
In Kind
Value (£)
Monetary
Value (£)

GRANT ADDITIONAL INFORMATION

"In line with the implementation of the Wakeham review, the indirect costs on this grant have been adjusted by the efficiency factor associated with the efficiency group in which your organisation has been placed, which in most cases results in a reduction compounded over the duration of the grant. Further information is available at http://www.rcuk.ac.uk/research/Efficiency/Pages/Efficiency2011.aspx"

GRANT CONDITIONS

CALL CONDITIONS

SCHEME CONDITIONS

Terms and Conditions of Research Council fEC Grants

These terms and conditions relate to grants, comprising Research Grants and Fellowships, costed and funded on the basis of full economic costs (fEC), calculated in accordance with the TRAC methodology (universities and other higher education bodies) or by an equivalent methodology by other Research Organisations.

Grants awarded by the Research Councils are made to Research Organisations on the basis of this single set of core terms and conditions. The Research Councils are:

Arts and Humanities Research Council (AHRC)
Biotechnology and Biological Sciences Research Council (BBSRC)
Economic and Social Research Council (ESRC)
Engineering and Physical Sciences Research Council (EPSRC)
Medical Research Council (MRC)
Natural Environment Research Council (NERC)
Science and Technology Facilities Council (STFC)

Individual Councils may add additional conditions to the grant to reflect the particular circumstances and requirements of their
organisation, or the nature of a particular grant. Acceptance of a grant constitutes acceptance of both the core conditions and any
additional conditions.

The Research Councils reserve the right to vary these terms and conditions

Definitions

Research Council: any of the bodies listed above.

Grant: support for a proportion of the full economic costs of a project. A Grant may be either a Research Grant or a Fellowship.

• Research Grant: a contribution to the costs of a stated research project which has been assessed as suitable for funding through
the procedures established by the relevant Research Council.

• Fellowship Grant: an award made through a fellowship competition providing a contribution to the support of a named individual. It
covers the cost of the time dedicated by the fellow to their personal research programme, and may or may not include research support costs.

Grant Holder: the person to whom the grant is assigned and who has responsibility for the intellectual leadership of the project and for the overall management of the research. The Grant Holder is either the Principal Investigator (in the case of a Research Grant) or a Research Fellow (in the case of a Fellowship Grant)

Co-Investigator: a person who assists the Grant Holder in the management and leadership of a project.

Research Organisation: the organisation to which the grant is awarded and which takes responsibility for the management of the research project and the accountability of funds provided.

Full Economic Costs (fEC): a cost which, if recovered across an organisation's full programme, would recover the total cost (direct, indirect and total overhead) including an adequate recurring investment in the organisation's infrastructure.

Directly Incurred Costs: costs that are explicitly identifiable as arising from the conduct of a project, are charged as the cash value actually spent and are supported by an audit record.

Directly Allocated Costs: the costs of resources used by a project that are shared by other activities. They are charged to projects on the basis of estimates rather than actual costs and do not represent actual costs on a project-by-project basis.
Indirect Costs: non-specific costs charged across all projects based on estimates that are not otherwise included as Directly Allocated Costs. They include the costs of the Research Organisation's administration such as personnel, finance, library and some departmental services. Exceptions: Directly Incurred Costs that Research Councils fund at 100% of fEC, subject to actual expenditure incurred, or items that are outside fEC.
Transparent Approach to Costing (TRAC): an agreed methodology used by universities and other higher education bodies for calculating full economic costs.
Funding Assurance Programme: a programme of visits and office-based tests to seek assurance that grant funds are used for the purpose for which they are given and that grants are managed in accordance with the terms and conditions under which they are awarded.
Data Protection Regulations
The Research Councils will use information provided on the grant proposal for processing the proposal, the award of any consequential grant, and for the payment, maintenance and review of the grant. This may include:
• Registration of proposals.
• Operation of grants processing and management information systems.
• Preparation of material for use by referees and peer review panels.
• Administration, investigation and review of grant proposals.
• Sharing proposal information on a strictly confidential basis with other funding organisations to seek contributions to the funding of proposals.
• Statistical analysis in relation to the evaluation of research and the study of trends.
• Policy and strategy studies.
To meet the Research Councils' obligations for public accountability and the dissemination of information, details of grants may also be made available on the Research Councils' web sites and other publicly available databases, and in reports, documents and mailing lists.
After completion of the grant, the Research Council may contact the Grant Holder concerning funding opportunities or events, or for the purposes of evaluation. In some instances, the Research Council may wish to authorise an affiliate organisation to contact the Grant Holder on its behalf. It is assumed that, by agreeing to these terms and conditions, the Research Organisation consents to this on behalf of the Grant Holder, but if the Grant Holder prefers not to be contacted in this way, he or she should state this to the Research Council. Grant Holders may choose to opt out at any point, provided they comply with all other terms and conditions
associated with the grant.
Freedom of Information Act and Environmental Information Regulations
Attention is drawn to the provisions of the Freedom of Information Act 2000 (FOIA) and the Environmental Information Regulations (EIRs). Research Councils have issued Publication Schemes which set out the types of information publicly available on their websites or published as documents. In addition, Research Councils have an obligation to respond to specific requests and may be required to disclose information about or provided by Research Organisations. In some cases the Research Council may consult the Research Organisation before disclosure, but it is under no obligation to do so. If a Research Organisation considers that any information it provides to a Research Council would be subject to an exemption under FOIA or the EIRs it should clearly mark the information as such and provide an explanation of why it considers the exemption applies and for how long. The Research Council will consider this explanation before disclosure, but it is not obliged to accept it as binding.
Where a Research Council determines that a Research Organisation is holding information on its behalf that it requires in order to comply with its obligations under FOIA or EIRs, the Research Organisation undertakes to provide access to such information as soon as reasonably practicable on request of the Research Council and in any event within 5 working days. In some cases Research Organisations may be directly responsible for complying with FOIA and the EIRs; in such cases the Research Councils accept no responsibility for any failure to comply by the Research Organisations.
Grant Conditions GC1 – GC25
GC 1 Responsibilities of the Research Organisation
• The Research Organisation must ensure that any part of the Full Economic Cost of the project not funded by the Research Council grant is committed to the project before it starts.
• The Research Organisation must ensure that the Grant Holder and Co-Investigators are made aware of their responsibilities and that they observe the terms and conditions of grants.
• The Research Organisation must ensure that the research supported by the grant complies with all relevant legislation and Government regulation, including that introduced while work is in progress. This requirement includes approval or licence from any regulatory body that may be required before the research can commence.
• The Research Organisation is expected to adopt the principles, standards and good practice for the management of research staff set out in the 2008 Concordat to Support the Career Development of Researchers, and subsequent amendments. The Research Organisation must create an environment in which research staff are selected and treated on the basis of their merits, abilities and potential. It must ensure that reliable systems and processes are in place so that the principles of the Concordat are embedded into
practice within the Research Organisation. It must ensure compliance with all relevant legislation and Government regulation, including any subsequent amendments introduced while work is in progress.

• The Research Organisation is expected to adopt the principles, standards and good practice for public engagement with research set out in the 2010 Concordat for Engaging the Public with Research: http://www.rcuk.ac.uk/per/Pages/Concordat.aspx. The Research Organisation must create an environment in which public engagement is valued, recognised and supported. It must ensure that reliable systems and processes are in place so that the principles of the Concordat are embedded into practice within the Research Organisation.
• The Research Organisation must appoint a Research Fellow as an employee for the full duration of the award.
• The Research Organisation must integrate the Research Fellow within the research activities of the host department, whilst ensuring that he or she is able to maintain independence and focus on their personal research programme.
• The Research Organisation must notify the Research Council of any change in its status, or that of the Grant Holder, that might affect the eligibility to hold a grant.
• The Research Organisation must ensure that the requirements of the Employing Organisation under the Department of Health's Research Governance Framework for Health and Social Care (or equivalent) are met for research involving NHS patients, their organs, tissues or data, and that the necessary arrangements are in place with partner organisations. Where it also accepts the responsibilities of a Sponsor (as defined in the Governance Framework), it must also ensure that the requirements for Sponsors are met.
• The Research Organisation must ensure proper financial management of grants and accountability for the use of public funds.

GC 2 Research Governance

It is the responsibility of the Research Organisation to ensure that the research is organised and undertaken within a framework of best practice that recognises the various factors that may influence or impact on a research project. Particular requirements are to ensure that all necessary permissions are obtained before the research begins, and that there is clarity of role and responsibility among the research team and with any collaborators. The Research Councils expect research to be conducted in accordance with the highest standards of research integrity and research methodology.

Research Ethics

The Research Organisation is responsible for ensuring that ethical issues relating to the research project are identified and brought to the attention of the relevant approval or regulatory body. Approval to undertake the research must be granted before any work requiring approval begins. Ethical issues should be interpreted broadly and may encompass, among other things, relevant codes of practice, the involvement of human participants, tissue or data in research, the use of animals, research that may result in damage to the environment and the use of sensitive economic, social or personal data.

Use of Animals in Research

Wherever possible, researchers must adopt procedures and techniques that avoid the use of animals. Where this is not possible, the research should be designed so that:
• The least sentient species with the appropriate physiology is used.
• The number of animals used is the minimum sufficient to provide adequate statistical power to answer the question posed.
• The severity of procedures performed on animals is kept to a minimum. Experiments should be kept as short as possible.

Appropriate anaesthesia, analgesia and humane end points should be used to minimise any pain and suffering. The provisions of the Animals (Scientific Procedures) Act 1986, and any amendments, must be observed and all necessary licences must have been received before any work requiring approval takes place.

Medical and Health Research The Research Organisation is responsible for managing and monitoring the conduct of medical and health research in a manner consistent with the Department of Health's Research Governance Framework for Health and Social Care (or equivalent). There must be effective and verifiable systems in place for managing research quality, progress and the safety and well-being of patients and other research participants. These systems must promote and maintain the relevant codes of practice and all relevant statutory review, authorisation and reporting requirements.

Research involving human participants or data within the social sciences that falls outside the Department of Health's Research Governance Framework must meet the provisions and guidelines of the ESRC's Research Ethics Framework. While this research may involve patients, NHS staff or organisations, it is defined as research that poses no clinical risk or harm to those who are the subjects of research. Research Organisations must ensure that appropriate arrangements are in place for independent ethics review of social science research that meets local research ethics committee standards. Significant developments must be assessed as the research proceeds, especially those that affect safety and well-being, which should be reported to the appropriate authorities and to the Research Council. The Research Organisation must take appropriate and timely action when significant problems are identified. This may include temporarily suspending or terminating the research. The Research Organisation is responsible for managing and monitoring statutory requirements for which it accepts responsibility, for example, in relation to legislation on clinical trials, use of human organs, tissues and data. Guidance by the MRC on the conduct of medical research, and by ESRC on the conduct of social science research, provided on behalf of all Research Councils, must be observed.

Health and Safety The Research Organisation is responsible for ensuring that a safe working environment is provided for all individuals associated with a research project. Its approach and policy on health and safety matters

must meet all regulatory and legislative requirements and be consistent with best practice recommended by the Health & Safety Executive.
Appropriate care must be taken where researchers are working off-site. The Research Organisation must satisfy itself that all reasonable health and safety factors are addressed. The Research Councils reserve the right to require the Research Organisation to undertake a safety risk assessment in individual cases where health and safety is an issue, and to monitor and audit the actual arrangements made. Misconduct and Conflicts of Interest
The Research Organisation is required to have in place procedures for governing good research practice, and for investigating and reporting unacceptable research cond ct that meet the requirements set out in the Research Councils' Code of Conduct and Policy on the Governance of Good Research Conduct (2009) and any subsequent amendments. The Research Organisation must ensure that potential conflicts of interest in research are declared and subsequently managed.
GC 3 Use of Funds
Subject to the following conditions, grant funds may be used, without reference to the Research Council, in such a manner as to best carry out the research.
Grant funds include a provision for inflation based on the GDP Deflators published by HM Government. The value of the grant may be varied by the Research Council during the lifetime of the grant in accordance with the deflators or to take into account any other
Government decisions affecting the funding available to the Research Councils. Grant funds are provided for a specific research
project. Under no circumstances may Directly Incurred and Exceptions funds be used to meet costs on any other grant or activity.
Directly Incurred and Exceptions funds cannot be used to meet the costs of an activity that will fall beyond the actual end date of the grant, e.g. when travel falls after the end of the grant, the costs cannot be charged to the grant even if the tickets, etc. can be purchased in advance.
Any proposal to purchase an item of equipment in the last 6 months of the grant is subject to prior written approval by the Research
Council. The Research Council will wish to be assured that the item of equipment is essential to the research.
GC 4 Starting Procedures
The process for activating a grant consists of two separate stages. The Research Organisation must formally accept the grant by
completing and returning the Offer Acceptance within 10 working days of the offer letter being issued. Returning the Offer
Acceptance will result in the Start Confirmation and the Payment Schedule being issued. The Start Confirmation must be submitted within 42 (calendar) days of the research/training starting and the start date shown on the start confirmation will be regarded as the start date of the grant. The start of research may be delayed by up to 6 months (ESRC 3 months) from the start
date shown in the offer letter, the duration of the grant remaining unchanged. The grant may lapse if it is not started within this period.
Where there are staff funded by the grant who were intended to be appointed from the start date, payments will take effect from the date when the first such staff start work. Otherwise, payments will take effect from the start date given on the start confirmation.
Expenditure may be incurred prior to the start of research and subsequently charged to the grant, provided that it does not precede the date of the offer letter.
GC 5 Changes in Research Project
The Research Council must be consulted in the event of any major change in the proposed research, including failure to gain access to research facilities and services, or to gain ethical committee approval for the research, particularly those which make it unlikely that the objectives of the research can be achieved. If appropriate, revised proposals may be required. The Research Council reserves the right to make a new grant in place of the existing grant, or to revise, retain or terminate the existing grant.
It is the responsibility of the Research Organisation to manage the resources on the grant, including the staff, and the Research
Council need not be consulted if staffing levels on the grant are changed. However, a proportionate reduction should be made in the value of Estates, Indirect Costs and Infrastructure Technicians claimed by the Research Organisation in the following
circumstances:
1. a post that attracts these costs is not filled.
2. a staff member who attracts these costs leaves more than six months before the end of the period for which the post was funded
and is either not replaced, or is replaced by a category of staff that does not attract the costs e.g. project student or technician.
GC 6 Transfers of Funds between Fund Headings
Transfers of funds between fund headings are permitted only within and between Directly Incurred costs and Exceptions, excluding
equipment. Equipment funding is ring-fenced and transfers into or out of the equipment headings, whether under Directly Incurred or Exceptions, is not permitted. Transfers will be at the rate applicable for the heading, as set out in the award letter. Funds can only be transferred and used to meet the cost of activity or activities that meet the

agreed aims and objectives of the project. While approval does not need to be sought from the Research Council for transfer of funds, the Research Councils reserve the right to query any expenditure outlined in the Final Expenditure Statement, which has not been incurred in line with the Grant Terms and Conditions.

GC 7 Extensions

Research Grants: After a research grant has started, the duration may be extended by a total of up to 6 months, subject to prior written approval. Extensions may cover breaks or delays in the appointment of staff, periods of maternity leave, paternity leave, adoption leave, parental leave, extended jury service or paid sick leave exceeding 3 months (or possibly shorter periods of sick leave if the member of staff is disabled for the purposes of the Equality Act 2010 or other exceptional circumstances with the agreement of the Research Council).

Fellowship Grants: After a fellowship grant has started, the duration may be extended to cover maternity leave, paternity leave, adoption leave, parental leave, extended jury service or paid sick leave for a Research Fellow in line with the terms and conditions of the fellow's employment. For staff other than the fellow extensions may cover breaks or delays in the appointment of staff, periods of maternity leave, paternity leave, adoption leave, parental leave, extended jury service or paid sick leave exceeding 3 months (or possibly shorter periods of sick leave if the member of staff is disabled for the purposes of the Equality Act, or other
exceptional circumstances with the agreement of the Research Council).

Any request for an extension should be made via the Grant Maintenance facility in JeS as soon as the requirement is identified. All requests for extensions must be made before the grant ends.

GC 8 Staff

The Research Organisation must assume full responsibility for staff funded from the grant and, in consequence, accept all duties owed to and responsibilities for these staff, including, without limitation, their terms and conditions of employment and their training and supervision, arising from the employer/employee relationship.

The Research Organisation must provide research staff with a statement, at the outset of their employment, setting out the provisions for career management and development, including personal skills training, and ensure that they have access to appropriate training opportunities. Provided it is related to the research project on which they are currently working, Research staff and Research Fellows may, during normal working hours, undertake teaching and demonstrating work, including associated training, preparatory, marking and examination duties, for up to an average of 6 hours a week (pro rata for part-time staff) calculated over the period that they are
supported on the grant.

GC 9 Maternity, Paternity, Adoption and Parental Leave

The research organisation will be compensated at the end of the grant to cover any additional net costs, that cannot be met within the cash limit, of paid maternity, paternity, adoption and parental leave for staff within the Directly Incurred and Exceptions fund headings (excluding the principal and co-investigators, unless they are also research fellows or research assistants funded by the grant) if they fulfil the relevant qualifying conditions of the employing Research Organisation. The net cost is the amount paid to the individual less the amount the Research Organisation can recover for Statutory Maternity Pay and Statutory Adoption Pay from
HMRC. Maternity, paternity, adoption and parental pay is payable by the Research Council only for directly incurred staff that are funded for 100% of their contracted time on the grant (apart from staff acting as principal or co-investigators unless they are also research fellows or research assistants funded by the grant).

Grant funds, within the announced cash limit, may be used to meet the costs of making a substitute appointment and/or extending the grant to cover a period of maternity, paternity, adoption or parental leave for staff within the directly incurred and exceptions fund headings (excluding the principal and co-investigators, unless they are also research fellows or research assistants funded by the grant). The duration of a grant will be extended only if the period can be accommodated within the maximum period allowed for extensions. Directly Allocated and Indirect funds will not be increased as a result of such extensions.

Research Grants: Research Grant funds may be used to meet the costs of paid maternity, paternity, parental and adoption leave only to the extent that it is taken during the original period of the grant. The Research Organisation will be responsible for any liability for maternity, paternity, parental and adoption leave pay for staff supported by the grant outside the original period of the grant. If, for example, a grant ends while a member of research staff is part-way through her maternity leave, the Research Organisation will be responsible for that part of the maternity leave which is taken after the research grant has ended.

Fellowship Grants: Fellows are entitled to take maternity, paternity, adoption or parental leave in accordance with the terms and conditions of the fellow's employment. If requested, consideration will be given to allowing a fellowship grant to be placed in abeyance during the absence of the Research Fellow for maternity, paternity, adoption or parental leave, and the period of the fellowship extended by the period of leave. Consideration will be given to requests to continue the fellowship on a flexible or part time basis to allow the Research Fellow to meet caring responsibilities.

GC 10 Sick Leave

The Research Organisation will be compensated at the end of the grant to cover any additional net costs, that cannot be met within the cash limit, of paid sick leave for staff within the Directly Incurred and Exceptions fund headings (excluding the Principal and Co-Investigators, unless they are also Research Fellows or Research Assistants funded by the grant) who fulfil the qualifying conditions of the Research Organisation. The net cost is the amount paid to the individual less the amount the Research Organisation can recover from HMRC.

Sick pay is payable by the Research Council only for directly incurred staff that are funded for 100% of their contracted time on the grant (apart from staff acting as principal or co-investigators unless they are also research fellows or research assistants funded by the grant).

Grant funds, within the announced cash limit, may be used to meet the approved costs of making a substitute appointment and/or extending the grant to cover a period of sick leave for staff within the directly incurred and exceptions fund headings (excluding the principal and co-investigators, unless they are also research fellows or research assistants funded by the grant). The duration of a grant will be extended only if the period can be accommodated within the maximum period allowed for extensions. Directly Allocated and Indirect funds will not be increased as a result of such extensions.
Research Grants: Where there is a continuous period of sick leave in excess of 3 months, the Research Organisation may apply to the Research Council to discuss the possibility of a substitute appointment to safeguard progress on the project. Where a Research Assistant has been on sick leave in excess of 3 months the Research Organisation must comply with all their obligations to consider reasonable adjustments before making a substitute appointment. Where a Research Assistant has been on sick leave for
an aggregate (not necessarily continuous) period in excess of 3 months, where this is due to a single condition or a series of related conditions, the Research Organisation may request an extension to the duration of the project
Fellowship Grants: Fellows are entitled to take sick leave in accordance with the research organisation's terms and conditions. If requested, consideration will be given to allowing a fellowship grant to be placed in abeyance during the absence of the Research Fellow due to sick leave, and the period of the fellowship extended by the period of sick leave. The additional salary costs for the fellow (pro rata to their percentage FTE on the fellowship) should be claimed, as necessary, at the end of the extended period.
GC 11 Procurement of Equipment
The procurement of equipment, consumables and services, including maintenance, must comply with all relevant national and EU legislation and the Research Organisation's own financial policy and procedures. Accepted procurement best practice in the higher education sector must be observed. For all equipment and services where the contract value is more than £25,000, excluding VAT, professionally qualified procurement staff must be consulted before the procurement process begins, and, where appropriate, at the
market research stage, and must approve the order/contract before it is placed with a supplier.
GC 12 Ownership and Use of Equipment purchased from grant funds is primarily for use on the research project for which the research grant was awarded, and belongs to the Research Organisation. In certain circumstances the Research Council may wish to retain ownership throughout the period of the grant and possibly beyond. In such cases, the grant will be subject to an additional condition. The Research Council must be informed if, during the life of the research grant, the need for the equipment diminishes substantially or it is not used for the purpose for which it was funded. The Research Council reserves the right to determine the disposal of such
equipment and to claim the proceeds of any sale. Any proposal to transfer ownership of the equipment during the period of the grant is subject to prior approval by the Research Council. After the research project has ended, the Research Organisation is free to use the equipment without reference to the Research Council, but it is nevertheless expected to maintain it for research purposes as long as is practicable. Where there is spare capacity in the use of the equipment, the Research Council expects this to be made available to other users.
Priority should be given to research supported by any of the Research Councils and to Research Council-funded students.
GC 13 Transfer of a Grant to another Research Organisation
The Research Organisation must notify the Shared Services Centre via the Grant Maintenance facility in if the Grant Holder intends to transfer to another organisation. If this organisation is eligible to hold grants, and is able to provide a suitable environment to enable the project to be successfully completed, the expectation is that the grant would be transferred with the Grant Holder. Written agreement to this is required from both the relinquishing and receiving organisations; this will normally be triggered automatically by the initial request to JeS. The Research Council will wish to be assured that satisfactory arrangements have been agreed that will enable the project to be undertaken, or to continue, in accordance with its research objectives. If suitable arrangements cannot be agreed, the Research Council will consider withdrawing its support or terminating the grant. Where there is a basis for continuing involvement by the relinquishing organisation, agreement should be reached between both organisations on the apportionment of work and the distribution of related funding.
Grants will not be re-costed following transfer. The unspent balance of Directly Incurred and Exceptions, together with a pro rata share of Directly Allocated and Indirect costs, will be transferred to the new Research Organisation. The receiving organisation will be required to confirm, by return of an offer acceptance, that it will provide any balance of resources needed to complete the project.
GC 14 Change of Grant Holder Research Grants: The Research Organisation must consult the Research Council via the Grant Maintenance facility in JeS if it is proposed to change the Grant Holder, for example, following retirement or resignation. Where the Grant Holder is transferring to
another organisation eligible to hold a grant, the provisions of GC 13 will apply. In other circumstances, the Research Organisation may nominate a replacement Grant Holder. The Research Council will wish to be assured that the replacement meets the eligibility criteria and has the expertise and experience to lead the project to a successful conclusion, in accordance with its research objectives.
Fellowship Grants: A fellowship grant is awarded on the basis of a named individual's suitability to undertake and benefit from the period of research: therefore changes to the Grant Holder are not permitted. The resignation of the Research Fellow, or the termination of their employment, constitutes the end of the grant for the purpose of submitting a final report and the Council's financial liabilities.
GC 15 Annual Statement

The Research Organisation may be sent a statement to return each year showing payments made by the Research Council during the previous financial year for all the grants it holds. Where a statement is required, the Research Organisation must certify, by returning the statement, that: • expenditure has been incurred in accordance with the grant conditions, and • those grants shown as current are continuing.
No further payments will be made until the annual statement has been received and accepted by the Research Council.
GC 16 Expenditure Statements
The Research Organisation must complete and return an expenditure statement within 3 months of the end date of a grant. Once an expenditure statement has been received and the expenditure incurred has been reconciled against payments made, it will be considered as final. Expenditure shown in the Directly Incurred and Exceptions headings must show the actual expenditure incurred by the project. Settlement by the Research Council will reflect the proportion of fEC stated in the award letter applied to actual expenditure, within the cash limit.
For the Directly Allocated and Indirect Costs headings, the Research Council will pay the amount shown as spent, within the cash limit, provided that the grant ran its full course. Where a grant is terminated more than 6 months before the planned end date, a pro rata share will be paid. Where a grant terminates within 6 months of the planned end date, estates and Indirect Costs will be paid in full, but Investigators' costs and Other Directly Allocated Costs will be paid pro rata. Costs arising from maternity, paternity, adoption or sick leave should be identified in the Absence heading of the statement. The Research Council reserves the right to require the Research Organisation to complete and submit a statement of expenditure at any time during the course of a grant, or to provide supplementary information in support of an interim or final expenditure statement.
If there are exceptional reasons that will prevent submission of the expenditure statement within the period allowed, a written request may be made via the Grant Maintenance facility in JeS, before the due date passes, for the submission period to be extended.
GC 17 Inspection
The Research Council reserves the right to have reasonable access to inspect the records and financial procedures associated with grants or to appoint any other body or individual for the purpose of such inspection.
The Research Organisation must, if required by the Research Council, provide a statement of account for the grant, independently examined by an auditor who is a member of a recognised professional body, certifying that the expenditure has been incurred in accordance with the research grant terms and conditions.
Research Councils will undertake periodic reviews of Research Organisations within the Funding Assurance Programme to seek assurance that grants are managed in accordance with the terms and conditions under which they are awarded.
GC 18 Final Report
A report on the conduct and outcome of the project must be submitted by the Research Organisation within three months of the end of the grant, on the form provided. No further application from a Grant Holder will be considered while a final report is overdue. If there are exceptional reasons that will prevent submission of the final report within the period allowed, a written request may be made via the Grant Maintenance facility in JeS, before the due date passes, for the submission period to be extended.
GC 19 Sanctions
The Research Councils reserve the right to impose financial sanctions where they identify areas of non-compliance in relation to the terms and conditions of grants. Further details on the assurance requirements of the Research Councils can be found at: http://www.rcuk.ac.uk/about/aboutRCUK/Efficiency/Pages/fap.aspx
If the final report or the financial expenditure statement is not received within the period allowed, the research council may recover 20% of expenditure incurred on the grant. All payments may be recovered if the report or statement is not received within 6 months of the end of the grant. In relation to the current Quality Assurance and validation project for TRAC implementation in universities, the Research Councils reserve the right to apply sanctions of 75% of the non-compliant rate where an institution is found to be using rates which are materially inaccurate (>10% variance on any single rate). These sanctions would only apply to future applications although Councils may exercise a higher sanction where there has been evidence of significant overpayments to research organisation based on inaccurate rates.
GC 20 Public Engagement
It is the responsibility of the Research Organisation and the Grant Holder and Co-Investigators to communicate the research to the public at both local and national level, and to raise awareness of the role of science and research in any related issues of public interest. Special schemes exist in some Research Councils providing additional support for these activities. GC 21 Exploitation and Impact
It is the responsibility of the Research Organisation, and all engaged in the research, to make every reasonable effort to ensure that the intellectual assets obtained in the course of the research, whether protected by intellectual property rights or not, are used to the benefit of society and the economy. Research outcomes should be disseminated to both research and more widespread audiences - for example to inform potential users and beneficiaries of the research. Unless stated otherwise, the ownership of all intellectual assets, including intellectual property, and responsibility for their application, rests with the organisation that generates them.
Where the grant is associated with more than one research organisation and/or other project partners, the basis of collaboration
between the organisations, including ownership of intellectual property and rights to exploitation, is expected to be set out in a formal collaboration agreement. It is the responsibility of the Research Organisation to put such an agreement in place before the research begins. The terms of collaboration agreements must not conflict with the

Research Councils' terms and conditions. Arrangements for collaboration and/or exploitation must not prevent the future progression of research and the dissemination of research results in accordance with academic custom and practice. A temporary delay in publication is acceptable in order to allow
commercial and collaborative arrangements to be established. The Research Council may, in individual cases, reserve the right to retain ownership of intellectual assets, including intellectual property (or assign it to a third party under an exploitation agreement) and to arrange for it to be exploited for the national benefit
and that of the Research Organisation involved. This right, if exercised, will be set out in an additional grant condition. There should be suitable recognition and reward to researchers who undertake activities that deliver benefit through the application of research outcomes. The Research Organisation must ensure that all those associated with the research are aware of, and accept, these arrangements.

GC 22 Research Monitoring and Evaluation

While it is the responsibility of the Research Organisation to manage the research, the Research Council reserves the right to call for periodic information on progress or to visit the project team. The Grant Holder may also be asked to attend meetings to exchange information and ideas with others undertaking research in the same or similar fields. The Grant Holder must make all reasonable efforts, if so invited, to respond to requests for information or to attend events or activities organised by the Research Council concerning the research undertaken. Such events may be held after a grant has finished.

GC 23 Publication and Acknowledgement of Support

The Grant Holder should, subject to the procedures laid down by the Research Organisation, publish the results of the research in accordance with normal academic practice. Publications and other forms of media communication, including media appearances, press releases and conferences, must acknowledge the support received from the Research Council, quoting the grant reference number if appropriate.

Journal publications should acknowledge the funding source using the standard format agreed by funders and publishers and detailed in the additional information accompanying this grant.

GC 24 Disclaimer

The Research Councils accept no liability, financial or otherwise, for expenditure or liability arising from the research funded by the grant, except as set out in these terms and conditions, or otherwise agreed in writing.

Where studies are carried out in an NHS Trust, the Trust has a duty of care to its patients. The Research Council does not accept liability for any failure in the Trust's duty of care, or any negligence on the part of its employees.

The Research Councils reserve the right to terminate the grant at any time, subject to reasonable notice and to any payment that may be necessary to cover outstanding and unavoidable commitments.

Further to GC3, the Research Councils reserve the right to amend the payment profile at their discretion. The Research Organisation will be advised, in advance, of any such a change. Changes to payment profiles may affect the overall value of the grant. If a grant is terminated or reduced in value, no liability for payment or redundancy or any other compensatory payment for the dismissal of staff funded by the grant will be accepted, but, subject to the provisions of GC16, negotiations will be held with regard to other contractual commitments and concerning the disposal of assets acquired under the research grant.

GC 25 Status

These terms and conditions will be governed by the laws of England and Wales; all matters relating to the terms and conditions will be subject to the exclusive jurisdiction of the courts of England and Wales.

If any provision of these terms and conditions is found by a court or other legitimate body to be illegal, invalid or unreasonable, it will not affect the remaining terms and conditions which will continue in force.

These terms and conditions, together with any additional conditions set out in the grant, contain the whole agreement between the Research Council and the Research Organisation in relation to the stated research grant. The Research Council and the Research Organisation do not intend that any of these terms and conditions should be enforceable by any third party.

Annex VIII. Consortium Agreement

ACADEMIC COLLABORATION AGREEMENT

THIS AGREEMENT dated is made **BETWEEN**:

(1) **THE UNIVERSITY OF NOTTINGHAM** whose administrative offices are at University Park, Nottingham, NG7 2RD (hereinafter "Lead University");
(2) **THE CHANCELLOR MASTERS AND SCHOLARS OF UNIVERSITY OF CAMBRIDGE** of The Old Schools, Trinity Lane, Cambridge CB2 1TN (hereinafter "Collaborating University")
(3) **THE CRANFIELD UNIVERSITY** whose administrative offices are at Cranfield, Bedfordshire, MK43 OAL (hereinafter "Collaborating University");
(4) **THE HERIOT-WATT UNIVERSITY** a Scottish Charity registered under number SC 000278 and having its principle offices at Riccarton, Edinburgh EH14 4AS (hereinafter "Collaborating University")
(5) **THE UNIVERSITY OF LEEDS** whose administrative offices are at Leeds, LS2 9JT (hereinafter "Collaborating University")
(6) **THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCES** whose administrative offices are at Houghton Street, London WC2A 2AE (hereinafter "Collaborating University")
(7) **THE UNIVERSITY OF NEWCASTLE UPON TYNE** whose administrative offices are at King's Gate, Newcastle upon Tyne, NE1 7RU (hereinafter "Collaborating University")
(8) **THE UNIVERSITY OF THE WEST OF ENGLAND, BRISTOL** whose administrative offices are at Frenchay Campus, Coldharbour Lane, Bristol, BS16 1QY (hereinafter "Collaborating University")

each a "Party" and collectively "the Parties"

WHEREAS

A. The Lead University was the lead applicant in a proposal to EPSRC, for a research project called "Delivering and evaluating multiple flood risk benefits" ("the Project") as set out in Schedule 1; and

B. The Collaborating University(s) was a co-applicant to the Funding Body in the proposal submitted to the Funding Body for the Project as set out in Schedule 1; and

C. The Funding Body has awarded a contract to the Lead University to carry out the Project and this is set out in Schedule 2 ("the Contract"); and

D. The Lead University wishes the Collaborating University(s) to carry out a portion of the project as envisaged in the proposal to the Funding Body as set out in Schedule 1.

In the event of any conflict between the terms of this Collaboration Agreement and the terms of the Contract, then the terms of the Contract will prevail.
This Agreement sets out the terms under which the Parties shall perform the Allocated Work:

1. DEFINITIONS

1.1 The following expressions shall have the following meanings in this Collaboration Agreement including its recitals, unless the context requires otherwise:

'Steering Panel'	shall mean a committee to advise on the strategic direction of the Project as a whole, the terms of reference of which are as set out in Schedule 4

'Allocated Work'	shall mean the research allocated to each Collaborating University, as defined in the Project at Schedule 1
'Arising Intellectual Property'	shall mean any Intellectual Property which is generated or first reduced to practice by any Party or Parties directly as a result of the work undertaken in accordance with this Collaboration Agreement
'Background Intellectual Property'	shall mean any Intellectual Property excluding Arising Intellectual Property owned or controlled by any Party prior to commencement of or independently from the Project, and which the owning Party contributes or uses in the course of performing the Project
'Co-investigator(s)'	shall be Richard Fenner at the University of Cambridge, shall be Jenny Mant at the Cranfield University, shall be Heather Haynes at the Heriot-Watt University, shall be Nigel Wright and Dabo Guan at the University of Leeds, shall be Leonard Smith at the London School of Economics and Political Science, shall be Chris Kilsby at the University of Newcastle upon Tyne, shall be Jessica Lamond at the University of the West of England or their successors as determined by Clause 8.3 of this Agreement.
'Confidential Information'	shall mean any Background Intellectual Property disclosed by one Party to the others for use in the Project [and identified as confidential before or at the time of disclosure], and any Arising Intellectual Property in which that Party owns the Intellectual Property.
'Funding Body'	shall mean the Engineering and Physical Sciences Research Council (EPSRC), incorporated by Royal Charter, with registered number RC000708 and having its principal office at Polaris House, North Star Avenue, Swindon SN2 1ET
'Intellectual Property'	shall mean intellectual property of any description including but not limited to all inventions, designs, information, specifications, formulae, improvements, discoveries, know-how, data, processes, methods, techniques and the intellectual property rights therein, including but not limited to, patents, copyrights, database rights, design rights (registered and unregistered), trademarks, trade names and service marks, any intellectual property protection either arising automatically at law or arising further to any statutory procedure, and applications for any of the above.
'Principal Investigator'	shall be Prof Colin Thorne at the Lead University, or his/her successor as agreed by the Funding Body
'Project Period'	shall be from 1st January 2013 TO 31 December 2015.

In this Collaboration Agreement, references to Clauses and Schedules refer to clauses and schedules of this Collaboration Agreement; references to a gender shall include any other

gender, as required by the context; and the singular form of any word includes the plural, and vice versa, as required by the context.

THE PARTIES HEREBY AGREE

2. THE PROJECT

2.1 The Parties will each use their reasonable endeavours to collaborate on the Project as described in Schedule 1 of this Collaboration Agreement including any modifications, deletions or expansions approved in writing by all Parties. The Parties to this Collaboration Agreement shall be bound *mutatis mutandis* by the terms and conditions of the Contract, which form part of this Collaboration Agreement; except that provisions of the Contract that are particular to the Lead University and/or other parties to the Contract shall apply only to those parties.

2.2 The Project shall be performed by or under the direction and supervision of the Principal Investigator and Co-investigator(s) as listed in the original proposal to the Funding Body.

2.3 In respect of the Allocated Work, each Party will use its reasonable endeavours to provide adequate facilities; to obtain any requisite materials, equipment and personnel; and to carry out the work diligently within the scope allowed by its funding. Although each Party will use its reasonable endeavours to perform the Project, no Party undertakes that work carried out under or pursuant to this Collaboration Agreement will lead to any particular result, nor is the success of such work guaranteed. For the avoidance of doubt, nothing in this clause purports to permit any Party to reverse engineer or otherwise analyse any of the materials provided to it under this Collaboration Agreement except in accordance with the provisions of this Collaboration Agreement and to the extent applicable by law.

2.4 The Parties shall establish a Steering Panel. In his/her co-ordination of the Project, Prof Colin Thorne shall be guided by the Steering Panel. The role and authorities of the Steering Panel are set out in Schedule 4.
For the avoidance of doubt any decisions changing the terms of this Collaboration Agreement or budgets associated with this project will require the written approval of an authorised signatory in the case of Party (8) University of the West of England, Bristol.

2.5 Where an employee of the Lead or Collaborating University(s) is going to be based at another University's premises for the purposes of undertaking all or some of the Project, the Parties shall liaise to put in place the necessary documentation as follows:

(a) if employee is intended to return to their own University following the completion of their work on the Project to fulfil an identified role within their own University, to provide for the secondment of the employee to the host University; or

(b) for the transfer of the employee's employment to that University on terms to be agreed in writing by the relevant Parties.

3. PAYMENT

3.1 The Funding Body has undertaken to provide funding for the Project and the Lead University shall act as recipient of the funding for the Parties. The sole financial obligation of the Lead University under this Agreement shall be to forward the payments allocated to the other Parties, in accordance with Schedule 3 of this Agreement.

3.2 In the event that the Funding Body requires the reimbursement by the Lead University of any sums paid under this Collaboration Agreement, then to the extent that such

requirement arises from the acts or omissions of a Collaborating University, the Collaborating University hereby agrees to reimburse the Lead University the sum received by the Collaboration University together with any interest charged thereon.

3.3 Without prejudice to the fact that the Parties will receive income from the Funding Body towards the cost of the Project, each Party agrees that it is responsible for meeting its own costs in carrying out its obligations in relation to the Project.

The budget allocation to each of the Parties is set out in Schedule 3.

3.4 All Parties shall maintain full and accurate financial records relating to its expenditure under the Project and shall provide copies of all such records to the Funding Body upon request.

The Lead University, as the main administrator of the Project, shall maintain full records of all income received from the Funding Body under the Contract and consequently disbursed. The Lead University shall be responsible for preparing all financial reports due to the Funding Body, and the other Parties shall provide all information relating to their expenditure pursuant to the Project necessary to enable the Lead University to comply with any accounting obligations owed to the Funding Body under the Contract.

3.5 The Lead University shall pass on each Party's respective proportions (as detailed in Schedule 3) of income received from the Funding Body under the Contract within thirty (30) days of its receipt of a valid invoice of actual expenditure.

4. PUBLICATION and CONFIDENTIALITY PROCEDURES

4.1 Subject to Clauses 4.4 and 4.5, each Party will use all reasonable endeavours not to disclose to any third party any Confidential Information nor use for any purpose except as expressly permitted by this Collaboration Agreement, any of another Party's Confidential Information.

4.2 No Party shall incur any obligation under clause 4.1 with respect to information which:

4.2.1 is known to the receiving Party before the start of the Project Period, and not impressed already with any obligation of confidentiality to the disclosing Party; or

4.2.2 is or becomes publicly known without the fault of the receiving Party; or

4.3.3 is obtained by the receiving Party from a third party in circumstances where the receiving Party has no reason to believe that there has been a breach of an obligation of confidentiality owed to the disclosing Party; or

4.2.4 is independently developed by the receiving Party; or

4.2.5 is approved for release in writing by an authorised representative of the disclosing Party; or

4.2.6 the receiving Party is specifically required to disclose by law, requirement by a regulatory body or in order to fulfil an order of any Court of competent jurisdiction provided that, in the case of a disclosure under the Freedom of Information Act 2000 or The Freedom of Information (Scotland) Act 2002, none of the exemptions in that Act applies to the Confidential Information.

4.3 If any Party receives a request under the Freedom of Information Act 2000 or The Freedom of Information (Scotland) Act 2002 to disclose any Confidential Information, it will notify and consult with the other Parties. The other Parties will respond within five (5) working days after receiving notice if the notice requests assistance in determining whether or not an exemption in that Act applies.

Publications:

4.4 The Project will form part of the actual carrying out of a primary charitable purpose of the Parties; that is, the advancement of education through teaching and research. There must therefore be some element of public benefit arising from the Project, and this is secured through the following sub-clauses.

4.4.1 This Collaboration Agreement shall not prevent or hinder registered students of any Party from submitting for degrees of that Party theses based on results obtained during the course of work undertaken as part of the Project; or from following that Party's procedures for examinations and for admission to postgraduate degree status.

4.4.2 In accordance with normal academic practice, all employees, students, agents or appointees of the Parties (including those who work on the Project) shall be permitted:-

4.4.2.1 following the procedures laid down in Clause 4.5, to publish results, jointly where applicable, obtained during the course of work undertaken as part of the Project; and

4.4.2.2 in pursuance of the Parties' academic functions, to discuss work undertaken as part of the Project in internal seminars and to give instruction within their organisation on questions related to such work.

4.5 Each Party will use all reasonable endeavours to submit material intended for publication to the other Parties in writing not less than thirty (30) days in advance of the submission for publication. The publishing Party may be required to delay submission for publication if in any other Party's opinion such delay is necessary in order for that other Party to seek patent or similar protection for material in respect of which it is entitled to seek protection, or to modify the publication in order to protect Confidential Information. A delay imposed on submission for publication as a result of a requirement made by the other Party shall not last longer than is absolutely necessary to seek the required protection; and therefore shall not exceed three (3) months from the date of receipt of the material by such Party, although the publishing Party will not unreasonably refuse a request from the other Party for additional delay in the event that property rights would otherwise be lost. Notification of the requirement for delay in submission for publication must be received by the publishing Party within thirty (30) days after the receipt of the material by the other Party, failing which the publishing Party shall be free to assume that the other Party has no objection to the proposed publication.

4.6 The provisions of Clause 4.1 and 4.2 shall survive for a period of three (3) years from the date of termination of this Collaboration Agreement. The provisions of Clause 4.5 shall survive for a period of one year from the date of termination of this Collaboration Agreement.

5. INTELLECTUAL PROPERTY RIGHTS

5.1 For the avoidance of doubt all Background Intellectual Property used in connection with the Project shall remain the property of the Party introducing the same. No Party will make any representation or do any act which may be taken to indicate that it has any right, title or interest in or to the ownership or use of any of the Background Intellectual Property of the other parties except under the terms of this Collaboration Agreement. Each Party acknowledges and confirms that nothing contained in this Collaboration Agreement shall give it any right, title or interest in or to the Background Intellectual Property of the other Parties save as granted by this Collaboration Agreement. The Parties agree that any improvements or modifications to a Party's Background Intellectual Property arising from the Project which are not severable from that Background Intellectual Property will be deemed to form part of that Party's Background Intellectual Property.

5.2 Each Party grants the others a royalty-free, non-exclusive licence for the duration of the Project to use its Background Intellectual Property for the sole purpose of carrying out the Project. No Party may grant any sub-licence over or in respect of the other's Background Intellectual Property.

5.3 Each Party shall own the Arising Intellectual Property generated by its employees, students and/or agents under the Project and shall ensure that it secures ownership of such Arising Intellectual Property from its employees, students and agents. Subject to the terms of the Contract, the Party owning any Arising Intellectual Property shall be entitled to use and exploit such Arising Intellectual Property as that Party sees fit, and subject always to Clauses 5.6 and 5.7

5.4 Each Party shall promptly disclose to the other(s) all Arising Intellectual Property generated by it and each Party shall co-operate, where required, in relation to the preparation and prosecution of patent applications and any other applications relating to Arising Intellectual Property.

5.5 Where any Arising Intellectual Property is created or generated by two or more Parties jointly and it is impossible to segregate each Party's intellectual contribution to the creation of the Arising Intellectual Property, the Arising Intellectual Property will be jointly owned by those Parties in equal shares. The owners may take such steps as they may decide from time to time, to register and maintain any protection for that Arising Intellectual Property, including filing and prosecuting patent applications for any Arising Intellectual Property, and taking any action in respect of any alleged or actual infringement of that Arising Intellectual Property. If one or more of the owners does not wish to take any such step or action, the other owner(s) may do so at their expense, and the owner not wishing to take such steps or action will provide, at the expense of the owner making the request, any assistance that is reasonably requested of it.

5.6 Any joint owner of any of the Arising Intellectual Property may commercially exploit the Arising Intellectual Property upon consultation and agreement with the other Party/Parties. In such circumstances, the Party which is commercially exploiting the Arising Intellectual Property will pay the other Party/Parties a fair and reasonable royalty rate/revenue on the value of any products or processes commercially exploited by it which incorporate any Arising Intellectual Property taking into consideration the respective financial and technical contributions of the Parties to the development of the Arising Intellectual Property, the expenses incurred in securing intellectual property protection thereof and the costs of its commercial exploitation and the proportionate value of the Arising Intellectual Property in any such product or process.

5.7 Each Party is hereby granted an irrevocable, non-transferable, royalty-free right to use all Arising Intellectual Property generated in the course of the Project for academic and research purposes, including research involving projects funded by third parties provided that those parties gain or claim no rights to such Arising Intellectual Property.

5.8 If any Party (the "Exercising Party") requires the use of Background Intellectual Property of any other (the "Other Party") in order to exercise its rights in Arising Intellectual Property (whether solely or jointly owned) then, provided the Other Party is free to license the Background Intellectual Property in question, the Other Party will not unreasonably refuse to grant or delay granting a license to the Exercising Party on fair and reasonable terms to be agreed so that the Exercising Party may use such Background Intellectual Property for the purpose of exercising its rights in Arising Intellectual Property.

6. ASSIGNMENT

No Party will assign this Collaboration Agreement without the prior written consent of the other Parties, such consent not to be unreasonably withheld, denied or delayed.

7. WITHDRAWAL

7.1 Any Party (the "Withdrawing Party") may withdraw from the Project upon six (6) months prior written notice to the others, where it considers withdrawal justified on the grounds that no further purpose to the Project would be served by the Withdrawing

Party continuing in the Project. Withdrawal by the Withdrawing Party will only take place after discussions in the Steering Panel. Such discussions to occur within three (3) months of submission by the Withdrawing Party of notice to withdraw, after which the Parties will confirm to the Withdrawing Party the official date of withdrawal ("Date of Withdrawal").

7.2 In the event of withdrawal of a Party, the Steering Panel in collaboration with the other Parties will make all reasonable attempts to reallocate the obligations of the Withdrawing Party under this Collaboration Agreement to another existing Party or a new Party acceptable to the remaining Parties to this Collaboration Agreement and the Funding Body provided that such Party agrees to be bound by the terms of this Collaboration Agreement. If the reason for withdrawal is that the work allocated to the Withdrawing Party is no longer viable, the Steering Panel shall discuss with the Funding Body the re-allocation or reimbursement of funds in accordance with the Contract.

7.3 The Withdrawing Party shall not from the Date of Withdrawal be entitled to recover any of its costs incurred in connection with the Allocated Work and shall, from the Date of Withdrawal, comply with any conditions that may be imposed pursuant to Clause 7.1 which shall include (without limitation);

7.3.1 rights granted to the other Parties in respect of the Withdrawing Party's Background Intellectual Property shall continue for the duration of the Project solely for the purposes of carrying out the Project, subject to the restrictions contained in this Collaboration Agreement;

7.3.2 to the extent that exploitation of any other Party's/Parties' Arising Intellectual Property is dependent upon the Withdrawing Party's Background Intellectual Property, then the Withdrawing Party shall, to the extent that it is free to do so, grant to the other Party/Parties a non-exclusive license to such Background Intellectual Property on fair and reasonable terms to be agreed;

7.3.3 the Withdrawing Party shall grant to the other Parties a non-exclusive, royalty-free license to use the Withdrawing Party's Arising Intellectual Property for the purposes of carrying out the Project. For the avoidance of doubt any exploitation of such Withdrawing Party's Arising Intellectual Property will be dealt with in accordance with Clauses 5.4 and 5.5;

7.3.4 all rights acquired by the Withdrawing Party to the Background Intellectual Property and Arising Intellectual Property of the other Parties shall cease immediately other than in respect of the Withdrawing Party's interest in any jointly owned Intellectual Property under Clause 5.5.

8. TERMINATION

8.1 A Party (the 'Terminating Party') may terminate its involvement in this Collaboration Agreement by giving ninety (90) days prior written notice to the Lead University of its intention to terminate if another Party (the 'Party in Breach') commits a material breach of the terms of this Collaboration Agreement, or is persistently in breach of this Collaboration Agreement in such a manner that the Terminating Party is hindered in its ability to carry out its obligations in the Project. The notice shall include a detailed statement describing the breach. If the breach is capable of being remedied and is remedied within the ninety (90) day notice period, then the termination shall not take effect. If the breach is of a nature such that it can be fully remedied but not within the ninety (90) day notice period, then termination shall also not be effective if the Party involved begins to remedy the breach within that period, and then continues diligently to remedy the breach until it is remedied fully. If the breach is incapable of remedy, or a persistent breach, then the termination shall take effect at the end of the ninety (90) day notice period in any event.

8.2 All rights acquired by the Terminating Party to Background Intellectual Property and Arising Intellectual Property of the other Parties shall cease immediately other than in

respect of the Terminating Party's interest in any jointly owned Intellectual Property; the Terminating Party shall, however, continue to comply with the obligations under Clause 7.3.

8.3 Each Party agrees to notify the other Party(s) promptly if at any time their key academic is unable or unwilling to continue the direction and supervision of the Allocated Work. Within sixty (60) days after such incapacity or expression of unwillingness that Party shall nominate a successor to replace their key academic. The other Party(s) will not decline unreasonably to accept the nominated successor. However, if the successor is not acceptable on reasonable and substantial grounds, then either (i) such Party will be asked to withdraw from the Project in accordance with Clause 7.2; or (ii) this Collaboration Agreement may be terminated by giving ninety (90) days' written notice to the other Party(s).

8.4 The Lead University agrees to notify the Collaborating University(s) promptly if at any time Prof Colin Thorne is unable or unwilling to continue the direction and supervision of the Project. Within sixty (60) days after such incapacity or expression of unwillingness the Lead University shall nominate a successor to replace Prof Colin Thorne. The Collaborating University(s) will not decline unreasonably to accept the nominated successor. However, if the successor is not acceptable to the Collaborating University(s) on reasonable and substantial grounds, then the Lead University may terminate this Collaboration Agreement by giving ninety (90) days' written notice to the other parties.

8.5 The expiration of the Project Period, or the termination of this Collaboration Agreement under Clauses 8.1, 8.3 or 8.4, shall cause the termination with effect from the date of expiry or termination of the obligations imposed on the Parties under Clause 2.

8.6 In addition to the remedies contained in Clause 7 (Withdrawals); in the event that any Party shall commit any material breach of or default in any terms or conditions of this Collaboration Agreement, the Steering Panel may decide by unanimous vote of the non-defaulting Parties to instruct the Lead University to serve written notice of such breach on the defaulting Party and in the event that such Party fails to remedy such breach within ninety (90) days after receipt of such written notice (where such breach is remediable) the Parties may collectively, at their option and in addition to any other remedies which they may have at law or in equity, and with the approval of the Funding Body, remove the defaulting Party and continue with the Collaboration Agreement or terminate this Collaboration Agreement. Any removal of the defaulting Party shall be effective as of the date of the receipt of such notice, in respect of a breach incapable of remedy, and, otherwise at the end of the 90 day period referred to above, whereupon the provisions of Clause 7.3 shall apply to the defaulting Party.

8.7 If any Party (a) passes a resolution for its winding-up; or if (b) a court of competent jurisdiction makes an order for that Party's winding-up or dissolution; or makes an administration order in relation to that Party; or if any Party (c) appoints a receiver over, or an encumbrancer takes possession of or sells an asset of, that Party; or (d) makes an arrangement or composition with its creditors generally; or (e) makes an application to a court of competent jurisdiction for protection from its creditors generally; the remaining members of the Steering Panel shall meet to either suspend or terminate that Party's involvement in [the Steering Panel and] the Project. Any removal of the defaulting Party shall be effective as of the date of the receipt of such notice whereupon the provisions of Clause 7.3 shall apply to the defaulting Party.

8.8 In the event that it is agreed by all the Parties that there are no longer valid reasons for continuing with the Project the Steering Panel may decide by unanimous vote to terminate this Collaboration Agreement. In the event of such termination each Party shall be reimbursed for all costs and non-cancellable commitments properly charged in accordance with this Collaboration Agreement and incurred or committed up to the date of termination, providing that such funds have been or are able to be recovered from the Funding Body. For the avoidance of doubt, no Party shall be required to contribute to any

losses suffered by another Party in circumstances where costs have not been recovered from the Funding Body.

9. LIMITATION OF LIABILITY

9.1 No Party makes any representation or warranty that advice or information given by any of its employees, students, agents or appointees who work on the Project, or the content or use of any materials, works or information provided in connection with the Project, will not constitute or result in infringement of third-party rights.

9.2 No Party accepts any responsibility for any use which may be made of any work carried out under or pursuant to this Collaboration Agreement, or of the results of the Project, nor for any reliance which may be placed on such work or results, nor for advice or information given in connection with them.

9.3 The Parties undertake to make no claim in connection with this Collaboration Agreement or its subject matter against any employees, students, agents or appointees of the other Parties (apart from claims based on fraud or wilful misconduct). This undertaking is intended to give protection to individual researchers: it does not prejudice any right which a Party might have to claim against any other Party.

9.4 The liability of any Party for any breach of this Collaboration Agreement, or arising in any other way out of the subject-matter of this Collaboration Agreement, will not extend to loss of business or profit, or to any indirect or consequential damages or losses.

9.5 In any event, the maximum liability of any Party under or otherwise in connection with this Collaboration Agreement or its subject matter shall not exceed the monies received by that Party under this Collaboration Agreement as detailed in Schedule 3.

9.6 Nothing in this Collaboration Agreement limits or excludes either Party's liability for:

9.6.1 death or personal injury resulting from negligence; or

9.6.2 any fraud or for any sort of other liability which, by law, cannot be limited or excluded.

9.7 If any sub-clause of this Clause 9 is held to be invalid or unenforceable under any applicable statute or rule of law then it shall be deemed to be omitted, and if as a result any Party becomes liable for loss or damage which would otherwise have been excluded then such liability shall be subject to the remaining sub-clauses of this Clause 9.

10. NOTICES

The Lead University's representative for the purpose of receiving reports and other notices shall until further notice be:
Prof Colin Thorne
The University of Nottingham, University Park, Nottingham, NG7 2RD.
For Legal Notices
Paul Cartledge, Head of Research Grants and Contracts,
The University of Nottingham, Kings Meadow Campus, Lenton Lane, Nottingham, NG7 2NR.

THE UNIVERSITY OF CAMBRIDGE representative for the purpose of receiving reports and other notices shall until further notice be:
The Assistant Director,
Physical Sciences and Technology, Cambridge University, Research Operations Office, 16 Mill Lane, Cambridge, CB2 1SB.

THE CRANFIELD UNIVERSITY representative for the purpose of receiving reports and other notices shall until further notice be:
Dr Jenny Mant

School of Applied Sciences, Cranfield University, Cranfield, Bedfordshire, MK43 0AL
For Legal Notices
Mr Stephen Holyoak, Head of Contracts
Vice Chancellor's Office, Cranfield University, Cranfield, Bedfordshire, MK43 0AL

THE HERIOT-WATT UNIVERSITY representative for the purpose of receiving reports and other notices shall until further notice be:
Dr Scott Arthur
Heriot-Watt University, School of the Built Environment, Riccarton, Edinburgh EH14 4AS
For Legal Notices
Derek G Brown
Heriot-Watt University, Riccarton, Edinburgh EH14 4AS.

THE UNIVERSITY OF LEEDS representative for the purpose of receiving reports and other notices shall until further notice be:
Professor Nigel Wright
School of Civil Engineering
The University of Leeds, Leeds, LS2 9JT.
For Legal Notices:
Director, Research and Innovation Service, The University of Leeds
Charles Thackrah Building, 101 Clarendon Road, Leeds, LS2 9LJ.

THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCES representative for the purpose of receiving reports and other notices shall until further notice be:
David Coombe (d.coombe@lse.ac.uk), Director of research Division, Research Division, London School of Economics and Political Science Houghton Street, London WC2A 2AE.

THE UNIVERSITY OF NEWCASTLE UPON TYNE representative for the purpose of receiving reports and other notices shall until further notice be:
Director of Research and Enterprise Services,
University of Newcastle upon Tyne, Research Beehive, Old Library Building, Newcastle upon Tyne, NE1 7RU.

THE UNIVERSITY OF THE WEST OF ENGLAND, BRISTOL representative for the purpose of receiving reports and other notices shall until further notice be:
Assistant Vice-Chancellor: Finance & Commercial Projects,
University of the West of England, Bristol, Frenchay Campus, Coldharbour Lane, Bristol BS16 1QY.

11. FORCE MAJEURE

11.1 A Party shall not be liable for failure to perform its obligations under this Collaboration Agreement, nor be liable to any claim for compensation or damage, nor be deemed to be in breach of this Collaboration Agreement, if such failure arises from an occurrence or circumstances beyond the reasonable control of that Party (excluding an obligation to make payment).

11.2 If a Party affected by such an occurrence causes a delay of three (3) months or more, and if such delay may reasonably be anticipated to continue, then the Parties shall, in consultation with the Funding Body, discuss whether continuation of the Project is viable, or whether the Project and this Collaboration Agreement should be terminated.

12. GENERAL

12.1 Clause headings are inserted in this Collaboration Agreement for convenience only, and they shall not be taken into account in the interpretation of this Collaboration Agreement.

12.2 Nothing in this Collaboration Agreement shall create, imply or evidence any partnership or joint venture between the Parties or the relationship between them of principal and agent.

12.3 Each Party shall ensure that it has well defined arrangements for investigating and resolving allegations of research misconduct. Where an allegation of research misconduct arises in respect of an individual Party's participation in the Project and leads to a subsequent formal investigation, the relevant Party shall inform the Steering Panel and the Funding Body of the investigation and its outcome. Where an allegation of research misconduct arises in respect of several Parties' participation in the Project, the relevant Parties will work together to determine how the allegation will be investigated and reported.

12.4 No Party shall use the name or any trademark or logo of any other Party or the name of any of its staff or students in any press release or product advertising, or for any other commercial purpose, without the prior written consent of the Party(s).

12.5 Except as otherwise expressly provided for herein, the Parties confirm that nothing in this Collaboration Agreement shall confer or purport to confer on any third party any benefit or any right to enforce any term of this Collaboration Agreement for the purposes of the Contracts (Rights of Third Parties) Act 1999.

12.6 This Collaboration Agreement and its Schedules (which are incorporated into and made a part of this Collaboration Agreement) constitute the entire agreement between the Parties for the Project and no statements or representations made by any Party have been relied upon by the other in entering into this Collaboration Agreement. Any variation shall be in writing and signed by authorised signatories for each Party.

12.7 This Collaboration Agreement shall be governed by English Law and the English Courts shall have exclusive jurisdiction to deal with any dispute which may arise out of or in connection with this Collaboration Agreement.

12.8 If any dispute arises out of this Collaboration Agreement the Parties will first attempt to resolve the matter informally through designated senior representatives of each Party to the dispute, who are not otherwise involved with the Project. If the Parties are not able to resolve the dispute informally within a reasonable time not exceeding two (2) months from the date the informal process is requested by notice in writing they will attempt to settle it by mediation in accordance with the Centre for Effective Dispute Resolution (CEDR) Model Mediation Procedure.

12.9 If any one or more clauses or sub-clauses of this Collaboration Agreement would result in this Collaboration Agreement being prohibited pursuant to any applicable competition law then it or they shall be deemed to be omitted. The Parties shall uphold the remainder of this Collaboration Agreement, and shall negotiate an amendment which, as far as legally feasible, maintains the economic balance between the Parties.

12.10 This Collaboration Agreement may be executed in any number of counterparts, each of which when executed (and delivered) will constitute an original of this Collaboration Agreement, but all counterparts will together constitute the same agreement. No counterpart will be effective until each party has executed at least one counterpart.

EXECUTED as an agreement:

SIGNED for and on behalf of **THE UNIVERSITY OF NOTTINGHAM**
Name:
Position:
Signature:

SIGNED for and on behalf of **THE UNIVERSITY OF CAMBRIDGE**

Name:
Position:
Signature:

SIGNED for and on behalf of **THE CRANFIELD UNIVERSITY**

Name:
Position:
Signature:

SIGNED for and on behalf of **THE HERIOT-WATT UNIVERSITY**
Name:
Position:
Signature:

SIGNED for and on behalf of **THE UNIVERSITY OF LEEDS**

Name:
Position:
Signature:

SIGNED for and on behalf of **THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCES**

Name:
Position:
Signature:

SIGNED for and on behalf of **THE UNIVERSITY OF NEWCASTLE UPON TYNE**
Name:
Position:
Signature:

SIGNED for and on behalf of **THE UNIVERSITY OF THE WEST OF ENGLAND, BRISTOL**

Name:
Position:
Signature:

Schedules:

Schedule 1: The Project (including Allocated Work)
Schedule 2: The Contract (award letter)
Schedule 3: Breakdown of costs to Collaborating University
Schedule 4: Steering Panel

Schedule 1: The Project

Schedule 2: The Contract (Award Letter)

Schedule 3

BREAKDOWN OF COSTS TO COLLABORATOR

The Collaborating University shall invoice the Lead University quarterly in arrears on the basis of actual expenditure against the budget headings listed in this Schedule 3 and the Lead University shall pay the Collaborating University within 30 days of said invoices, subject always to receipt of funds from the Funding Body. The final invoice should be sent to the Lead University within two (2) months of the end of the Project to allow preparation of the final cost statement by the Lead University. The cost statement should include the breakdown of the indexed fEC figures as well as the actual sums claimed.

The statements should be sent to:

Ms Lida Kaur, Research and Graduate Services
The University of Nottingham, Kings Meadow Campus, Lenton Lane,
Nottingham, NG7 2NR.

quoting reference RA1596.

Schedule 4: Steering Panel

Note: The role of the Steering Panel referred to here has been subsumed into that of the SAB, with support from the Management Committee.

1. Membership:

Each Party shall appoint one individual to the Steering Panel
Each nominated individual (and any changes thereto) shall be notified in writing to the other Parties. In addition each Party shall be entitled, but not bound, to appoint an additional individual to the Steering Panel to act as an observer. An observer appointed in such a manner shall be entitled to attend, but not vote, at meetings of the Steering Panel.

Prof Colin Thorne will be appointed as the Chairman or such other individual as the Parties may agree.

2. Role

All significant operational matters relating to the Project will be decided upon by the Steering Panel which shall also put in place any structure to manage the Project that it agrees.

3. Quorum

The quorum for a meeting of the Steering Panel shall be not less than 75% of the Parties to this Collaboration Agreement (or their proxies)

4. Meeting Frequency

The Steering Panel will meet every 6 months at venues to be agreed or at any time when reasonably considered necessary at the request of any of the Parties. Meetings shall be convened with at least twenty-one (21) days' prior written notice, which notice shall include an agenda. Minutes of the meetings of the Steering Panel shall be drafted by the Chairman and transmitted to the Parties without delay and in any event within 15 days of the meeting. The minutes shall be considered as accepted by the Parties if, within thirty (30) days from receipt, no Party has objected in writing to Prof Colin Thorne. Prof Colin Thorne will prepare progress reports as required by the Steering Panel and the Funding Body and a draft of each report will be circulated to each member of the Steering Panel along with the written notice for the relevant meeting.

Each Party shall, through its representative, have one vote in the Steering Panel. Decisions will be taken by a majority vote of a meeting of the Steering Panel except for those decisions specified elsewhere in this Collaboration Agreement. In the event of a tied vote under this Clause, a second vote shall be called with 100% quorum. In the event the second vote is again a tied vote, the matter shall be resolved in accordance with the dispute resolution procedures set out in Clause 12.8.

Meetings may also occur by telephone conference or virtually by e-mail correspondence.

5. Role of Prof Colin Thorne with relation to Steering Panel

attend Steering Panel meetings;
be the primary contact for and with the Funding Body;
be accountable to the Steering Panel for the day-to-day management of the Project;
be responsible for financial administration of the Project as required in the Contract;
be responsible for implementing decisions taken by the Steering Panel; and
monitor the progress of the Project with respect to milestones and deliverables.

Annex IX. Programme from the Mission to Portland, Oregon, 2013

Delivering and Evaluating multiple Flood-Risk Benefits in Blue-Green Cities

British Research Team Mission to Portland, OR

21-28 April, 2013

Programme Overview

Sunday - arrive from UK and transfer from Portland Airport (PDX) to the University Place Hotel, 310 SW Lincoln Street, Portland, OR 97201.

Monday - Johnson Creek (urban flood control, community engagement and stream restoration) hosted by Maggie Skenderian (Johnson Creek Watershed Manager, City of Portland, Environmental Services) and Gary Wolff (OTAK). Evening: pre-dinner drinks with Gary Wolff and colleagues.

Tuesday - Sustainable Urban Drainage Systems and urban stream management, hosted by Bruce Roll, Watershed Management Director, Clean Water Services (Oregon public utilities company). Evening: Dinner hosted by Clean Water Services.

Wednesday - Stormwater Management (conclusion and outcomes of the Combined Sewer Outfall replacement program), hosted by Maggie Skenderian and Linda Dobson, Manager, Sustainable Stormwater Division, City of Portland, Environmental Services). Evening: Consortium Mission Dinner, with after dinner speech by Mike Houck (author of 'Wild in the City – Exploring the Intertwine' (http://www.urbangreenspaces.org/). Title: 'A brief history of urban green spaces planning in Portland'.

Thursday – Northwest Regional Floodplain Management Association – One Day Conference (managing multiple pressures and issues on urban floodplains), hosted by Marjorie Wolfe, ESA Consulting Engineers. nb. This event is being held in the capital of Oregon (Salem), one-hour south of Portland.

Friday – morning: Developing equitable Blue Green strategies for Portland's under- engaged communities, hosted by Jeri Williams, City of Portland Neighborhoods Program. Afternoon: Intertwine Alliance Annual Summit (Advocacy group for urban ecology, trails and green spaces), hosted by Mike Wetter, Executive Director, The Intertwine Alliance. Evening: Happy Hour following summit.

Saturday – open for cultural activities.

Sunday – end of mission.

Monday April 22nd

Johnson Creek

City of Portland, Bureau of Environmental Services

http://www.portlandoregon.gov/bes/

Led by Maggie Skenderian - Johnson Creek Watershed Manager
(Maggie.Skenderian@portlandoregon.gov)

8:30 Briefing at University Place (conference room)

- Welcome and introductions
- Background and Orientation
  - Portland - general info; governance, geography, etc.
  - Significance of rivers in our community
  - CSO video (http://www.portlandoregon.gov/bes/article/402830)
  - Brief intro to JC

9:30 Depart for Johnson Creek

- Tour of Restoration sites
  - Tideman Johnson Natural Area – SE 45th and Johnson Creek Blvd. (25 minutes)

    http://www.portlandoregon.gov/bes/article/257373
  - Drive by 28th St Culvert (SE 28th and Crystal Springs Blvd)

    http://www.portlandoregon.gov/bes/article/439203
  - Foster Floodplain - SE Foster and 104th (25 minutes)

    http://www.portlandoregon.gov/bes/article/286175
  - Schweitzer - SE Circle Ave at Powell Butte (25 minutes)

    http://www.portlandoregon.gov/bes/article/263660

11:00 Arrive at venue for colloquium on Blue-Green Fluvial Flood Risk Management
http://www.oliverscafepdx.com/index.htm

Johnson Creek Floodplain Restoration

- Johnson Creek Restoration Plan (2001)

  http://www.portlandoregon.gov/bes/article/214367
- Effectiveness Monitoring

  http://www.portlandoregon.gov/bes/article/428010

12:00 Lunch

1:00 Foster Corridor Investment Strategy

- Industrial lands, Parks, Transportation, Flood damage reduction, Economic Redevelopment
- Foster Green

3:30 Closing remarks and Wrap up
3:45 Depart for University Place Hotel
4:15 Arrive back at University Place
6:00 Informal drinks and post-tour discussion at Jakes (corner of Stark Street and 12th Avenue: http://www.mccormickandschmicks.com/Locations/portland-oregon/portland-oregon/SW12thAve.aspx) with Gary Wolff, Kevin Timmins (project manager for Otak Johnson Creek project) and Ryc Loope (Otak CEO).

Tuesday April 23rd

Clean Water Services

(http://www.cleanwaterservices.org/**)**

Led by

Bruce Roll (RollB@CleanWaterServices.org)

8:30	Pickup from University Place Hotel and travel to Clean Water Services HQ at 2550 Hillsboro Hwy
9:00	Welcome and Introductions (BR & BG)
9:15	Overview Clean Water Services (MG, BG)
9:30	Tour Overview and Mutual Interests (BR & RH)
10:30	Travel to FernHill Viewing Area
11:00	Tour of Fern Hill Wet Lands (DT & RH)
12:00	Travel to Rock Creek Treatment Facility
12:30	Lunch and Overview of Facility (NC, BL, PS)
13:00	Tour of Resource Recovery Facility (NC, BL, PS)
14:00	Travel to Fanno Farm House
15:00	Tour Fanno Project (RH, BR)
16:00	Travel to Audubon
16:30	Tour of Audubon (BR RH, MR)
17:30	Travel to Bridgeport Brewery, 1313 NW Marshall, Portland 97209
19:30	Return to Hotel

Wednesday April 24th
Morning

Sustainable Management of Urban Flooding
(http://www.portlandoregon.gov/bes/)

City Hall - Pettygrove Room
1221 SW 4th Ave, Portland, Oregon

Led by Maggie Skenderian - Johnson Creek Watershed Manager
(Maggie.Skenderian@portlandoregon.gov)

9:00 Sub-watershed analysis and Integrated Stormwater Management

10:00 Break

10:15 Green Asset Management and Ecosystem Services

11:30 Move across street to Portland Bldg for lunch and afternoon programme

Afternoon
Sustainable Urban Stormwater Management

City of Portland, Bureau of Environmental Services
www.portlandonline.com/sustainablestormwater

Portland Bldg – 1120 SW 5th Avenue, 10th floor

Led by Linda Dobson - Division Manager,
Sustainable Stormwater Management
(linda.dobson@portlandoregon.gov)

12:00 Brown-bag lunch with briefing on the work of BES (Ponderosa/Lodgepole rooms).

1:00 Board bus for afternoon tour (led by Emily Hauth, Tim Kurtz and Linda Dobson).

Stop 1: Tabor Middle School. Example of a multi-objective retrofit school project using green infrastructure techniques to address local sewer back-up issues.
Stop 2: Tabor to the River Project Area. View a number of green street installations in Combined Sewer Project area addressing Sewer back-up and CSO issues. This project integrates the grey and the green infrastructure approach.
Stop 3: Multnomah County Ecoroof. Visit and discuss lessons learned on a downtown ecoroof installation
Stop 4: Portland State University. View one of our earliest green street installations and private property stormwater planters with reuse capabilities.

16:00 Return to University Place Hotel
18:30 Leave Hotel for Consortium Dinner at Serreto Restaurant, 2112 NW Kearney Street, Portland, OR 97210 http://www.serratto.com/. After dinner speaker: Mike Houck – Urban Greenspaces Institute (http://www.urbangreenspaces.org). Title: 'A brief history of urban green spaces planning in Portland'.

Thursday 25th April

NORFMA
NORTHWEST REGIONAL FLOODPLAIN MANAGEMENT ASSOCIATION

Floodplain Management: Adapting to Change mini-conference

PoC Marjorie Wolfe, ESA Consulting Engineers
(MWolfe@esassoc.com**)**

Chemeketa Center for Business and Industry
626 High Street NE
Salem, OR 97301

06:15 Bus departs for Salem from Portland Place Hotel
07:00 Registration, Networking and Continental Breakfast
8:00 Welcome
Marjorie Wolfe, NORFMA Oregon Representative, ESA

8:10 Opening Address: Recovering a flooded system: Lessons learned from flood recovery at Cedar Rapids where inundation levels extended beyond the 500 year floodplain.
Greg Eyerly, City of Salem

9:00 Session 1: Recent Changes in Management and Policy
Chair: *Chris Bahner*

Flood Risk 2050: Issues of change – *Kevin Coulton, AECOM*
New updates to the Community Rating System – *Dave Carlton, Atkins Global*
NFIP Reform update – *Christine Shirley, Oregon DLCD & FEMA representative (tbd)*

10:00 Break

10:30 Session 2: Salmon Habitat and Floodplain Development: Update on Biological Opinions
Chair: *Libby Barg*

What is a BiOP and what does it mean for floodplain management? – *Patricia Olson, Department of Ecology*
Working with local communities on BiOP compliance in Washington – *Aaron Booy, ESA*
FEMA perspectives – *John Graves, FEMA*
Conservation Perspectives– *Bob Sallinger, Audubon Society Portland*

12:00 Buffet Lunch

1:30 Session 3: Global Perspectives
Chair: *Marjorie Wolfe*

Implications of climate change on long term flood risk management and geomorphic aspects – *Colin Thorne, Nottingham University*
Integrated Urban Flood Risk Management for the 21st century – *Jessica Lamond - University of the West of England*
Urban Drainage and Multi-Criteria Analysis – *Dick Fenner, Cambridge University*

3:00 Break

3:30 <u>Session 4: New methodologies for managing floodplains</u>
Chair: *Terry Hsu*

New tools to minimize flood risk: Channel migration zones, Deep and Fast Flowing Water Floodways, Substantial Damage Tracking, etc. – *Hans Hunger, P.E., CFM, Pierce County*
LifeSim estimating potential life loss from Dam and Levee failure – *Chris Bahner, WEST Consulting*
Upper Sandy and Zig Zag Rivers communicating uncertainties – *Jay Wilson, Clackamas County*
Unique Floodplain Issues: Managing the lower flood flows and habitat – *Gary Wolff, OTAK*

4:45 Closing Remarks: NORFMA - *Hans Hunger, P.E., CFM, Pierce County*

5:15 Bus departs for Portland Place Hotel

6:15 Arrive back – Free evening

Friday 26th April
Morning

Developing Equitable Blue Green Strategies for Portland's Under-engaged communities

Host: Jeri Williams, City of Portland Neighborhoods Program
Jeri.Williams@portlandoregon.gov

City Hall - Pettygrove Room
1221 SW 4th Ave, Portland, Oregon

Presentations

08:30 Welcome and Introductions
Portland Team

08:40 Introductions (Name, organization and answer to the question, "What are you most curious about in Portland?"
British Team

09:00 History of Civic Engagement in Portland
Paul Leistner

09:15 How State and local policies have historically impacted communities of color, immigrants and refugees to present a barrier for involvement and Gentrification and forced displacement
Jeri Williams

09:30 Q & A

Solutions to Displacement Tour

10:00 Bus departs from City Hall

- Mississippi Avenue (Important spots along the way – Memorial Coliseum, Emanuel Hospital). Visit Urban League to hear a representative speak about historical challenges and what they do to combat them (State of Black Oregon - City of Portland Equity Strategy Guide).

- Stop at 3559 Albina to describe gentrification and history.

- Cully Park http://letusbuildcullypark.org/ (or Verde office http://www.verdenw.org/). Donita Fry (NAYA) and Judy Bluehorse (PSU) introduce Verde representative talking to us about hydrology, anti-displacement efforts and engaging historically under-engaged communities, and the Native garden.

11:30 Leave Cully Park and travel to Forestry Center (Lunch en route).

Afternoon

Intertwine Alliance Spring Summit[4]
(http://www.theintertwine.org/summits**)**

PoC: Mike Wetter, Executive Director, The Intertwine Alliance
(mike.wetter@theintertwine.org**)**

World Forestry Center, Miller Hall: 4033 SW Canyon Road, Portland

1:00 Energizing Urban Forestry in Your Community Workshop
Ray Tretheway (Sacramento, CA) and local leaders in a lively discussion moderated by *Ketzel Levine* (former National Public Radio senior correspondent).

2:45 Break

3:00 State of The Intertwine Report: From Hockinson Meadows to nine holes in Hillsboro the first annual State of the Intertwine Report makes the case for investing in the Intertwine. Witness the debut of an exciting new tool for policymakers and civic leaders - just one way the Alliance gets us on message to get the work done.

3:30 Promotions Campaign Debut
Engaging people with nature - a goal on which all our partners agree. *David Karstad* (of Frank Creative) shows us how our new campaign will help The Intertwine Alliance win hearts and minds - on street corners and civic agendas, in neighborhood parks and national forums.

4:15 25 Years of Regional Greenspace Planning.
Launched over beer one fine evening in June 2007, The Intertwine Alliance is the product of a greenspaces movement 25 years in the making. Celebrate with us as we showcase the movement highlights -- from the vision of the 1903 Olmsted Plan to the 1992 Greenspaces Master Plan – honor the movement's many leaders, and toast The Intertwine Alliance's next 25 years.

4:45 Networking and Happy Hour

6:00 Free evening (team travel back to City Centre/University Place Hotel via MAX)

[4] Note Claire Chambers (web wizard at Nottingham University, who provided technical assistance with the 1st quarterly Progress Meeting last month) is assisting the Intertwine Alliance in making the summit a webinar using Adobe Connect. Hence, people can attend remotely as well as in person. For details on how they can log into the webinar just e-mail Claire – Claire.chambers@nottingham.ac.uk

Saturday 27th April

Day: Open for cultural activities

Evening: option for Dinner Cruise on the Willamette River if there is sufficient interest (http://portlandspirit.reachlocal.com/?scid=1033779&kw=229551:17984).
Let Lindsey know whether or not you are interested in this event going ahead.

Sunday 28th April

Team Return to UK

Annex X. Clean Water for All Collaborative Research 2014

The Blue-Green Cities Research team will be working with academics from multiple institutions in the North-West US on an EPSRC collaborative research project "Clean Water for All". This will build on the collaborative partnerships with American colleagues engaged in National Science Foundation (NSF) funded research that complements, without duplicating, that of Blue-Green Cities.

The US partners have been chosen because the:

1. intellectual scope of the EPSRC project aligns precisely with socio-economic and natural science research at Portland State University (PSU), Oregon State University (OSU), Washington State University (WSU) and Reed College under the NSF Portland-Vancouver ULTRA-Ex project (http://www.fsl.orst.edu/eco-p/ultra/);

2. intensive, technical research on the dynamics of wood in rivers in WP2a and WP2b will benefit from collaboration with related, NSF-funded, engineering research at OSU;

3. research in all three projects falls within EPSRC's stated priority area of "water engineering within the context of Sustainability and Resilience" and coincides with topics mentioned in the 'Clean Water for All' call including: water reuse, storm water use, urban water sustainability, and resilience of water infrastructures.

Research topics include*;*

1. How property values relate to proximity to Blue-Green infrastructure
2. Community perceptions of Blue-Green infrastructure in the urban environment: The Social Dynamic
3. Loss and restoration of riparian habitat in urban watercourses
4. Climate change and flood risk: communicating risk and uncertainty; vulnerability and adaptability
5. Modelling flows and water quality in the urban water cycle
6. Modelling the dynamics of large and small wood in streams and rivers

Research Schedule

There will be three stages to this work;

1. Initial Workshop (Newcastle, UK) March 2014
2. Collaborative research in Oregon during one-week visits by the academics and 30-day periods of targeted, intensive research by their research associates and students (May 2014)
3. Wrap-up and Dissemination Event (December 2014), possibly at the University of Nottingham Ningbo Campus (UNNC)

Proposed UK and US collaborators are listed in the table below.

Proposed UK Researchers to be involved in this award:

No.	First Name	Last Name	Role	Research Institution	Department
1	Colin	Thorne	P.I.	Nottingham University	Geography
2	Dabo	Guan	Co-I	Leeds University	Earth and Environment
3	Jessica	Lamond	Co-I	UWE	Construction and Property
4	Jenny	Mant	Co-I	Cranfield University	River Restoration Centre
5	Lenny	Smith	Co-I	London School Economics	Centre for the Analysis of Time Series
6	Nigel	Wright	Co-I	Leeds University	Civil Engineering
7	Dick	Fenner	Co-I	Cambridge University	Centre for Sustainable Development
8	Scott	Arthur	Co-I	Heriot-Watt University	Built Environment
9	Chris	Kilsby	Co-I	Newcastle University	Civil Engineering
10	Nick	Mount	Co-I	Nottingham University	Geography
11	Deonie	Allen	RA	Heriot-Watt University	Built Environment
12	Glyn	Everett	RA	UWE	Construction and Property
13	Vassilis	Glenis	RA	Newcastle University	Civil Engineering
14	Hoang	Lan	RA	Cambridge University	Centre for Sustainable Development
15	Emily	Lawson	RA	Nottingham University	Geography
16	Shaun	Maskrey	PhD Student	Nottingham University	Geography

Proposed US Collaborators:

Number	First Name	Last Name	Research Institution
1	Alan	Yeakley	Portland State University
2	Heejun	Chang	Portland State University
3	Connie	Ozawa	Portland State University
4	Anita	Morzillo	Oregon State University
5	Sally	Duncan	Oregon State University
6	Julia	Jones	Oregon State University
7	Noelwah	Netusil	Reed College
8	Jeff	Kline	US Forest Service
9	Steve	Bollens	Washington State University
10	John	Harrison	Washington State University
11	Jennifer	Morse	Cary Institute of Ecosystem Studies

Annex XI. List of Acronyms and Abbreviations

ABM	Agent-Based Model
AHP	Analytic Hierarchy Process
ARCADIA	Adaptation and Resilience in Cities: Analysis and decision making using integrated assessment
ASCE	American Society of Civil Engineers
BG	Blue-Green
CATS	Centre for the Analysis of Time Series
CBA	Cost-Benefit Analysis
CIRIA	Construction Industry Research and Information Association
CityCAT	City Catchment Analysis Tool
CIWEM	Chartered Institution of Water and Environmental Management
Co-I	Co-Investigator
CWFA	Clean Water for All
DARD	Department of Agriculture and Rural Development
DEFRA	Department of Environment, Farming and Rural Affairs
EA	Environment Agency
EPSRC	Engineering and Physical Sciences Research Council
EQUIP	End-to-End Quantification of Uncertainty for Impacts Prediction
EU WFD	European Union Water Framework Directive
FCERM	Flood and Coastal Erosion Risk Management
Flood MEMORY	Flood Multi-Event Modelling Of Risk & recovery
FRGS	Fellow of the Royal Geographical Society
FRM	Flood Risk Management
FRMRC	Flood Risk Management Research Consortium
FUQVVR	Fidelity, Uncertainty, Quantification, Verification, Validation and Relevance
IAHR	International Association for Hydro-Environment Engineering and Engineering and Research
ICE	Institution of Civil Engineers
ICFM	International Conference on Fluid Mechanics
IC-SDCI	The International Conference on Sustainable Development of Critical Infrastructure
ICUD	International Conference on Urban Drainage
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual Property Rights
ISSUES	Implementation Strategies for Sustainable Urban Environment Systems
IWA	International Water Association
KPI	Key Performance Indicator
LSE	London School of Economics
MARE	Managing Adaptive Responses to changing Flood Risk
MAUT	Multi Attribute Utility Theory
MIT	Massachusetts Institute of Technology
NERC	National Environment Research Council
NGO	Non-Governmental Organisation
NORFMA	Northwest Regional Floodplain Management Association
NWL	Northumbrian Water Ltd
PEST	Public Engagement with Science and Technology
PI	Principal Investigator
PIT	Passive Integrated Transponder
PSD	Particle Size Distribution

RA	Research Associate
RDU	Relevant Dominant Uncertainties
RRC	River Restoration Centre
SAB	Strategic Advisory Board
SAWA	Strategic Alliance for integrated Water Management Actions
SEPA	Scottish Environment Protection Agency
SuDS	Sustainable Urban Drainage Systems
SUE	Sustainable Urban Environment
SWAT	Soil and Water Assessment Tool
SWITCH	Blue-Green Dream
SWITCH	EU-funded research programme aimed at achieving more sustainable integrated urban water management in the 'City of the Future'
UEA	University of East Anglia
UFRM	Urban Flood Risk Management
UKCP09	UK Climate Projections
UKRC	UK Research Consortium
UKWIR	UK Water Industry Research Ltd
USDA	United States Department of Agriculture
UWE	University of the West of England
WP	Work Package
WWF	World Wildlife Fund