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

incorporating

Clean Water for All (CWfA)

by

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on behalf of the Blue-Green Research Team

EPSRC Grant EP/K013661/1

So what is a Blue-Green City?

http://en.wikipedia.org/wiki/Blue-Green_Cities

Blue-Green Cities

From Wikipedia, the free encyclopedia

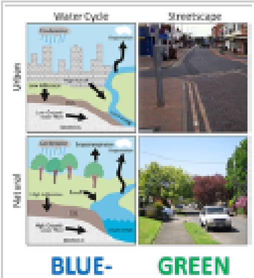
Blue-Green Cities aim to recreate a naturally oriented water cycle while contributing to the amenity of the city by bringing water management and green infrastructure together.[1] This is achieved by combining and protecting the hydrological and ecological values of the urban landscape while providing resilient and adaptive measures to deal with flood events. Blue-Green Cities (http://www.bluegreencities.ac.uk) generate a multitude of environmental, ecological, socio-cultural and economic benefits.[2] The innovative Blue-Green approach to water management in the city aims to satisfy the demands of urban drainage and planning via coherent and integrated strategies, and places value on the connection and interaction between blue and green assets.[3]

Contents

Background

Blue-Green Cities aim to reintroduce the natural water cycle into urban environments and provide effective measures to manage fluvial (river), coastal, and pluvial (urban runoff or surface water) flooding.[1]

The natural water cycle is characterised by high evaporation, a high rate of infiltration, and low surface runoff.[1] This typically occurs in rural areas with abundant permeable surfaces (soils, green space), trees and vegetation, and natural meandering water courses. In contrast, in most urban environments there is more surface runoff, less infiltration and less evaporation. Green and blue spaces are often disconnected. The lack of infiltration in urban environments may reduce the amount of groundwater, which can have significant implications in some cities that experience drought. In urban environments water is quickly transported over the impermeable concrete, spending little time on the surface before being redirected underground into a network of pipes and sewers. However, these conventional systems ('grey' infrastructure) may not be sustainable, particularly in light of potential future climate change. They may be highly expensive and lack many of the multiple benefits associated with Blue-Green infrastructure.



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

Land planning and engineering design approaches in Blue-Green Cities aim to be cost effective, resilient, adaptable, and help mitigate against future climate change, while minimising environmental degradation and improving aesthetic and recreational appeal. Key functions in Blue-Green Cities 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.[4] A key factor is interlinking the blue and green assets to create Blue-Green corridors through the urban environment.[3]

Blue-Green Cities favour the holistic approach and aim for interdisciplinary cooperation in water management, urban design, and landscape planning. Community understanding, interaction and involvement in the evolution of Blue-Green design are actively promoted. Blue-Green Cities typically incorporate sustainable urban drainage systems (SUDS), a term used in the United Kingdom, known as water-sensitive urban design (WSUD) in Australia, and low-impact development or best management practice (BMP) in the United States. Green infrastructure is also a term that is used to define many of the infrastructure components for flood risk management in Blue-Green Cities.

Blue-Green Infrastructure Components

Many infrastructure components and common practices may be employed when planning and developing a Blue-Green City, in line with the specific water management objectives. The primary functions of these components include water use/reuse, water treatment, detention and infiltration, conveyance and evapotranspiration. In most cases, the components serve several functions.

- Bioretention systems

- Bioretention swales
- Swales and buffer strips
- Storage ponds and lakes
- Controlled storage areas, e.g. car parks, recreational areas, minor roads, playing fields, parkland and hard standing in school playgrounds and industrial areas
- Sand filters and infiltration trenches
- Permeable paving
- Rain gardens
- Green roofs and green walls
- Street planting
- Stream and river restoration
- De-canalisation of river corridors and re-introduction of meanders
- Constructed wetlands

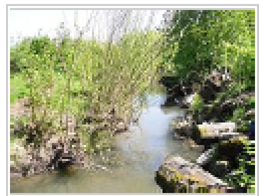
A photograph of a bioretention system, or rain garden, in Portland, Oregon, US.

Flood risk management components in Blue-Green Cities 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 the different features, as well as planned interactions between urban stormwater and green infrastructure facilities. 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.[4]

Benefits associated with Blue-Green Cities

A wide range of environmental, ecological, economic and socio-cultural benefits are directly and indirectly related to the enhanced flood risk management that will accrue in Blue-Green Cities. Many benefits can be utilised during times of no flood, giving Blue-Green Cities a competitive edge over otherwise comparable, conventional cities. The benefits include;

- climate change adaptation and mitigation
- reduction of the urban heat island effect
- better management of stormwater and water supply
- carbon reduction/mitigation
- improved air quality
- increased biodiversity (including the reintroduction and propagation of native species)
- habitat enhancement
- water pollution control
- public amenity (recreational water use, parks and recreation grounds, leisure)
- cultural services (health and well-being of citizens, aesthetics, spiritual)
- community engagement
- education



A photograph of a stream enhancement project in Portland, Oregon, to promote wildlife habitats and increase biodiversity

So what is a Blue-Green City?

Blue-Green Cities aim to recreate a naturally oriented water cycle while contributing to the amenity of the city by bringing water management and green infrastructure together[1].

1. Hoyer, J., Dickhaut, W., Kronawitter, L. and Weber B. 2011. *Water Sensitive Urban Design*. Jovis, University of Hamburg.

Blue-Green Research Aim

Develop and rigorously evaluate strategies for managing flood risk that deliver multiple benefits as part of urban planning and renewal

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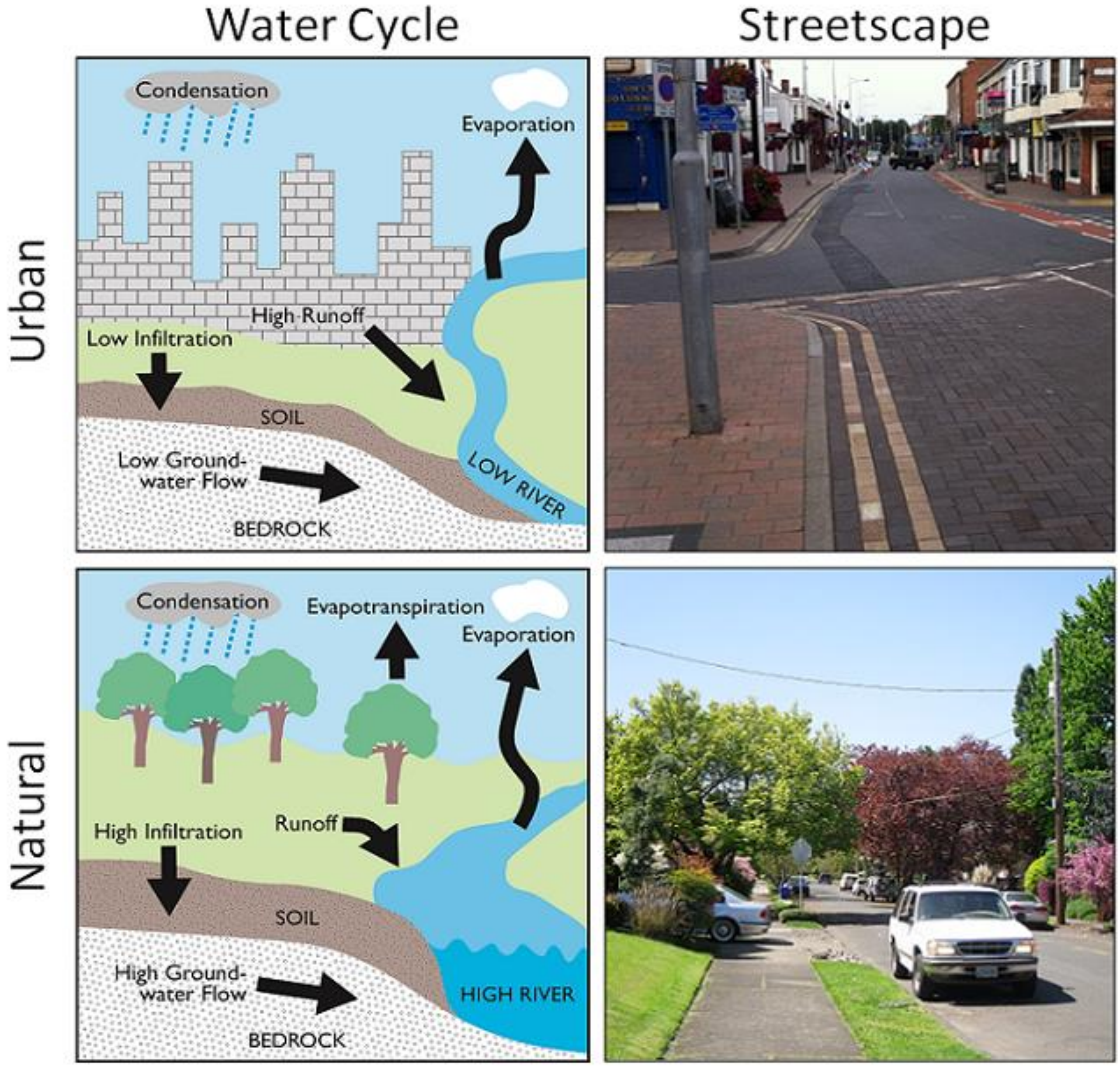

Hydrologic and environmental attributes of Grey versus Blue-Green Cities

BLUE- **GREEN**


HERIOT WATT UNIVERSITY
Newcastle University
UNIVERSITY OF LEEDS
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
RIVERS Agency
UNIVERSITY OF CAMBRIDGE
THE RIVER RESTORATION CENTRE
UEA
University of East Anglia
Cranfield UNIVERSITY
UWE BRISTOL
University of the West of England
LSE
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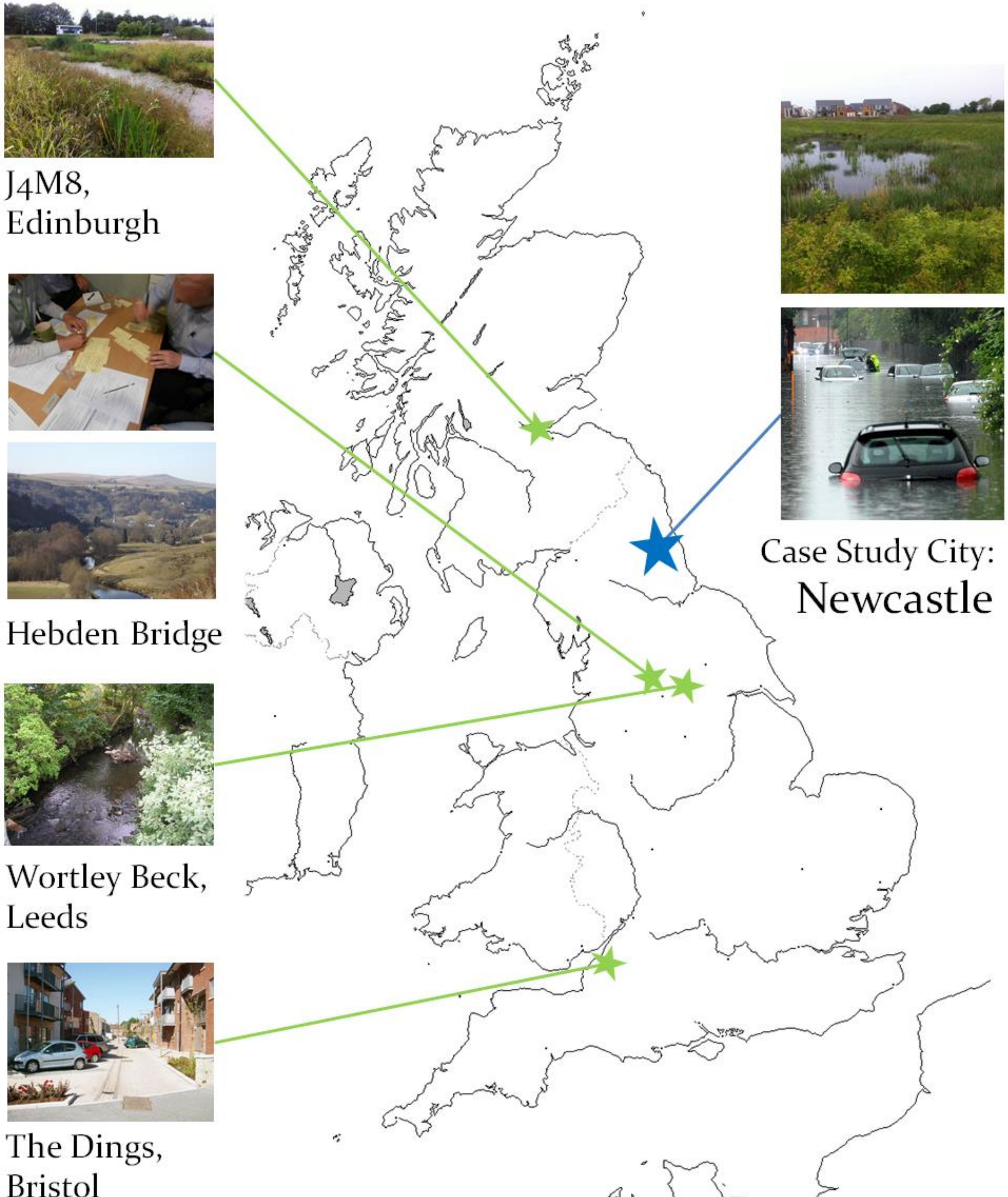
J4M8,
Edinburgh
Hebden Bridge
Wortley Beck,
Leeds
The Dings,
Bristol
Case Study City:
Newcastle

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International Collaborations

Portland, Oregon

Blue-Green Cities are working with:

OSU Oregon State University

Environmental Services City of Portland

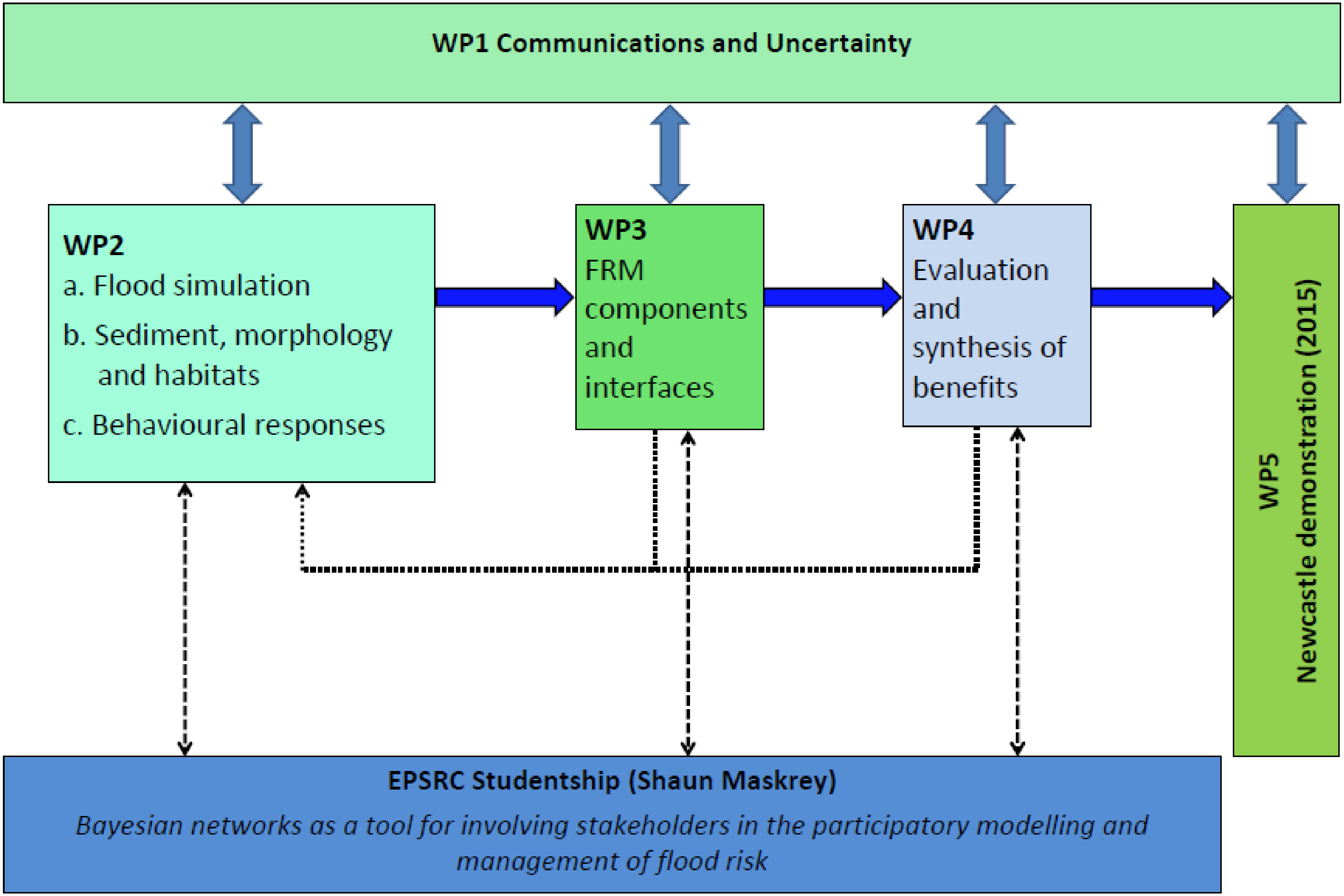
Washington State University

Portland State University

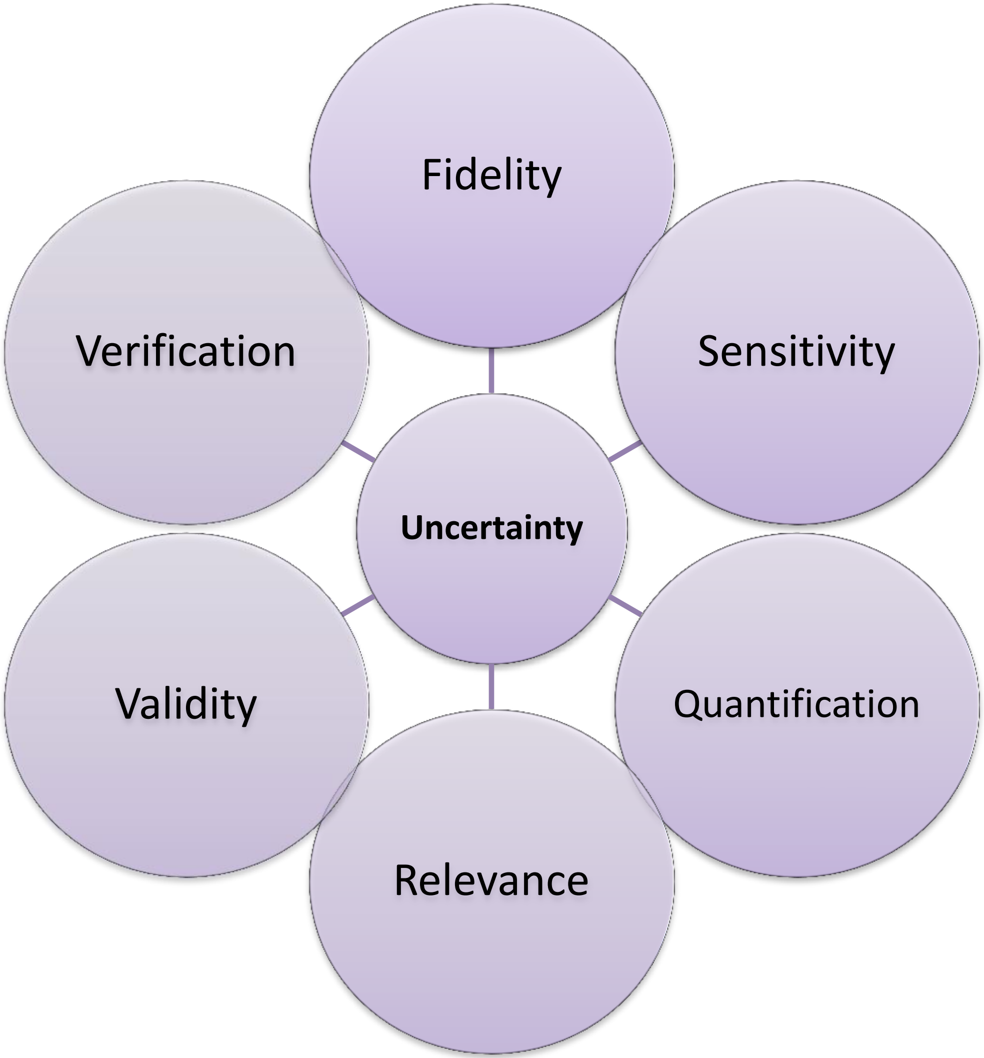
CleanWater Services

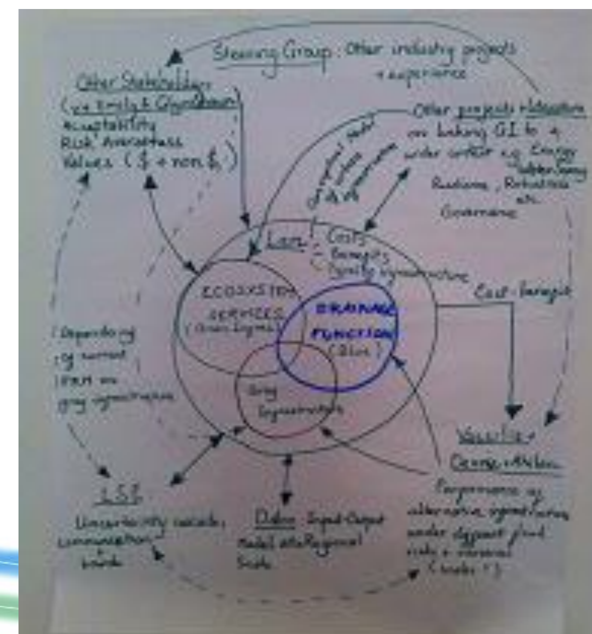
Ningbo, China

Blue-Green Cities are working with Ningbo academics
James Griffiths, David Higgitt, Faith Chan and Odette Paramor

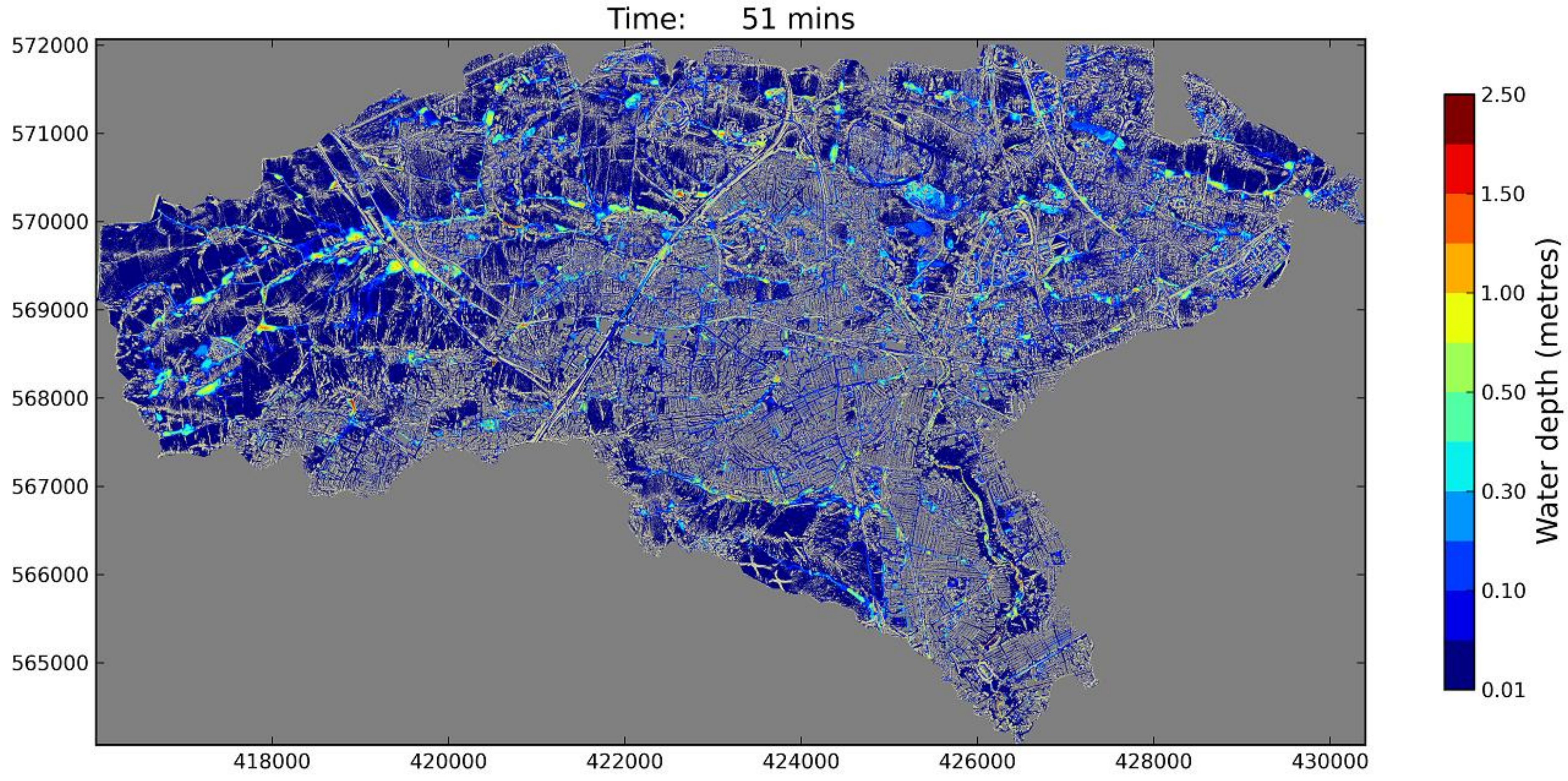

WP1 Communications and Uncertainty
WP2
a. Flood simulation
b. Sediment, morphology and habitats
c. Behavioural responses
WP3
FRM components and interfaces
WP4
Evaluation and synthesis of benefits
WP5
Newcastle demonstration (2015)
EPSRC Studentship (Shaun Maskrey)
Bayesian networks as a tool for involving stakeholders in the participatory modelling and management of flood risk

1. Uncertainty





2a. Flood Inundation – CityCAT and Tuflow



Water depth map of **Ouseburn catchment** (area = 120km^2 , cell size = 2m, cells = 30million). Storm event = 60 minutes, 100-year return period

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2b. Sediment, morphology, habitats

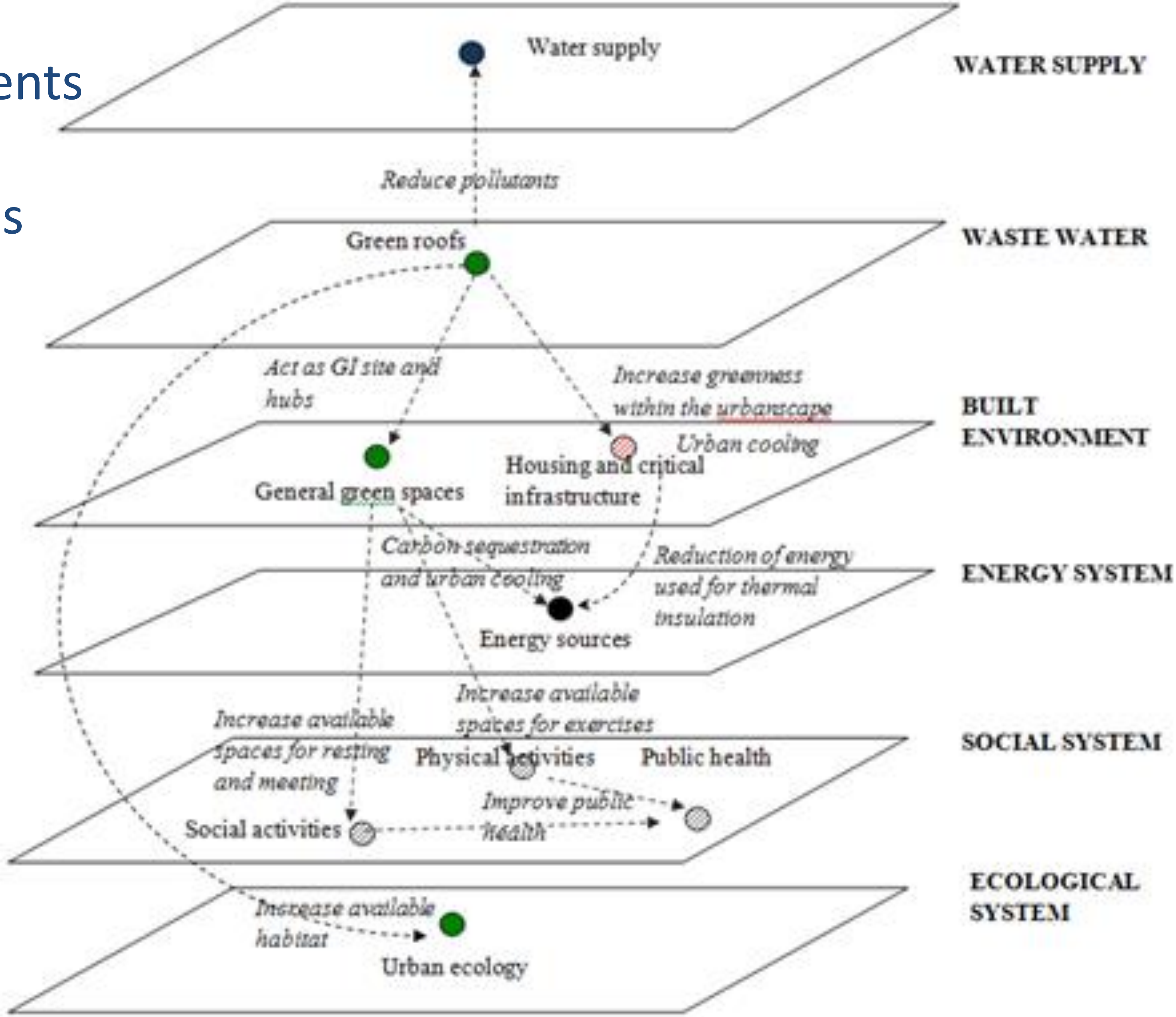
- Sediment transport and debris dynamics in urban drainage networks
- Risks and benefits of using Grey versus **Blue-Green** infrastructure
- Risks and benefits of stream restoration in urban watercourses

PIT technology

2c. Individual and Community Attitudes, Behaviours and Preferences

The Dings, Bristol (above), @Bristol (top-right), St Nicholas House, Bristol (bottom right)

3. FRM components and interfaces



Hoang & Fenner, 2014 *submitted*

4. Synthesis and Evaluation of benefits

Multi-criteria analysis and evaluation of functions and benefits of Blue-Green infrastructure as part of integrated Urban FRM

- **Systems** of **Grey** and **Blue-Green** Infrastructure
- **Relative significance of benefits** in context specific locations
- **Ratings** for **Urban Context** and **Stakeholder Values & Preferences**
- **Recommendations on design standards** to enhance significant flood and non-flood benefits
- Close link to **CIRIA Project RP993**

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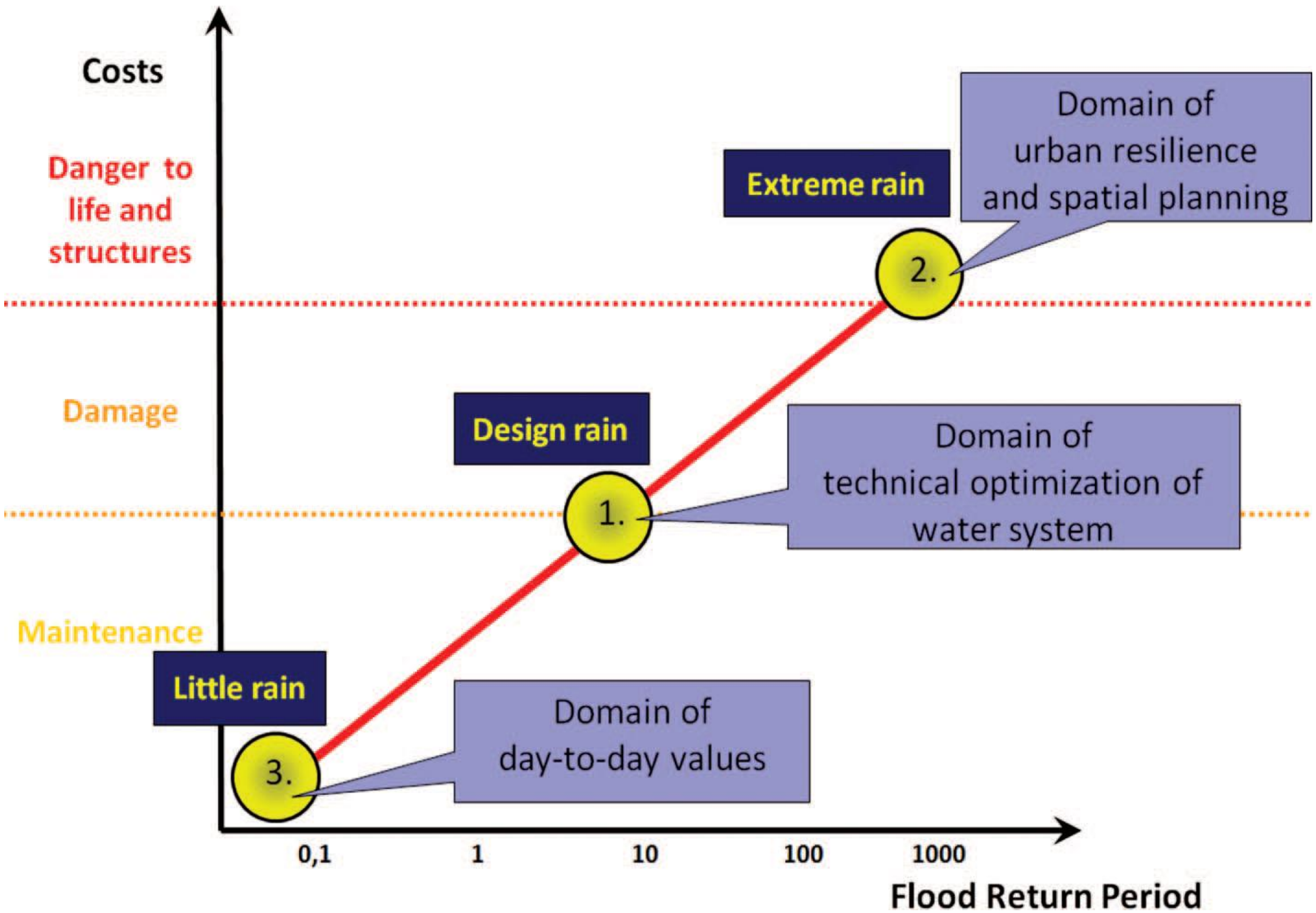
Designing for exceedance: the three point approach



Blue Condition

2. ***If extreme flooding occurs infrastructure facilitates managed urban conveyance and storage.***

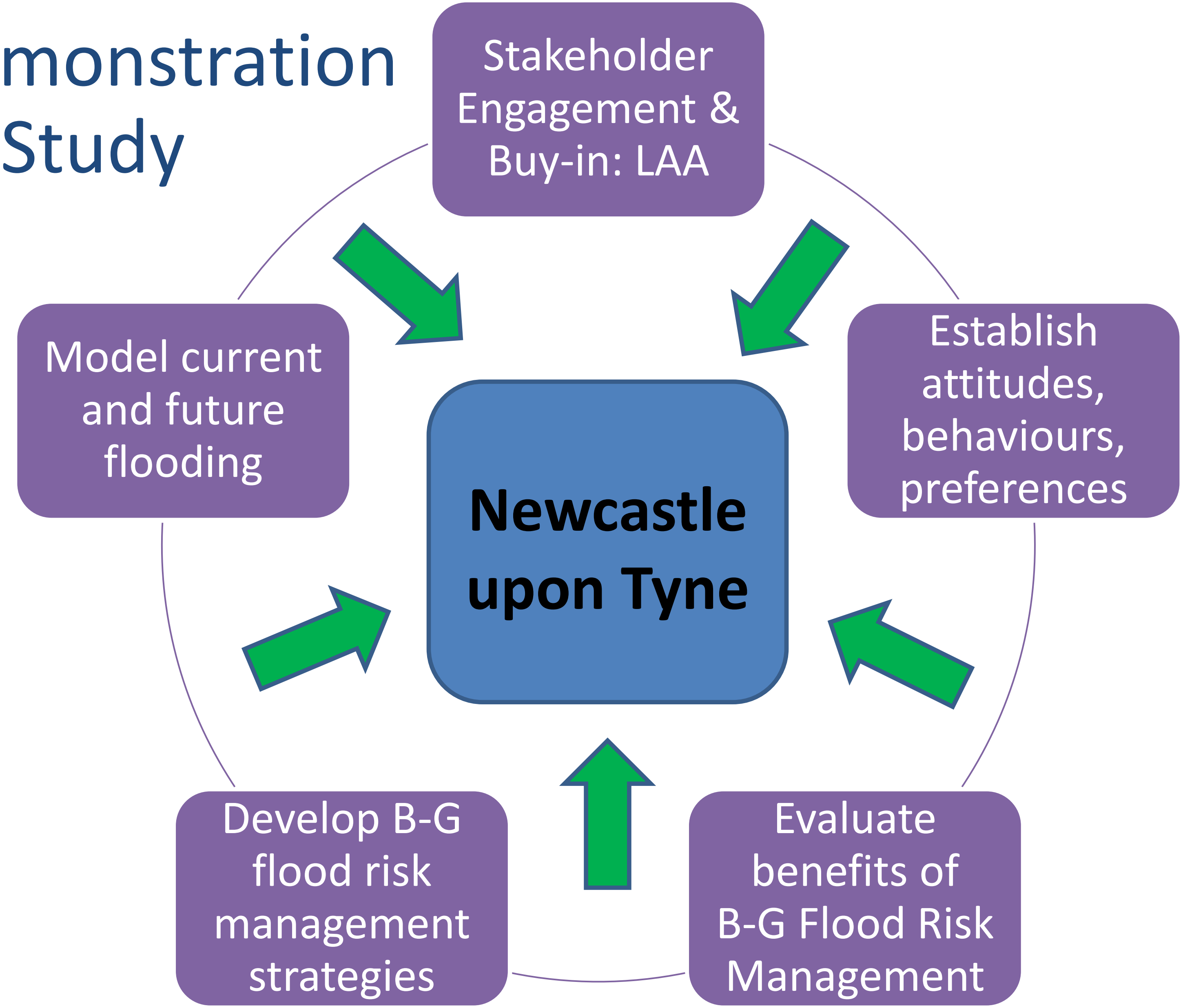
1. ***FRM infrastructure provides required level of service for flood defence.***

3. ***Green infrastructure and spaces used on a daily basis by communities and ecosystems.***

Green Condition

Fratini et al.,(2012) Three Points Approach (3PA) for urban flood risk management.

5. Demonstration Case Study



Nottingham PhD Studentship – Shaun Maskrey

Participatory modelling using Bayesian networks

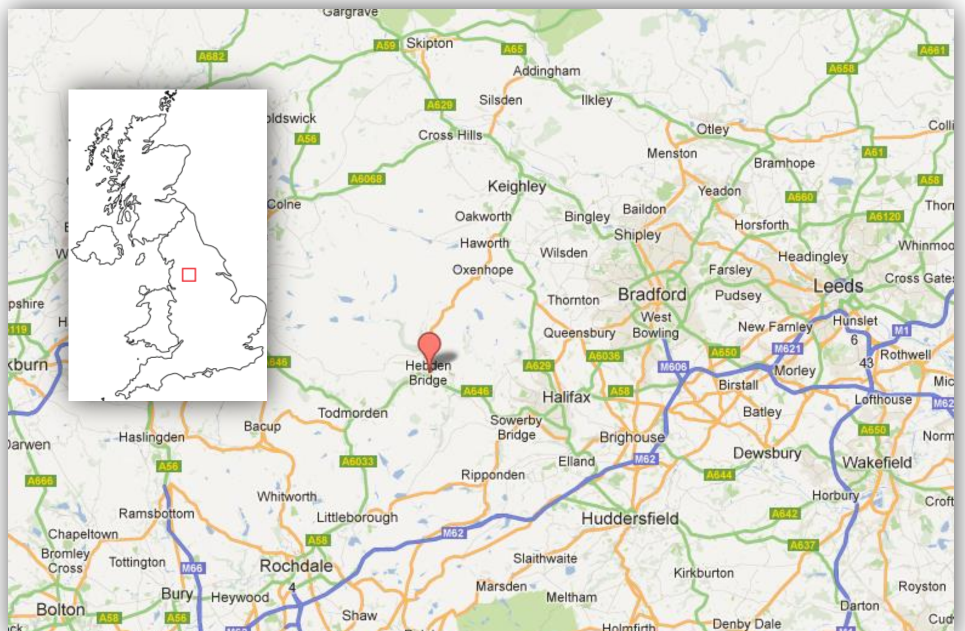


Figure 3: Brookside Wetlands, located in the East Lents target area.

Locations:

Hebden Bridge - West Yorkshire

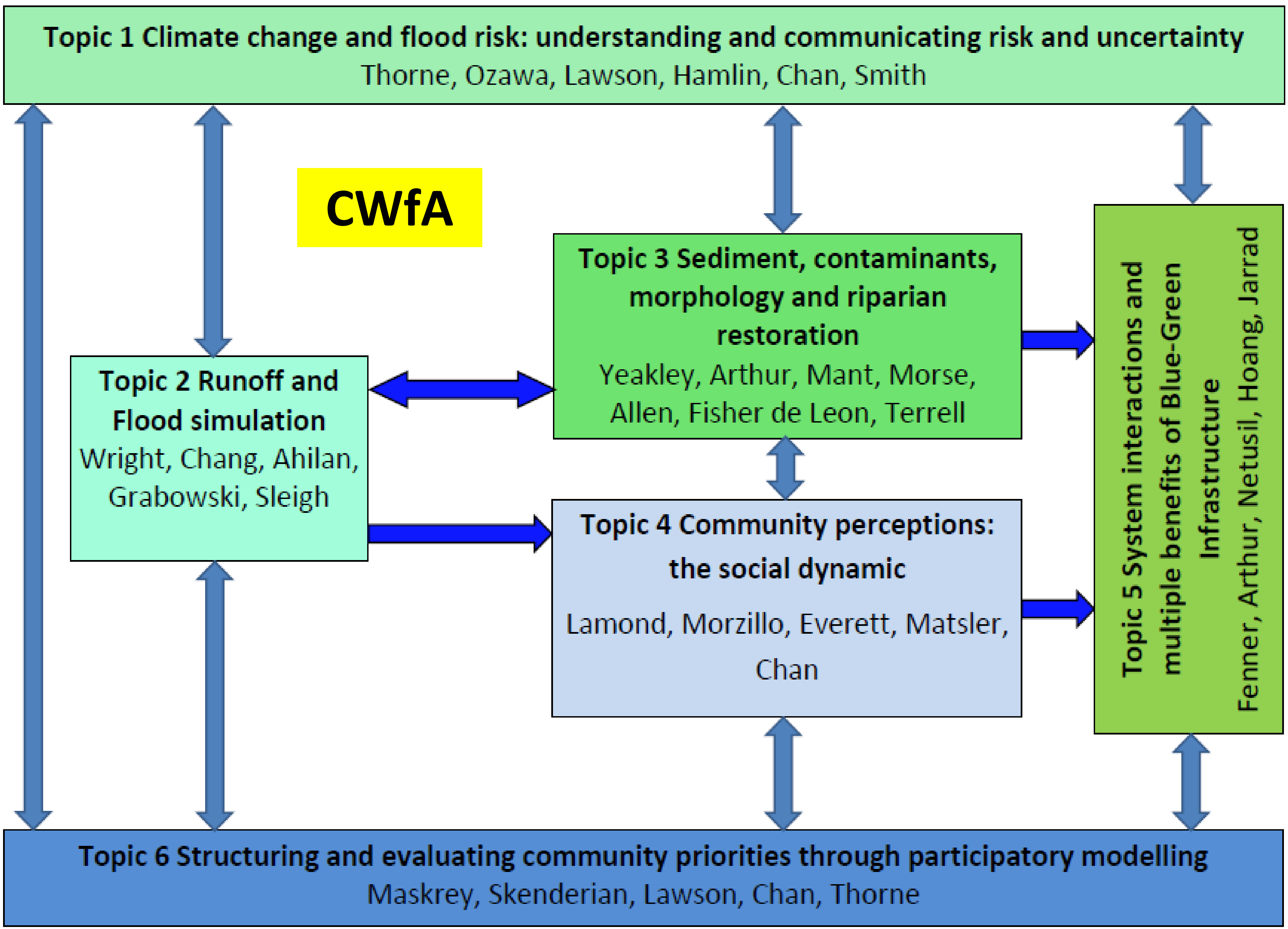
East Lents - Portland, Oregon

Objectives:

Ensure take up of local stakeholder knowledges, particularly about flooding and social processes in flood modelling and flood risk management

Establish the potential for achieving this through a participatory approach that facilitates co-production of knowledge by building a Bayesian Belief network

Clean Water for All (CWfA) 2014
UK+US collaboration


Topic 1 Climate change and flood risk: understanding and communicating risk and uncertainty
Thorne, Ozawa, Lawson, Hamlin, Chan, Smith
CWfA
Topic 3 Sediment, contaminants, morphology and riparian restoration
Yeakley, Arthur, Mant, Morse, Allen, Fisher de Leon, Terrell
Topic 2 Runoff and Flood simulation
Wright, Chang, Ahilan, Grabowski, Sleigh
Topic 4 Community perceptions: the social dynamic
Lamond, Morzillo, Everett, Matsler, Chan
Topic 5 System interactions and multiple benefits of Blue-Green Infrastructure
Fenner, Arthur, Netusil, Hoang, Jarrad
Topic 6 Structuring and evaluating community priorities through participatory modelling
Maskrey, Skenderian, Lawson, Chan, Thorne

Acknowledgement

The research reported in this presentation is being conducted as part of the Blue-Green Cities Research Consortium with support from:

- **Engineering and Physical Sciences Research Council**
- **Northern Ireland Rivers Agency**
- **Environment Agency**
- **National Science Foundation**
- **City of Portland Bureau of Environmental Services**

EPSRC Grant EP/K013661/1