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

Dr Emily Lawson University of Nottingham

EPSRC
Pioneering research and skills

Environment Agency

RIVERS Agency

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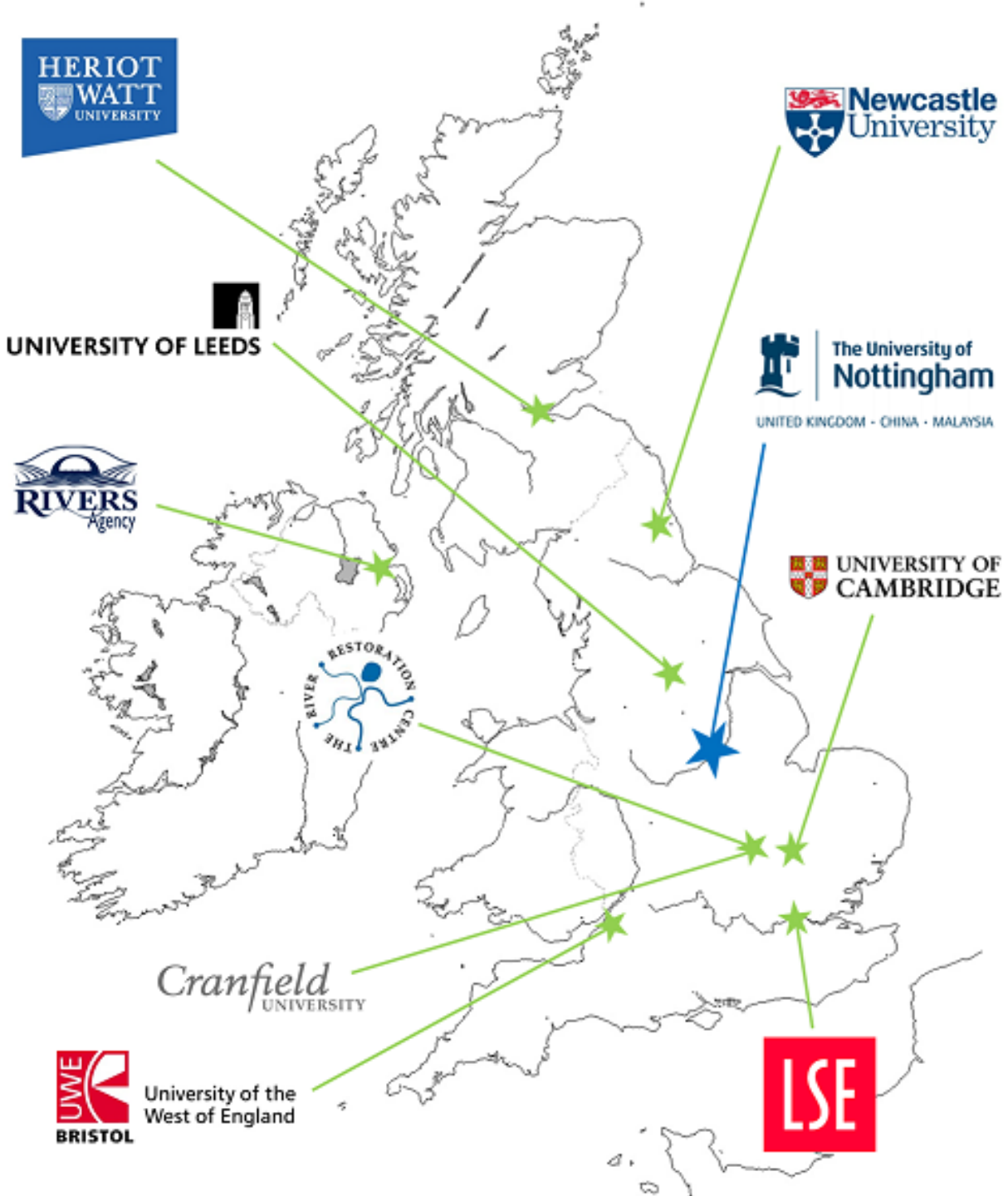
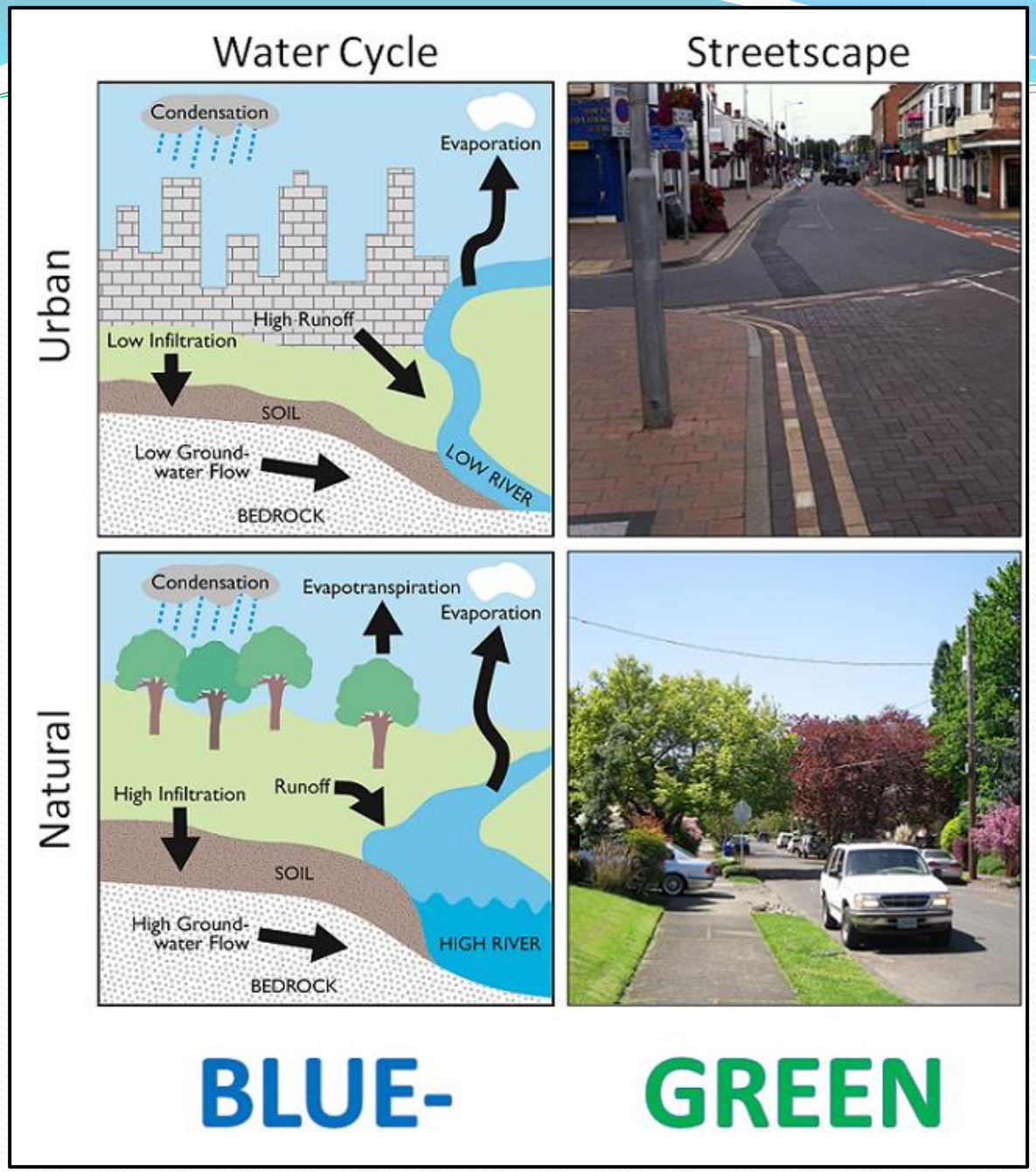
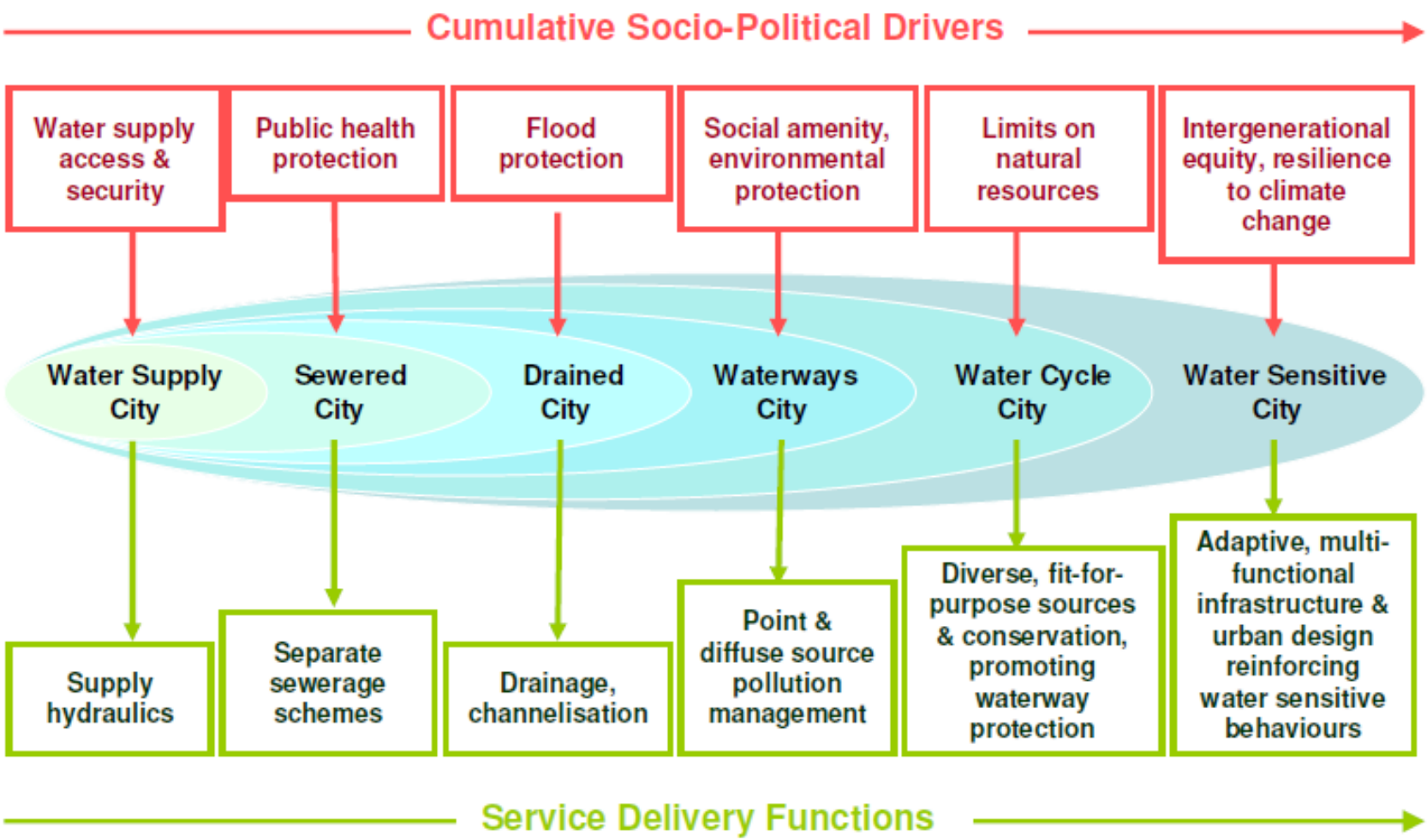




Comparison of the hydrologic (water cycle) and environmental (streetscape) attributes in conventional (upper) and Blue-Green Cities



Urban Water Management Transitions Framework

(Brown et al., 2008)

Moving towards UK Blue-Green Cities?

Images from Susdrain

SuDS and connected Green Infrastructure

Multiple benefits including surface water management, e.g. UHI, climate change, air pollution control…

- PPS17 and GI

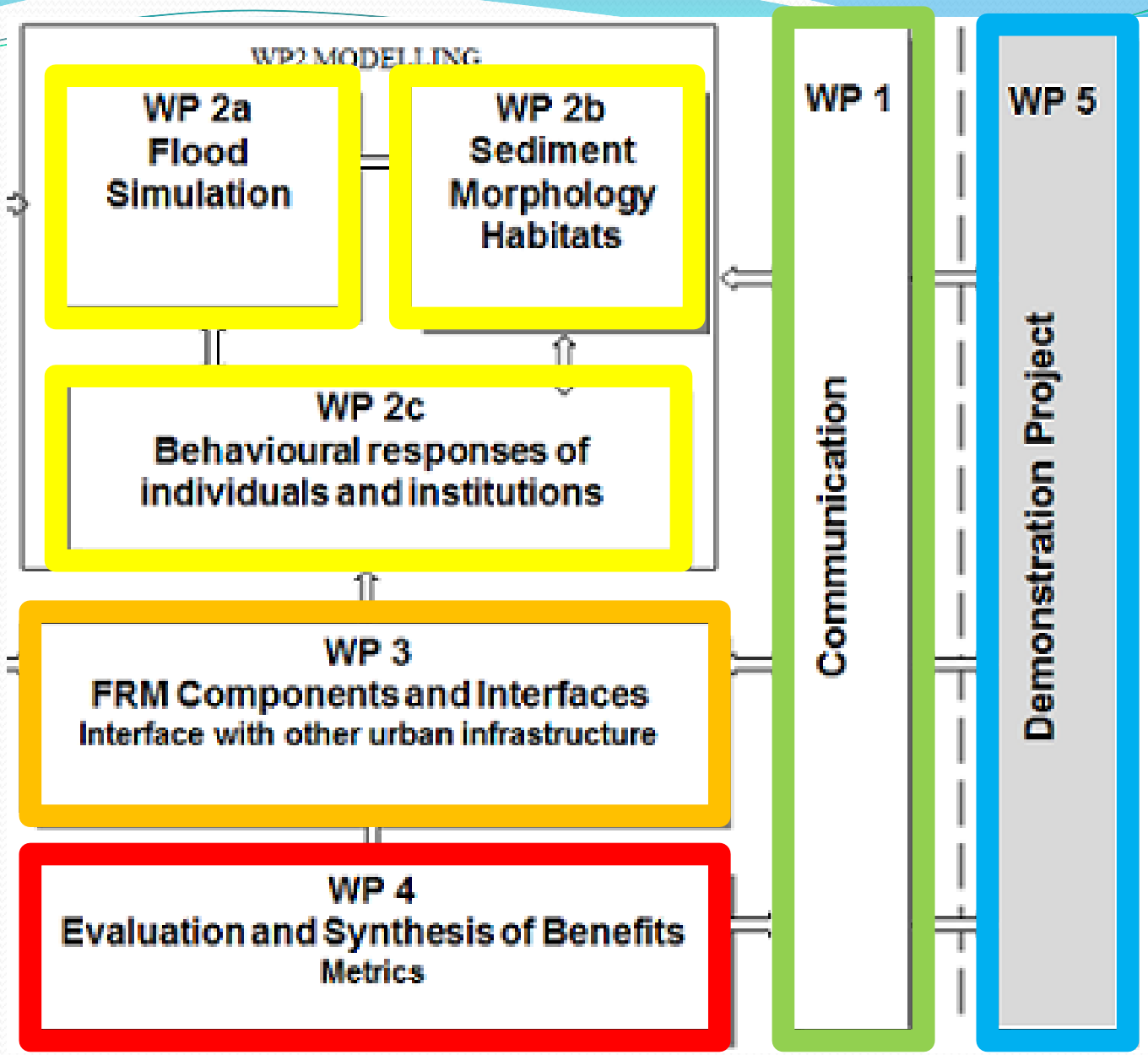
Blue-Green Research Aims

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

Demonstrate the underpinning science that defines success rate of Blue-Green infrastructure (vs. grey)

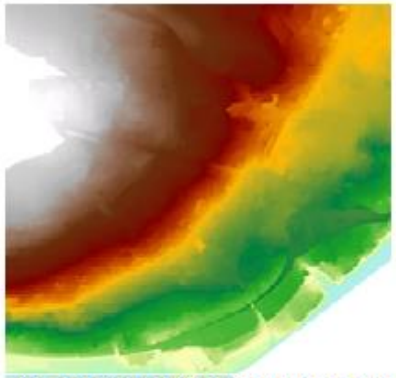
Project Deliverables

- A detailed model of urban flood inundation (pluvial+fluvial)
- Impact assessment of Blue-Green design
- Evaluation procedure to quantify and value benefits from individual components of Blue-Green infrastructure installations
- A decision support tool for option appraisal of appropriate Blue-Green infrastructure and FRM strategies
- A guide that defines the language used in FRM
- Robust method of uncertainty evaluation


WP2 MODELLING
WP 2a
Flood
Simulation
WP 2b
Sediment
Morphology
Habitats
WP 2c
Behavioural responses of
individuals and institutions
WP 3
FRM Components and Interfaces
Interface with other urban infrastructure
WP 4
Evaluation and Synthesis of Benefits
Metrics
WP 1
Communication
WP 5
Demonstration Project

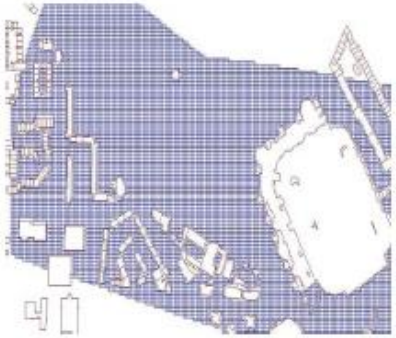
WP2a. Flood Inundation - CityCAT

- **City Catchment Analysis Tool** (developed at Newcastle University)
- Simulations of pluvial+fluvial flood events, driven by rainfall, flow and/or water depth time series
- 2-way coupling between surface and sub-surface flow networks
- Inclusion of simple SuDS (green/blue roofs, ponds, potentially bioswales)
- Key datasets:
  - a Digital Terrain Model (DTM)
  - OS MasterMap data
  - Subsurface pipe network (Northumbrian Water)

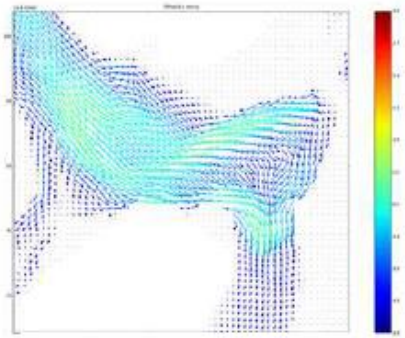


An example of terrain given by a Digital Terrain Model (DTM)

An example of Master Map coverage.



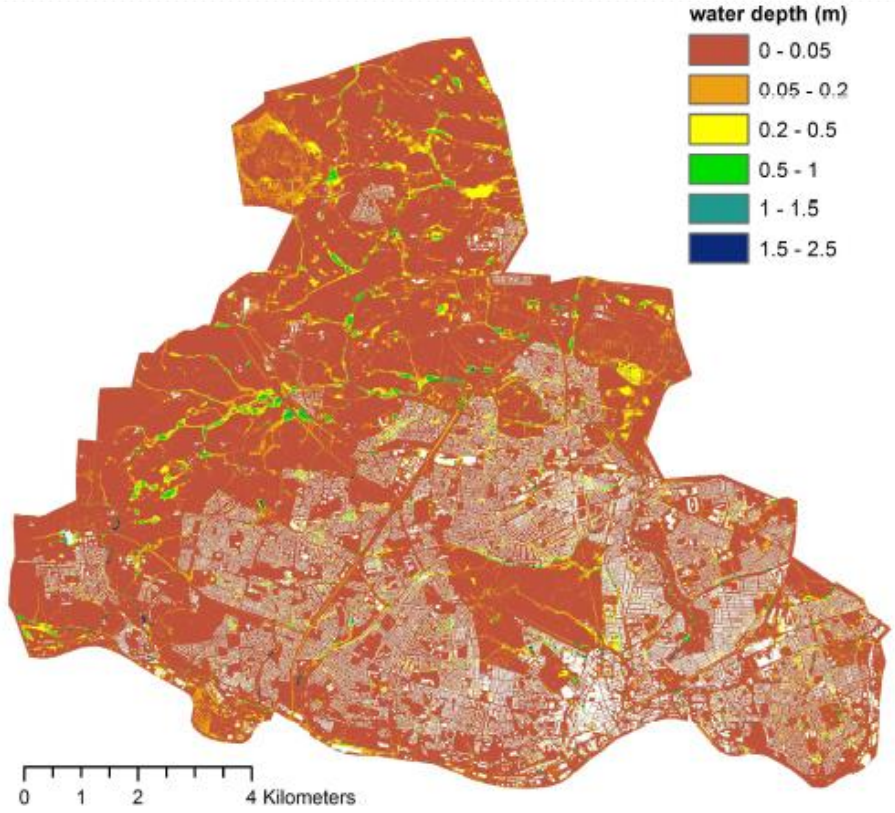
An example of the CityCAT grid without buildings



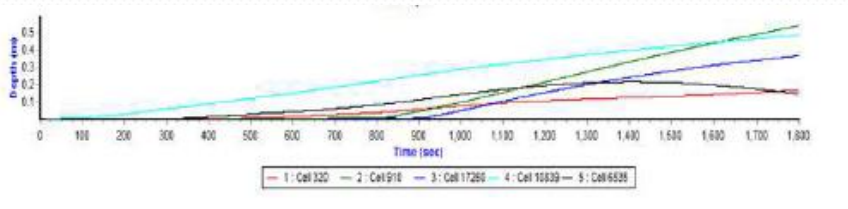
An output map showing flow velocity field

Newcastle University

WP2a. Flood Inundation - CityCAT



Water depth map of Newcastle City Council area (~130km^2). Storm event of 60 minutes and 100 years return period .



Outputs

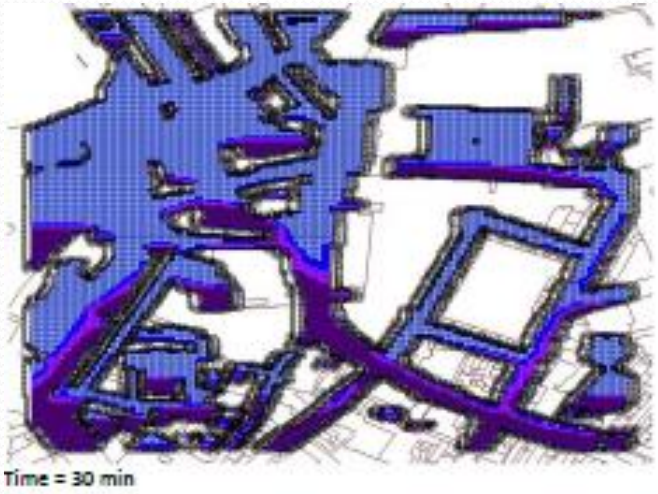
- time series of water depths and flow velocities at selected locations
- snapshot maps of water depths and velocities at specific times

Newcastle University

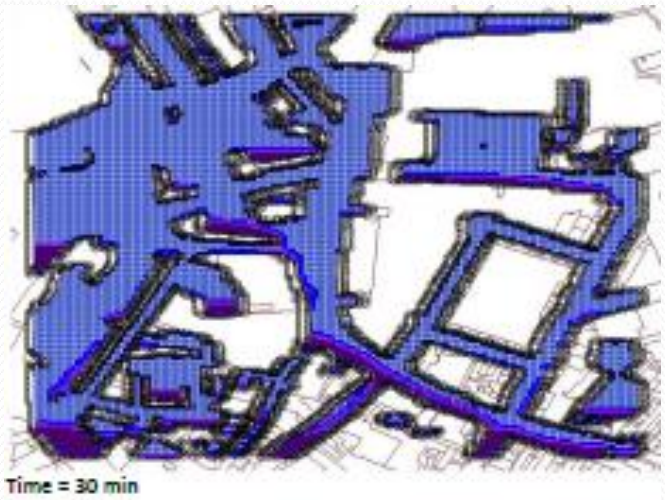
Newcastle “Toon Monsoon” June 2012

WP2a. Flood Inundation CityCAT

Test Scenario 1: Generation and propagation of a flood arising from a design storm before and after introduction of "green roof" storage on buildings



Without roof storage



With roof storage

Newcastle University

WP2b. Sediment/debris, culvert blocking

Modelling morphology, sediment transport and debris dynamics in Blue-Green features, e.g.
tagged debris and sediment

Research Qs

- Effectiveness + connectivity
- Sources and transfer
- Re-suspension + deposition
- Pollutants (WFD)

HERIOT WATT UNIVERSITY

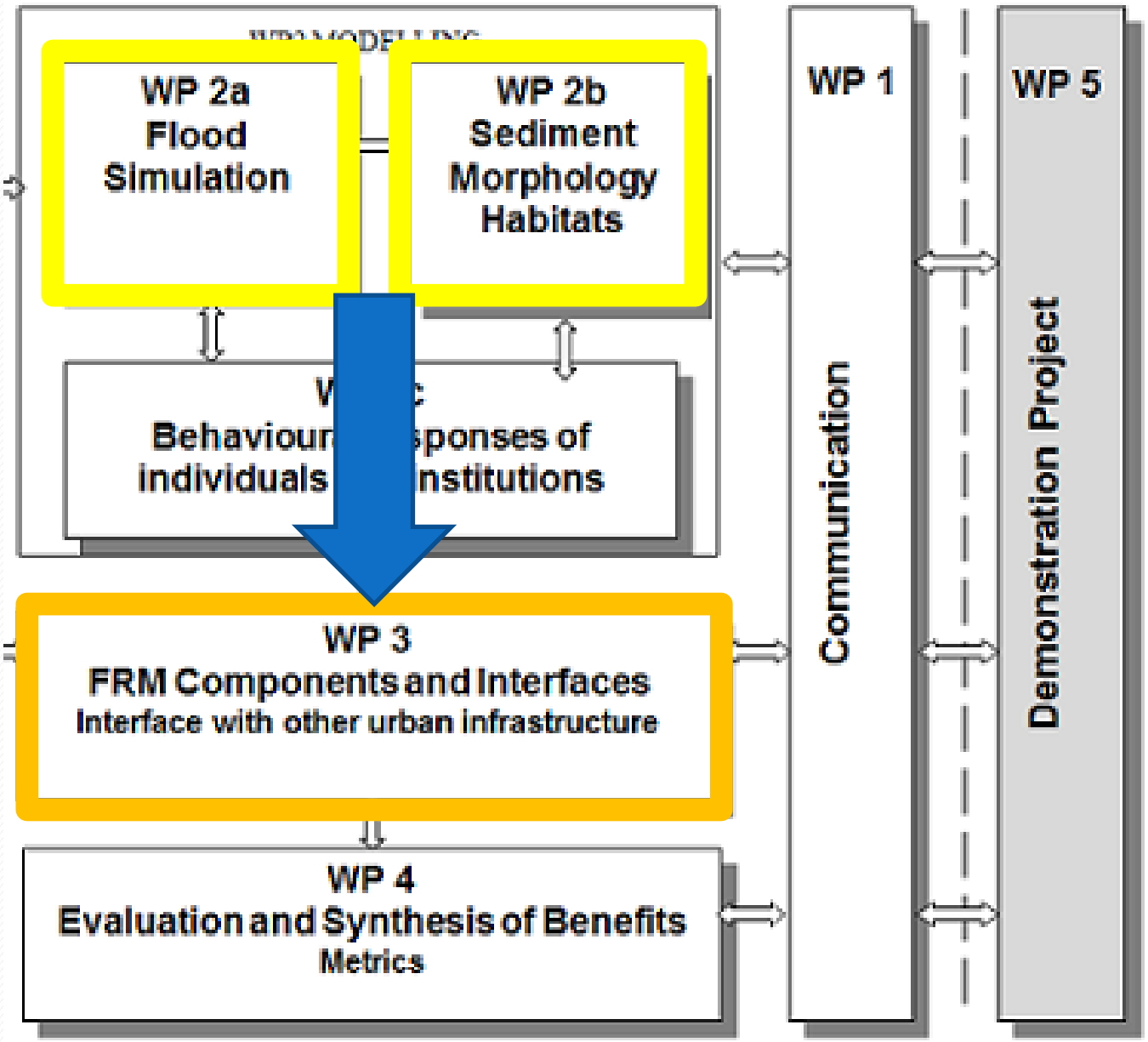
WP2b Debris movement through an urba PIT)

Source-receptor


HERIOT
WATT
UNIVERSITY

WP2b. Debris movement through an urban environment - experimental

Potential work on Ribblesdale Road Rain Gardens with Nottingham City Council and EA (Masters)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WP3. FRM components and interfaces

FRM = part of a wider "system of systems" providing vital services for urban communities

WP3; develop tools and methodologies which can represent urban FRM and Blue-Green networks within a single urban environment

- Surprise interactions?
  - Hull and pump failure 2007

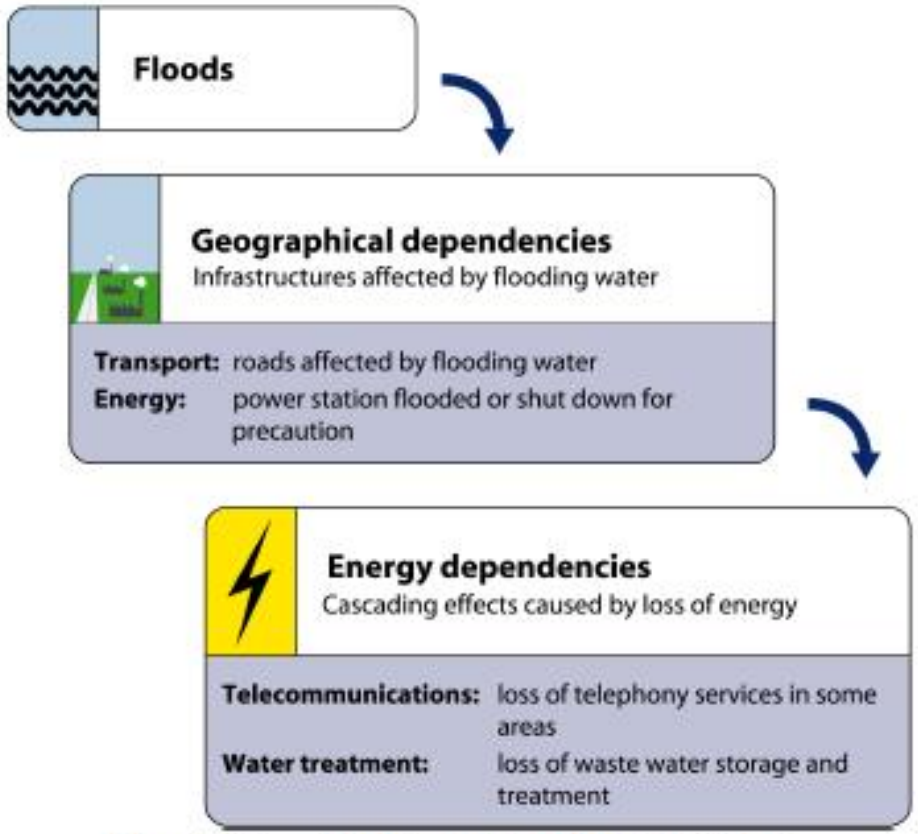
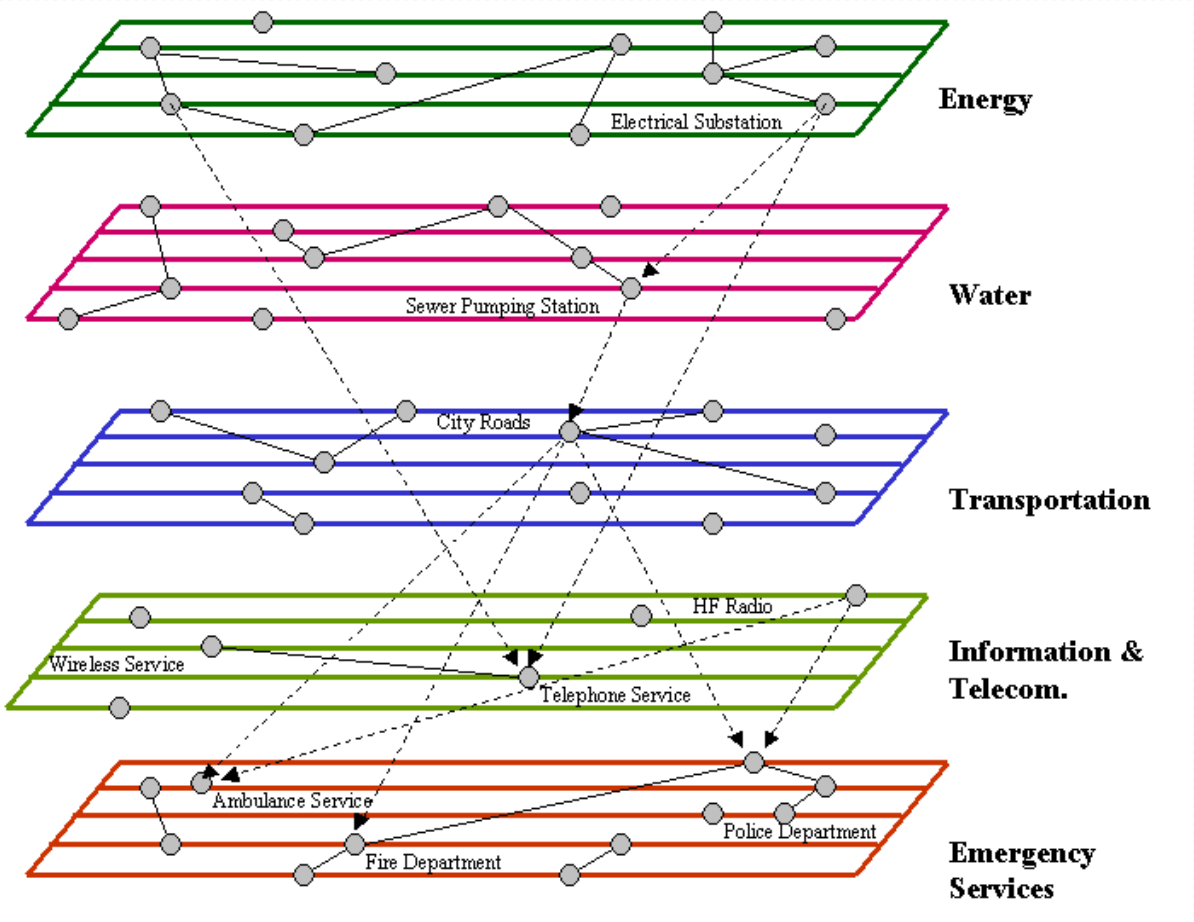


Figure 2: Cascading effects during the 2007 UK floods

Adelard Document 2009.

UNIVERSITY OF CAMBRIDGE

WP3. Critical Dependencies

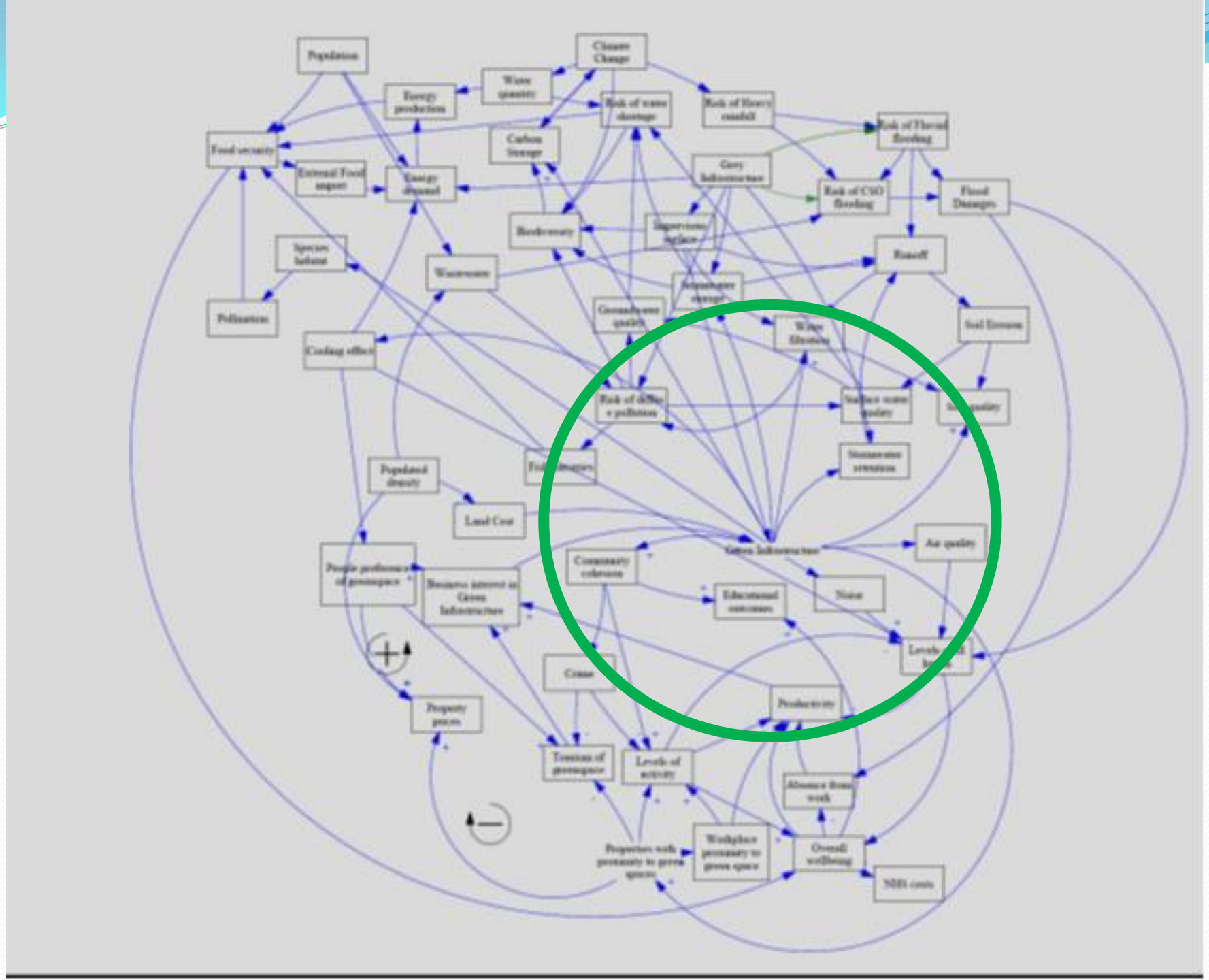


Key Question

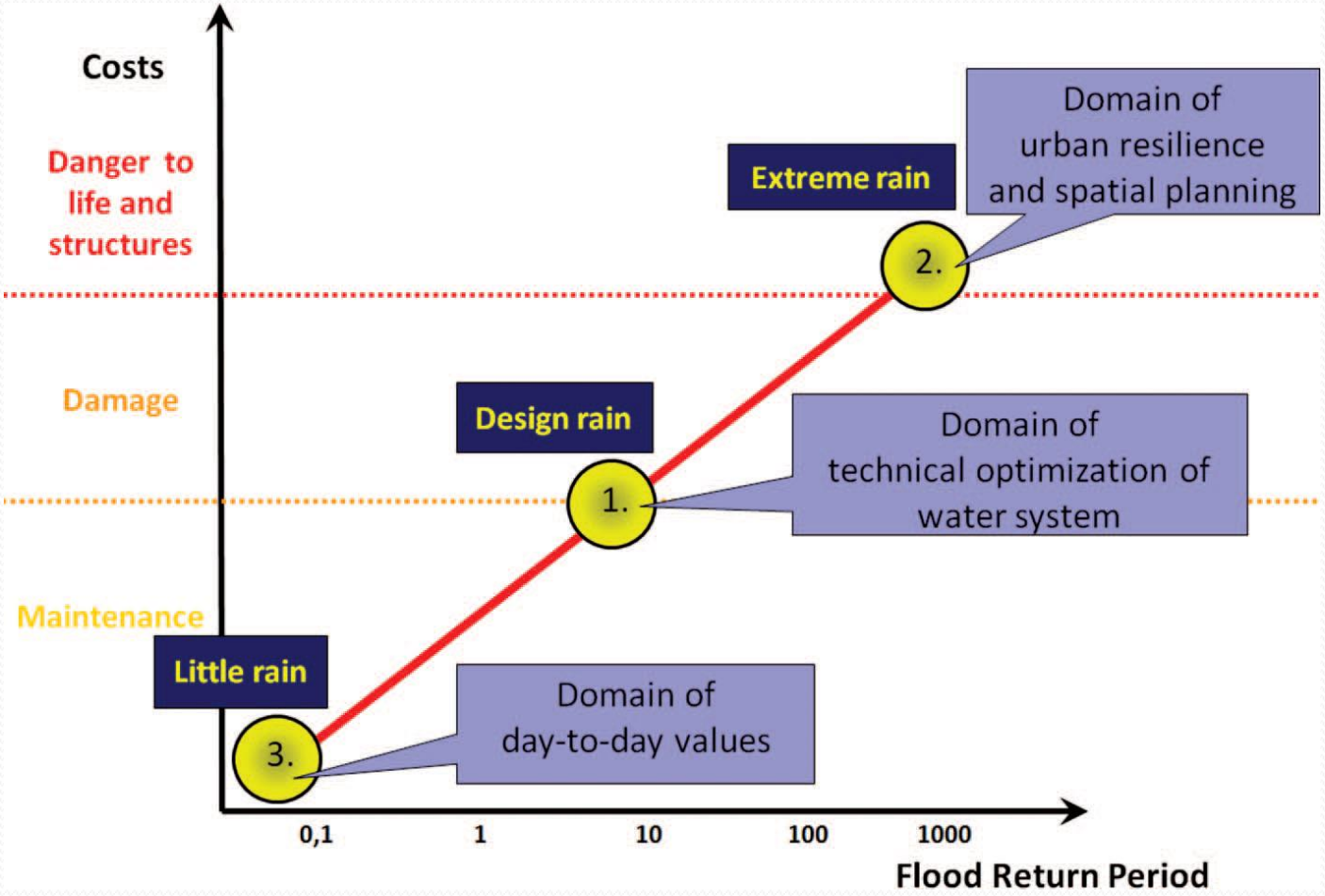
-Where does BG FRM infrastructure fit in a complex urban system?

- City scale
- Two-way interactions
- Based on US/Australia reported impacts

Pederson et al. (2006) Critical Infrastructure Interdependency Modeling.


Population
Climate Change
Water quantity
Energy production
Risk of water shortage
Risk of heavy rainfall
Risk of Thermal Stress
Food security
Carbon Storage
External Food import
Energy demand
Grey Infrastructure
Risk of CSO flooding
Flood Damages
Biodiversity
Impervious surface
Species habitat
Watercourse
Runoff
Pollinators
Groundwater quality
Water Efficiency
Soil Erosion
Cooling effect
Risk of diffuse pollution
Surface water quality
Pupulated density
Land Cost
Stormwater retention
Green Infrastructure
Air quality
People preference for greenspace
Community cohesion
Noise
Business interest in Green Infrastructure
Educational outcomes
Crime
Property prices
Productivity
Tourism of greenspace
Levels of activity
Absence from work
Proportion with proximity to green space
Workplace proximity to green space
Overall wellbeing
NHS costs

Three points approach for urban FRM



Blue Condition

2. ***Adaptation in the wider urban area. New spaces for water conveyance and urban storage***

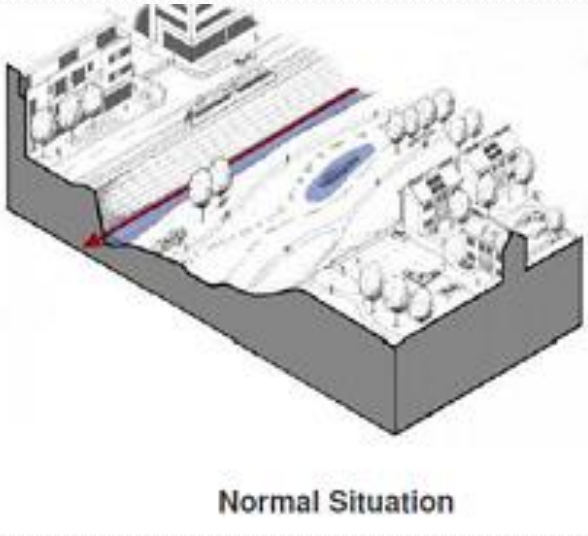
1. ***Design standards apply. Levels of service are met***

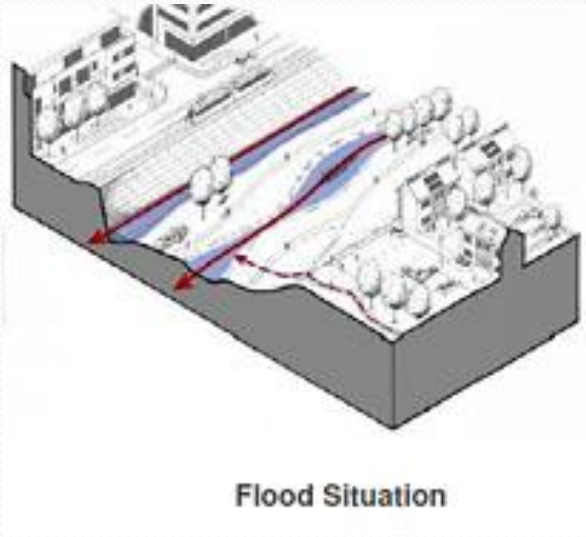
3. ***Urban green space used on a day to day basis by community***

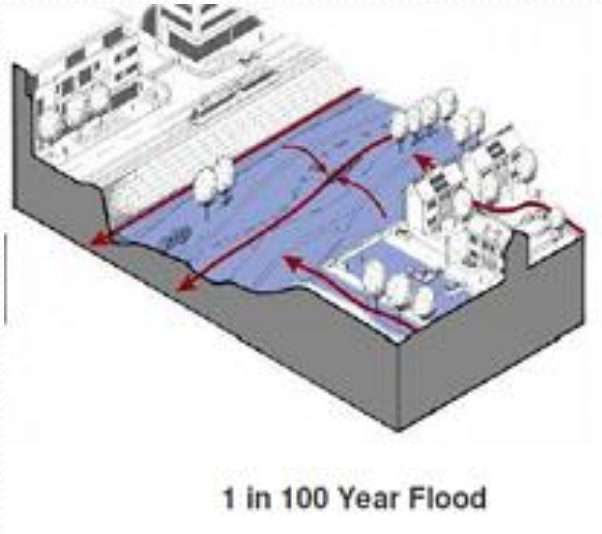
Green Condition

Fratini et al.,(2012)

Multifunctionality of urban blue corridors Defra 2011

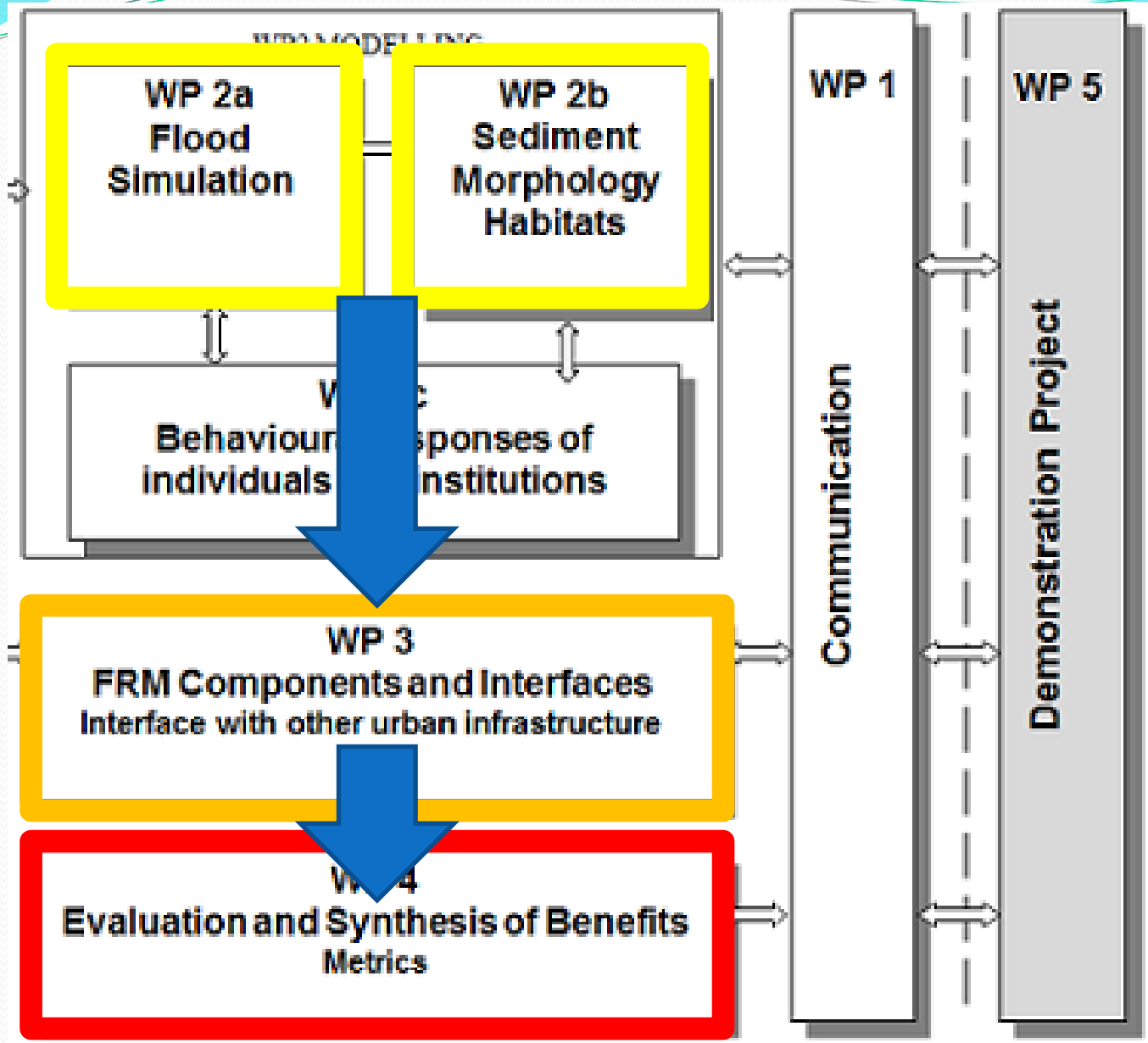






Green Condition

Blue Condition



Benefits;

- When?
- What?
- Who?

WP4. Evaluation and synthesis of benefits

Aim; Develop procedures for the robust evaluation of the multiple functionalities of Blue-Green infrastructure components within FRM strategies

Realising better design guidance

- Performance appraisal against a set of diverse criteria and, where possible, monetisation of the benefits to allow:
  - direct comparison between alternative measures, and
  - inclusion of multi-functionality advantages into cost benefit calc.

  - *Other work valuing multiple benefits…*
  - *Caveat – need appropriate maintenance (avoid overselling)*

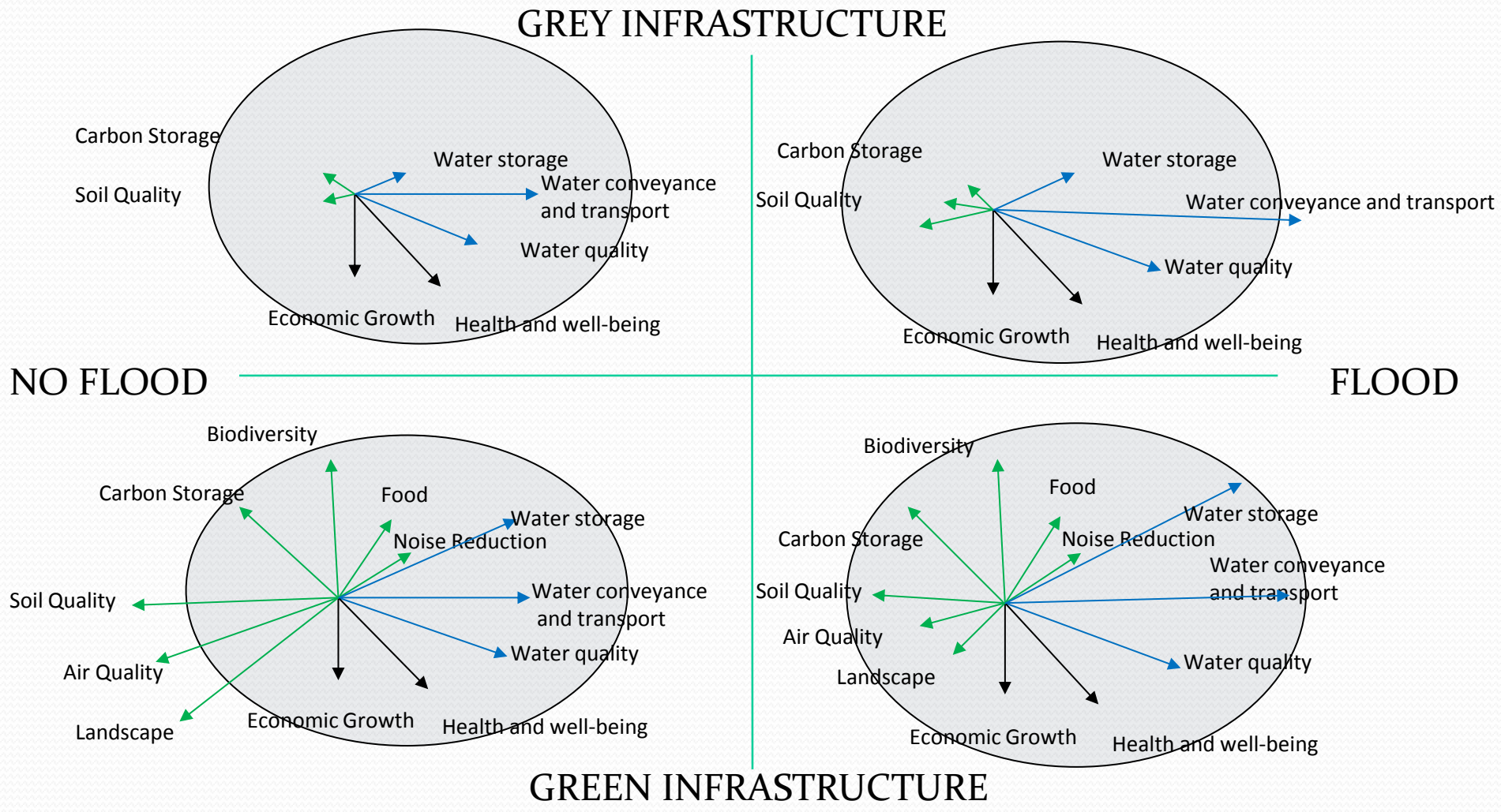
Potential Benefits of Blue-Green Infrastructure

- 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
- attractive landscaping and quality of place
- increased land and property values
- labour productivity (stress reduction, attracting and retaining staff)
- economic growth and investment
- tourism

Social
Economic
Environmental
Cultural

How can we maximise these benefits for a Blue-Green (and grey) element?

WP4. Evaluation and synthesis of benefits



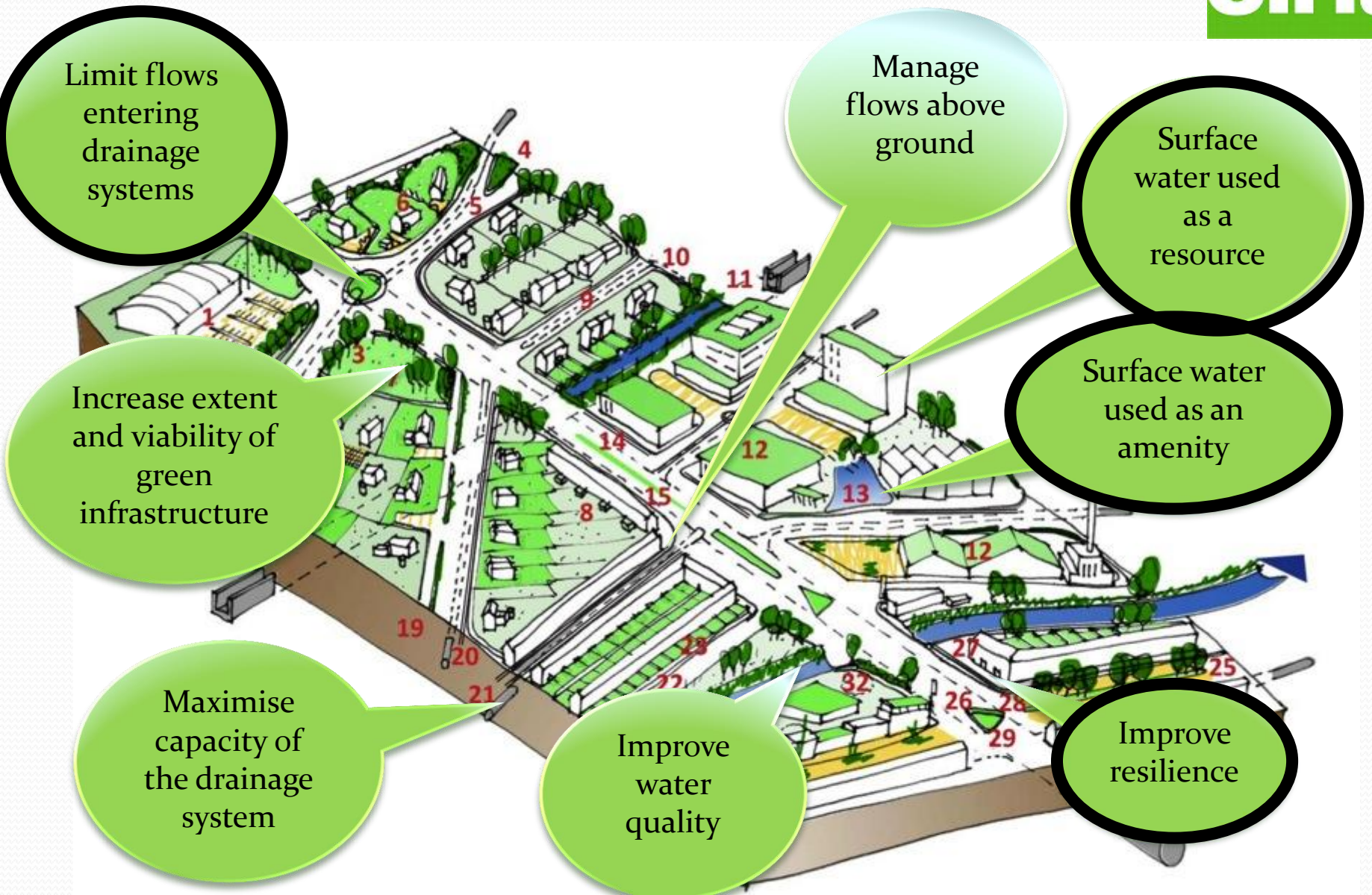
Setting a performance target – green roof

- What are the multiple benefits, costs and dis-benefits?
- What benefits do we want to prioritise?
- How can an element be built to maximise these benefits?
  - **Capacity calculations for a unit-sized element**
- Monetisation?
- Realistic in a UK context?

= better design guidance

The benefits of retrofitting (using SuDS)

ciria



WP4. Evaluating benefits

Building on existing work from;

- HR Wallingford
- Center for Neighborhood Technology (US) – **stormwater reduction runoff goal**
- Green Infrastructure North West calculator and valuation toolkit
- Links with CIRIA's Multiple Benefits Project RP 993

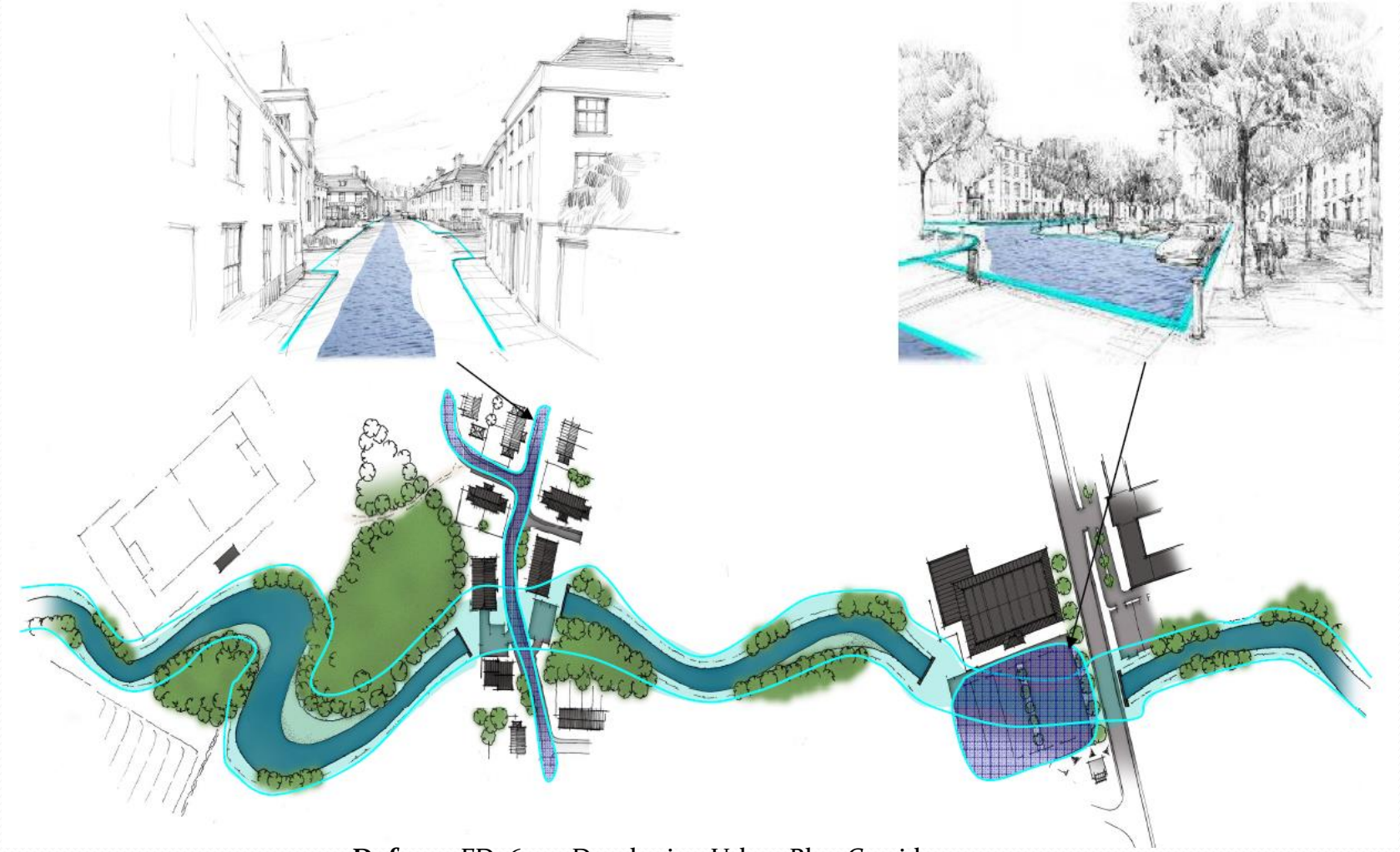
Multi-functionality and connectivity

Photo; Portland, Oregon, US

Retrofit rain gardens for traffic calming, stormwater management, aesthetics etc.

BUT do benefits scale up linearly?

Importance of connectivity for scaling up benefits?



Defra FD2619 – Developing Urban Blue Corridors

Concluding Remarks

- Blue-Green infrastructure, cities, regions…
- Project team – engineers, hydrologists, geomorphologists, ecologists, statisticians, geographers and more

- **Key deliverables;**
  - A detailed model of urban flood inundation (pluvial+fluvial) and sediment/debris transport
  - Impact assessment of Blue-Green design
  - Evaluation procedure to quantify and value benefits from individual components of Blue-Green infrastructure installations ***(based on performance evaluation and maximisation of benefits)***

  - **SuDS + GI + multifunctionality + connectivity**

Acknowledgements

Blue-Green Cities Team at: Universities of Nottingham, West of England, and Leeds; Cambridge, Newcastle, Cranfield, and Heriot-Watt Universities, and the London School of Economics, Environment Agency, LAs, Water Companies, our Strategic Advisory Board (details on website).

www.bluegreencities.ac.uk

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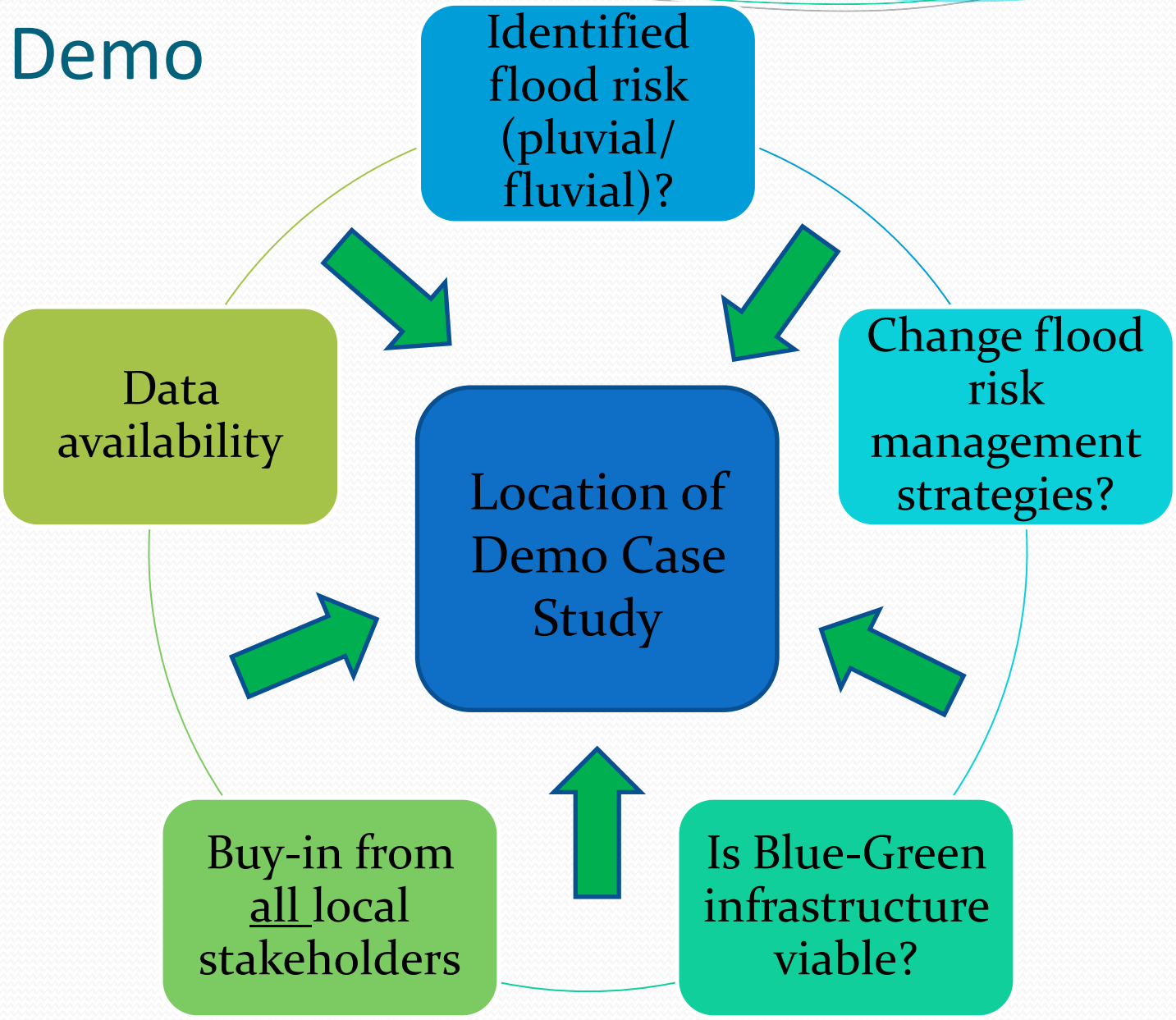
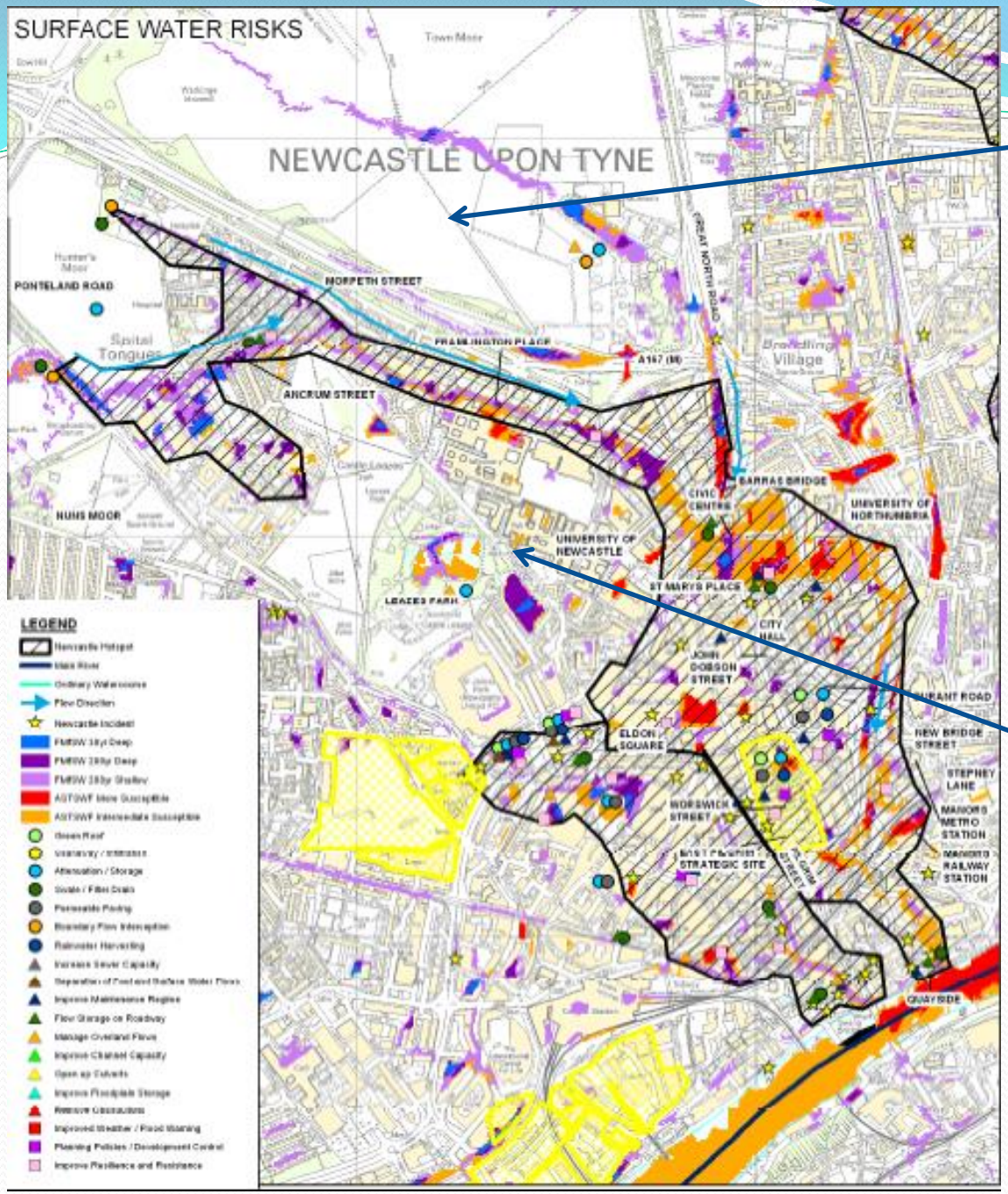
WP5. Demo Study





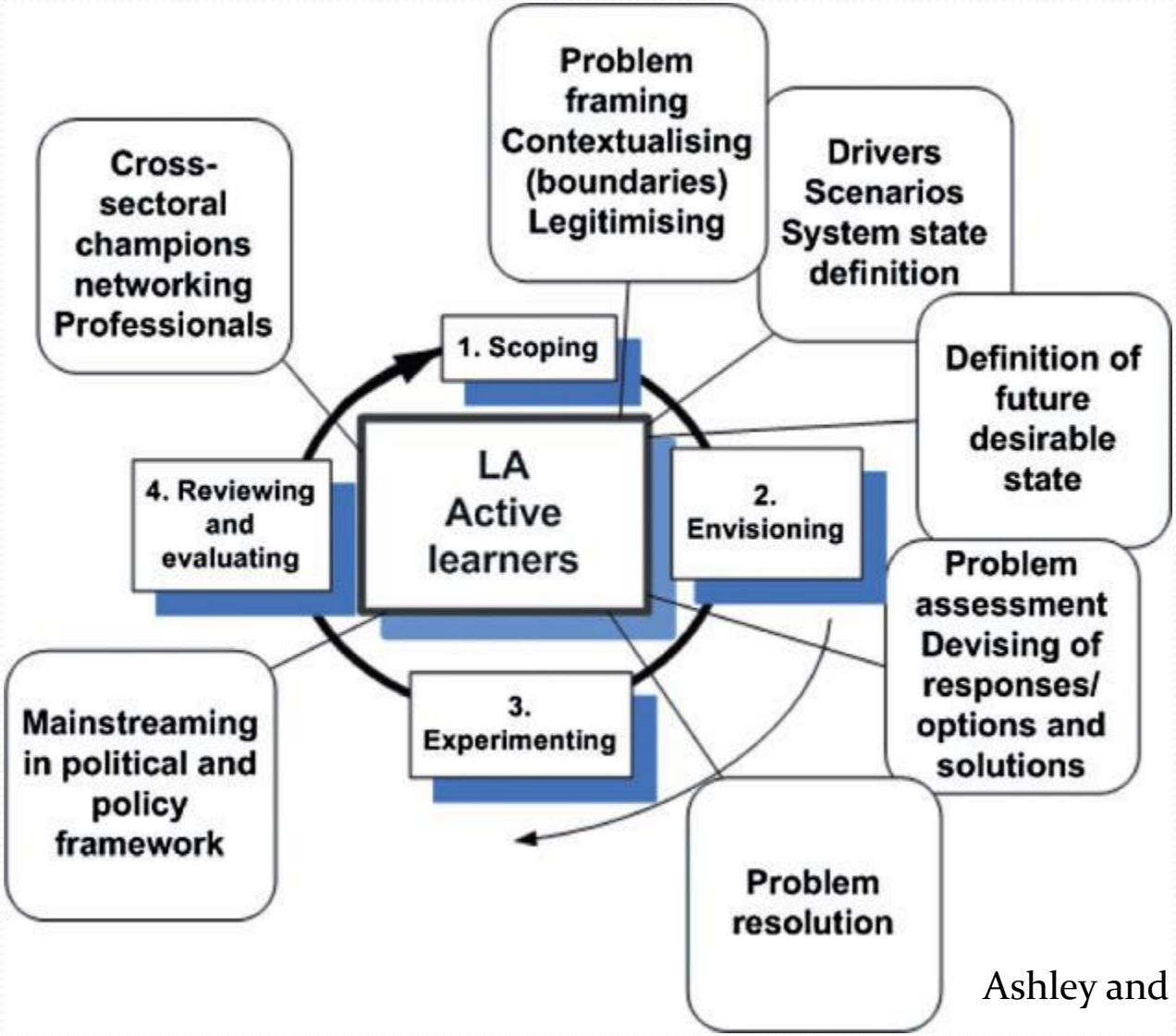
Town Moor

Newcastle City Centre surface water hotspots

Richardson Road

University buildings flooded during 2012 event, rebuild in 2014-15, onsite SuDS planned + wider Blue-Green infrastructure?

Learning and Action Alliances (LAA)



Ashley and Blanksby 2009