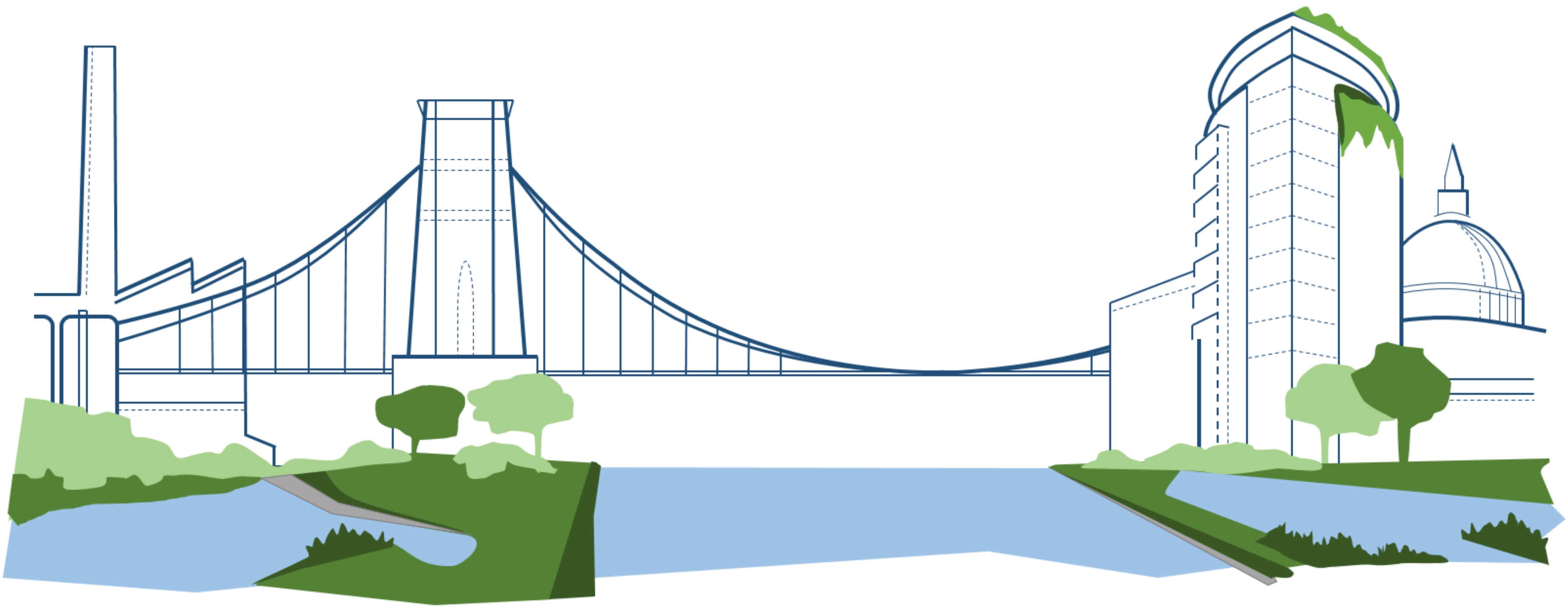
EPSRC Pioneering research and skills | Environment Agency | ATKINS | UKWIR | water industry forum | Ebbsfleet Development Corporation | Newcastle City Council

Achieving Urban Flood Resilience in an Uncertain Future



Aim

Make *urban flood resilience* achievable nationally, by making transformative change possible through adoption of the whole systems approach to urban flood and water management

Urban Flood Resilience

A city's capacity to maintain future flood risk at acceptable levels by:

1. preventing deaths and injuries,
2. minimising damage and disruption during floods,
3. recovering quickly afterwards,
4. ensuring social equity,
5. protecting the city's cultural identity and economic vitality

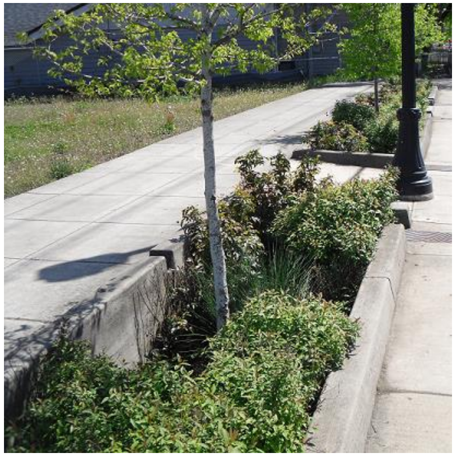
Urban Flood Resilience Research Themes

- **Engineering Design** of the integrated Blue/Green and Grey **(B/G+G)** treatment trains that support resilient management of both water quantity and quality

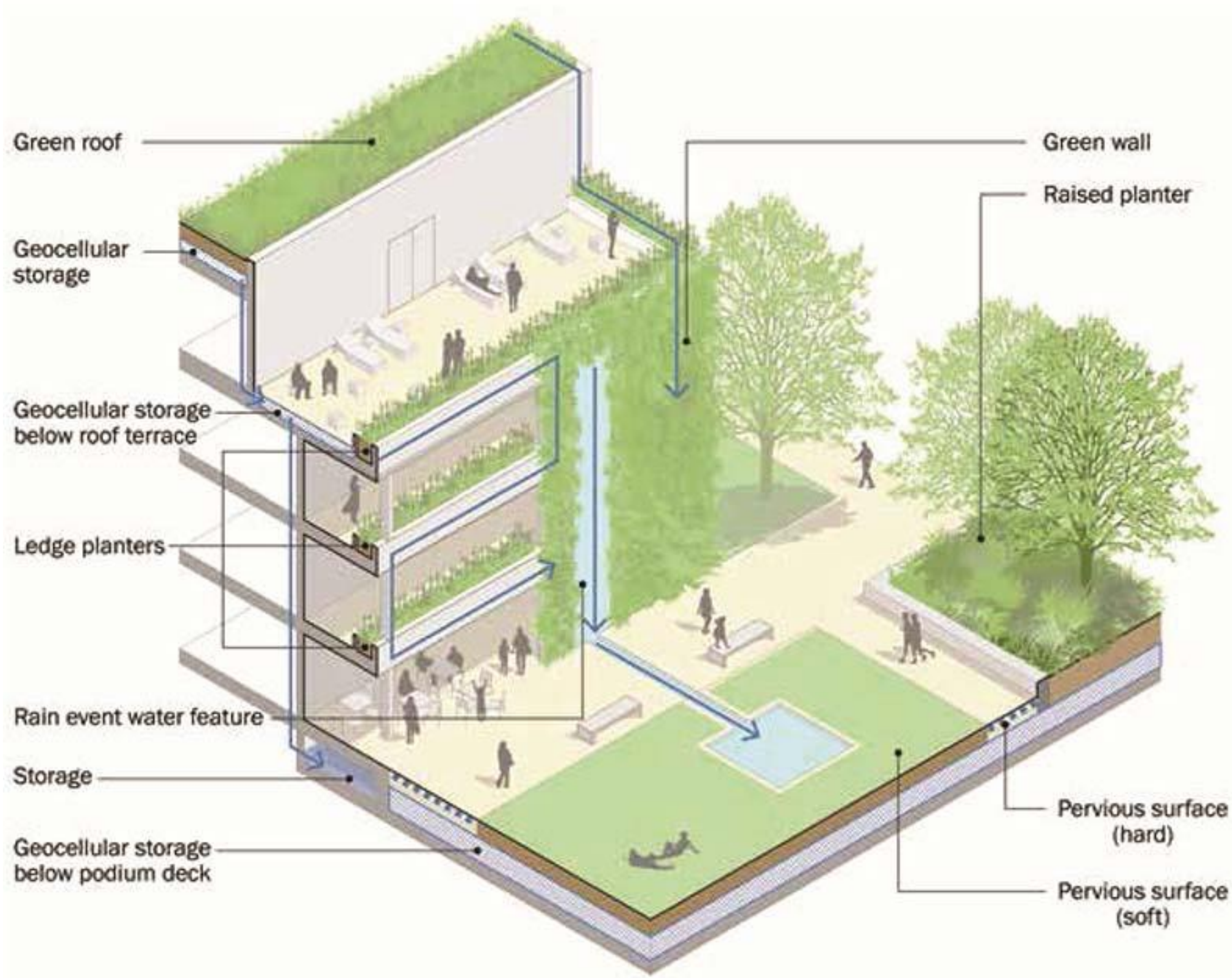
- **Planning** that puts UFRM at the heart of urban planning & focuses on interfaces between planners, developers, engineers and *beneficiary communities*

- **Development** of flood and water management assets that function inter-operably with other urban systems: transport, energy, land-use and natural systems

Blue-Green Infrastructure

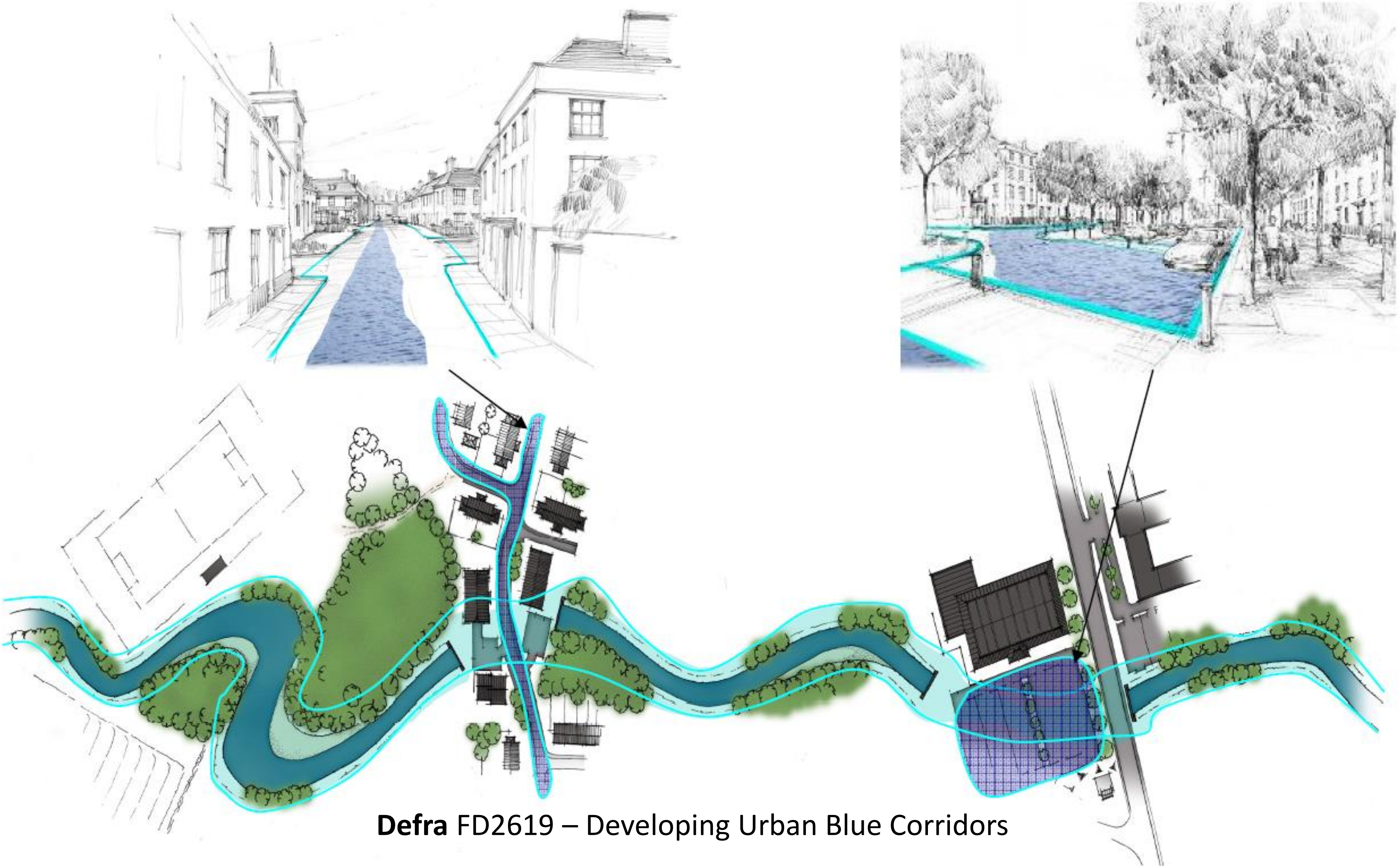


Sustainable Urban Drainage Systems (SuDS)



https://www.ice.org.uk/ICEDevelopmentWebPortal/media/Disciplines-Resources/Case%20Studies/figure-8-typology-suds.jpg

Multifunctional space, connections and corridors



Defra FD2619 – Developing Urban Blue Corridors

Ebbsfleet Vision for The Garden Grid

HorticultureWeek

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Sustainable drainage systems and parks shaping garden city

9 December 2016, by Sarah Cosgrove, Be the first to comment

The nature of the landscape where the Ebbsfleet garden city is taking shape is supporting the ambition for it to be threaded with green infrastructure and based on a network of sophisticated sustainable drainage systems (SuDS), with a park within five minutes' walk of every home.

Ebbsfleet: first new garden city in a century is still at the masterplanning stage with many details to be ironed out - image: Ebbsfleet Development Corporation

Ebbsfleet Development Corporation lead designer Simon Harrison added: "We're part of the Achieving Urban Flood Resilience in an Uncertain Future research project being led by the universities of Cambridge, Nottingham and Newcastle, and are currently investigating opportunities for maximising SuDs.

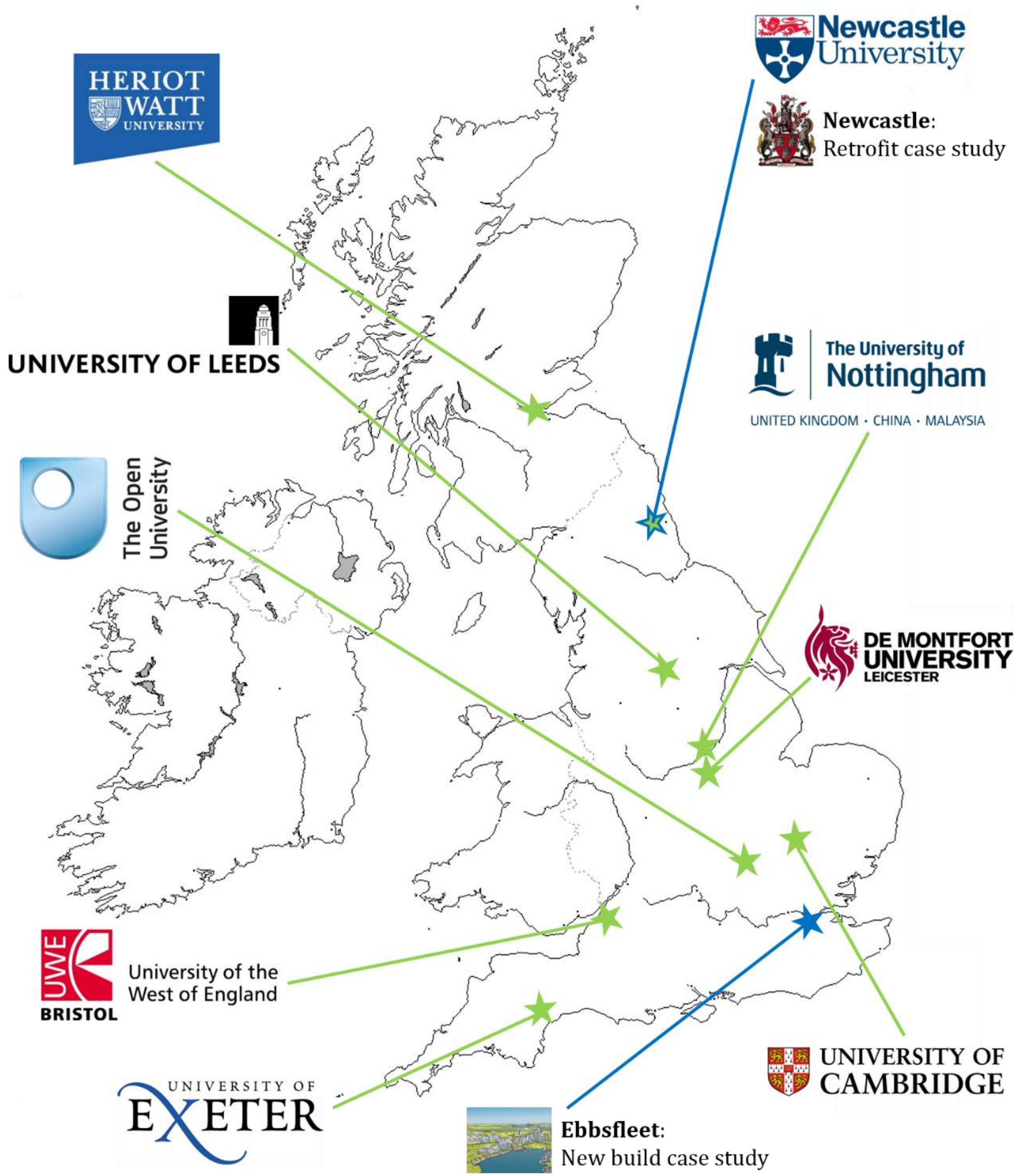
"We have a huge lack of capacity in the sewage network so it really does matter. It's really going to pay for itself and it's a really important aspect. The aspiration is to have SuDS everywhere." Green roofs and green walls are also goals, he added.

Among the ideas on the table is funnelling surface water down to the site's man-made lakes to recharge them, and diverting water from the sewerage system. "It's ambitious but this is what we should have in the future," said Smith. "This is one of the ideas that are possible."

He said the site has a particularly unusual landscape, with gorges cut to create the quarries and cement works and two large lakes created. When the Blue Lake quarry was dug workers hit a spring and it filled up with water. Elsewhere, the human landscaping ha been overlaid with years of natural growth. "It's important to try and keep some of the qualities of that landscape. Wouldn't it be fantastic if you could have a woodland, cliffs, gorges, lakes - there's even a tunnel."

http://www.hortweek.com/sustainable-drainage-systems-parks-shaping-garden-city/parks-and-gardens/article/1418002

UK Urban Flood Resilience Research Consortium



Consortium Objectives 1

1. Develop urban flood and water management system designs with the adaptive capacity essential to keep flood risk at acceptable levels however climate changes.

2. Produce a GIS-based tool to support comparative evaluation of the costs and benefits of alternative UFRM solutions and the potential for integrated B/G+G systems to deliver affordable urban flood resilience at the city, regional and national scales.

3. Design stormwater treatment trains capable of enhancing service provision, improving asset performance and delivering ecosystem services through integrated management of water quantity and quality that treats stormwater as both a hazard and an asset.

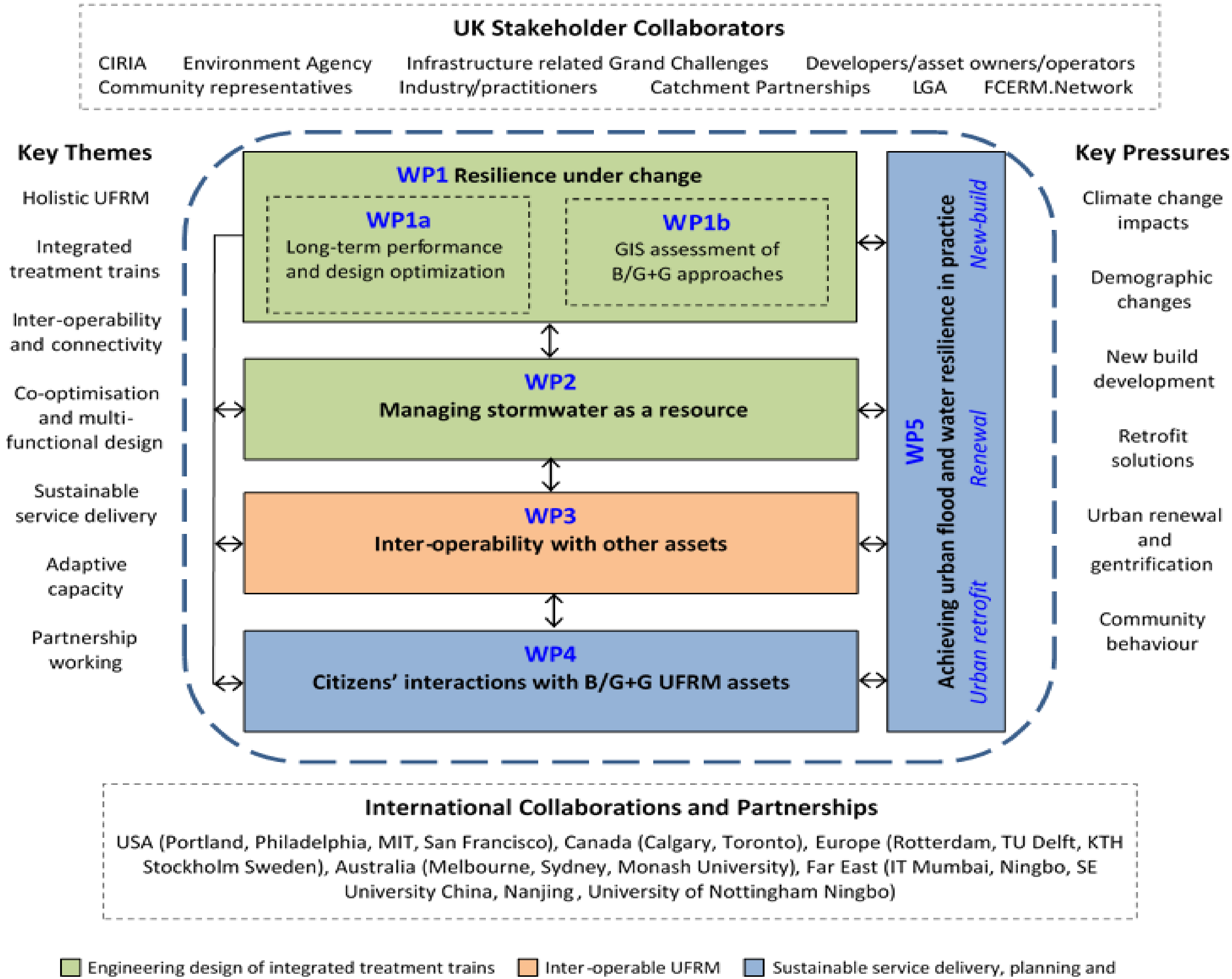
Consortium Objectives 2

4. Enhance inter-operability of UFRM assets with other systems (e.g. transport, energy, land-use) to expand the capacity of integrated systems of B/G+G infrastructure to contribute to wider urban resilience to climate change.

5. Make the objectives of multi-objective planning policies deliverable in practice by bringing together engineers, stakeholders and Local Authorities in partnership working.

6. Create connectivity in urban flood and water planning and management to support multiple functions while balancing trade-offs and facilitating positive interactions between:

   engineered assets; advances in water technology; natural processes; and the preferences and behaviours of the citizens and communities that benefit from B/G+G infrastructure.


UK Stakeholder Collaborators
CIRIA
Environment Agency
Infrastructure related Grand Challenges
Developers/asset owners/operators
Community representatives
Industry/practitioners
Catchment Partnerships
LGA
FCERM.Network
Key Themes
Holistic UFRM
Integrated treatment trains
Inter-operability and connectivity
Co-optimisation and multi-functional design
Sustainable service delivery
Adaptive capacity
Partnership working
WP1 Resilience under change
WP1a
Long-term performance and design optimization
WP1b
GIS assessment of B/G+G approaches
WP2
Managing stormwater as a resource
WP3
Inter-operability with other assets
WP4
Citizens' interactions with B/G+G UFRM assets
WP5
Achieving urban flood and water resilience in practice
New-build
Renewal
Urban retrofit
Key Pressures
Climate change impacts
Demographic changes
New build development
Retrofit solutions
Urban renewal and gentrification
Community behaviour
International Collaborations and Partnerships
USA (Portland, Philadelphia, MIT, San Francisco), Canada (Calgary, Toronto), Europe (Rotterdam, TU Delft, KTH Stockholm Sweden), Australia (Melbourne, Sydney, Monash University), Far East (IT Mumbai, Ningbo, SE University China, Nanjing , University of Nottingham Ningbo)
Engineering design of integrated treatment trains
Inter-operable UFRM
Sustainable service delivery, planning and

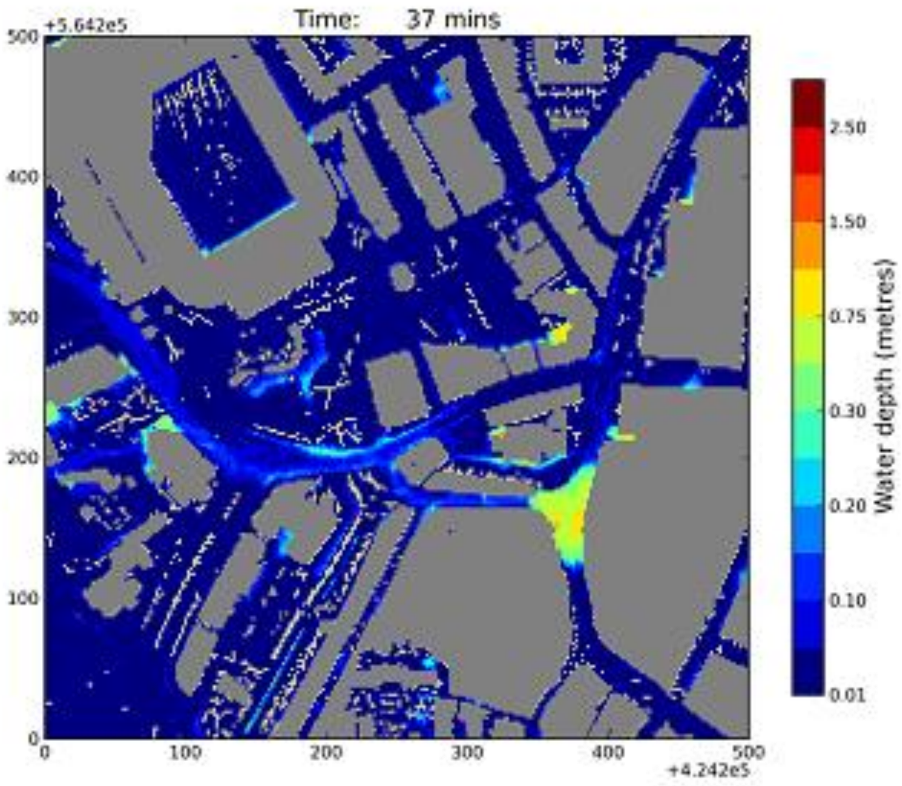
WP1a. Long-term performance and design optimization

WP1a will investigate co-optimisation of B/G+G and SuDS system performance under Flood Foresight-style future scenarios for climate and socio-economic change

- Replace design of coupled piped and surface systems (single ‘design flood’) with a whole systems approach based on coordinated management of the ‘stormwater cascade’

- Quantify performance of B/G+G systems using proven methods to trace flows, debris, sediments and pollutants

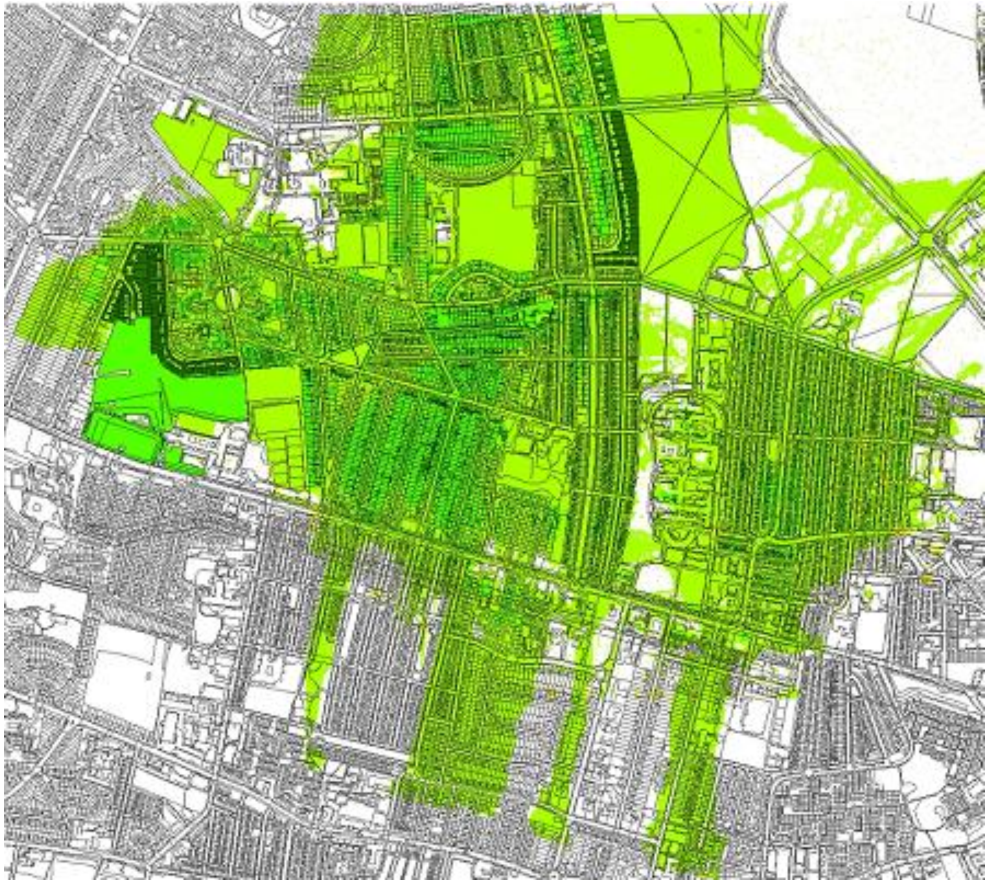
- Optimise design solutions for future flood resilience using a Real Options approach to develop adaptation decision pathways



WP1b. GIS assessment of B/G+G approaches

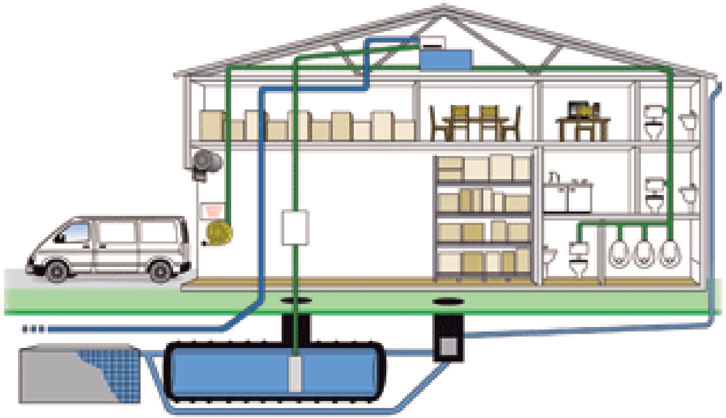
WP1b will build a GIS-toolbox to support comparative evaluation of the costs and benefits of alternative UFRM solutions

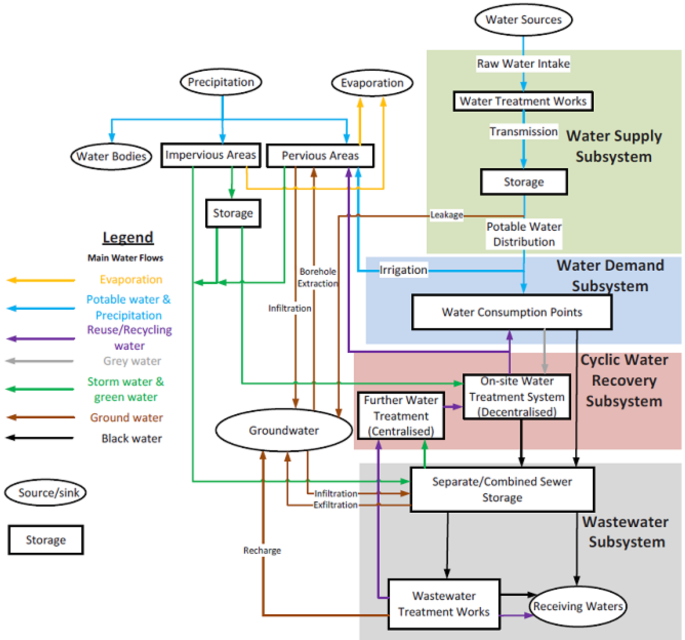
The GIS-toolbox will integrate *CityCAT* outputs with wider benefits and conflate these with regional climate change and rainfall-runoff layers, FRM treatment train performance indicators, and damage/disruption reductions gained through improving inter-operability between water and other urban systems



WP2. Managing stormwater as a resource

- Extend research on probabilistic rainwater harvesting tank sizing under climate change
- Use the Urban Water Metabolism model (WaterMet2) to calculate the B/G+G & SuDS stormwater development balance and assess its long-term resource potential
- Simulate surface, piped and soil water systems at fine spatial and temporal resolutions to assess surface hydrology and flood risk
- Assess how stormwater retention supports development of diverse vegetation within B-G spaces
- Investigate the cumulative effects of B/G+G and SuDS treatment trains on downstream channel forms and processes (SHETRAN)





WP3. Inter-operability with other assets

WP3 will investigate the potential for employing inter-operable B-G/G infrastructure design solutions to increase flood resilience across urban infrastructure systems

- Identify and evaluate the propagation of flood impacts across a combination of infrastructure sectors (e.g. water, transport, land-use and energy)
- Identify specific interdependencies and develop flood impact profiles for the case study cities
- Use the 'Systems of Provision' approach to evaluate system-wide resilience of multiple, inter-operable B/G+G infrastructure design solutions
- Develop methodology needed to integrate and evaluate water and UFRM decision-making as part of wider decision-making on infrastructure

WP4. Citizen’s interactions with B/G+G infrastructure

WP4 will investigate transformative change needed for urban flood resilience

- Co-develop new mechanisms for engaging communities, improving flood awareness and communicating B/G+G benefits
- Demonstrate how citizens’ priorities and lifestyles, affect their understanding of/support for B/G+G
- Participatory Action Research will be applied to support deep exchange of knowledge/beliefs
- On-line communications will be used to study changing attitudes, perceptions and opinions, and potentially shift citizens’ and professionals’ attitudes and behaviours with respect to B/G+G

WP5. Achieving urban flood and water resilience in practice

WP5 will inform and apply research in WPs 1-4 to establish how resilient UFRM service delivery can be put at the heart of urban planning and how barriers to innovation can be overcome despite future uncertainties

- **Learning and Action Alliances** in case study cities
- Investigation of the barriers to B/G+G innovation, including interviews and participatory observation of meetings of planning authorities
- Aligning research in WPs1-4 with the needs of practitioners and local Government

Case Study Cities

Newcastle

Retrofit and urban renewal

Ebbsfleet

New build in a 'garden city'

Deliverables: Engineering design to enhance service delivery

- **Next generation flood and water management models** that bridge the interfaces between urban/rural and engineered/natural hydrological systems: simulating urban floods, droughts and water cycles within their catchment and metropolitan contexts to deliver acceptable service provision 365 days a year (WP1a)

- **Recommendations on design, implementation and operation of B/G+G stormwater treatment trains** through development of adaptation designs and pathways appropriate to their location, community and scale (WP1a)

- **GIS toolbox for a National Assessment** identifying appropriate location specific B/G+G combinations, considering catchment and urban water resources and their variability, flood risk, sewer condition and capacity, and stormwater resource potential under present and future climates (WP1b)

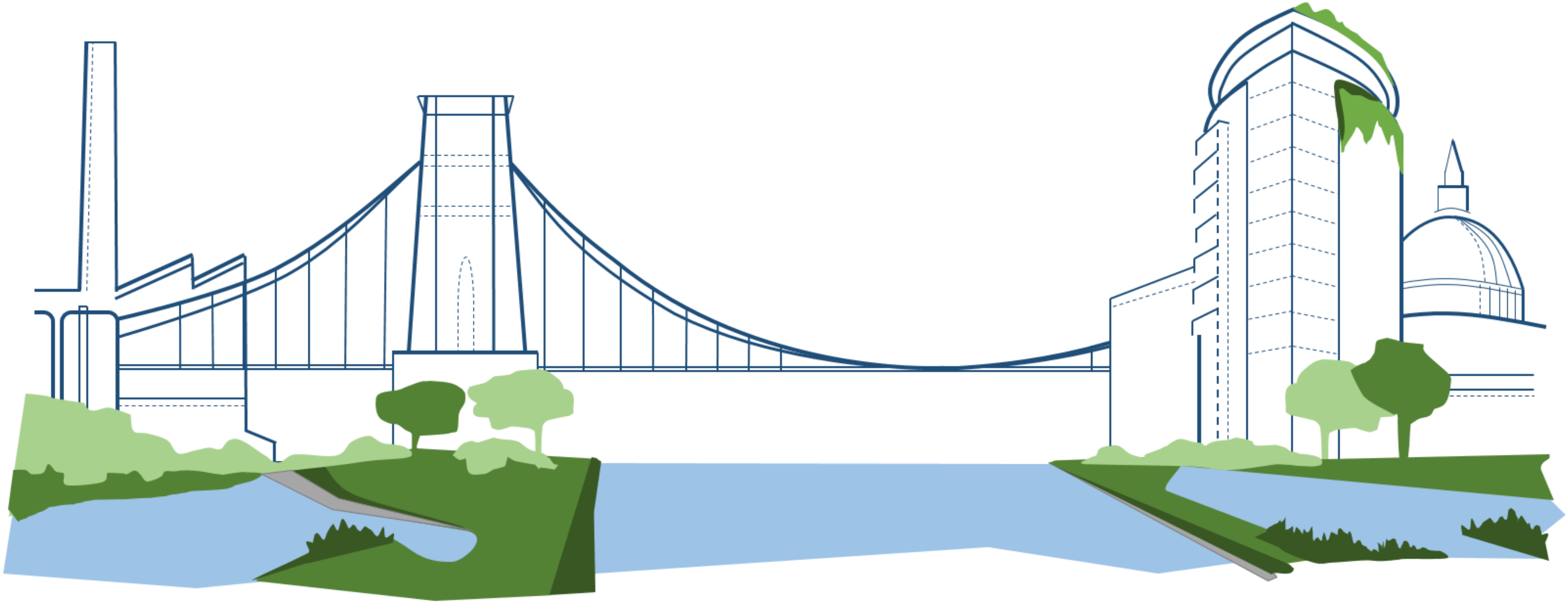
Deliverables: Engineering Development for resource use across drought – flood spectrum

- **Enhanced design methods** that co-optimise management of urban runoff both to mitigate flood hazards and capture the benefits of treating stormwater as a valuable, though under-utilised, resource leading to practical solutions for stormwater recovery, recycling and reuse (WP2)
- **Improved integration of UFRM and water, energy and transport infrastructure** and expanded inter-operability of urban systems-of-systems (WP3)

Deliverables: UFRM at the heart of urban planning, at multiple scales

- **Characterisation of citizen's behaviours and decision making** concerning flooding and urban water use, and means of informing those decisions through improved appreciation of flood risk and water literacy (WP4)
- **New protocols for placing flood and water management decision making at the heart of urban planning** as recommended by Pitt (2008) and legislated for in the 2010 Flood and Water Management Act (WP5)
- **Case studies** demonstrating Blue-Green approaches to flood and water management that are innovative, inclusive, resilient and suitable for retrofit, urban renewal, new build/new town applications (WP5)

Any questions?



Additional information

Research Questions

1. How can we adapt flood and water quality treatment infrastructure to meet the challenges posed by changes in climate, governance, economic development and environmental values that are unavoidable, but uncertain?

2. How can flood models, infrastructure data and community exposure/vulnerability information be combined to support local, regional and national assessment of the potential for integrated B/G+G infrastructure to meet these challenges?

3. How can engineered flood and water systems be aligned with natural processes to:

(a) realise the resource potential of all forms of urban water

(b) become inter-operable with other urban systems?

Research Questions

4. How can engineering, scientific and local knowledges be co-produced and applied to design adaptive flood and water infrastructure that provides safe, healthy and attractive Blue-Green urban spaces that are intensively used and highly valued by citizens and communities?

5. How must interactions between responsible Authorities and Stakeholders (e.g. planners, developers, engineers and scientists) evolve to enable cities to achieve flood resilience and water security that is sustainable, reliable and enduring (i.e. future proof)?

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Project Scope, Methods and Models

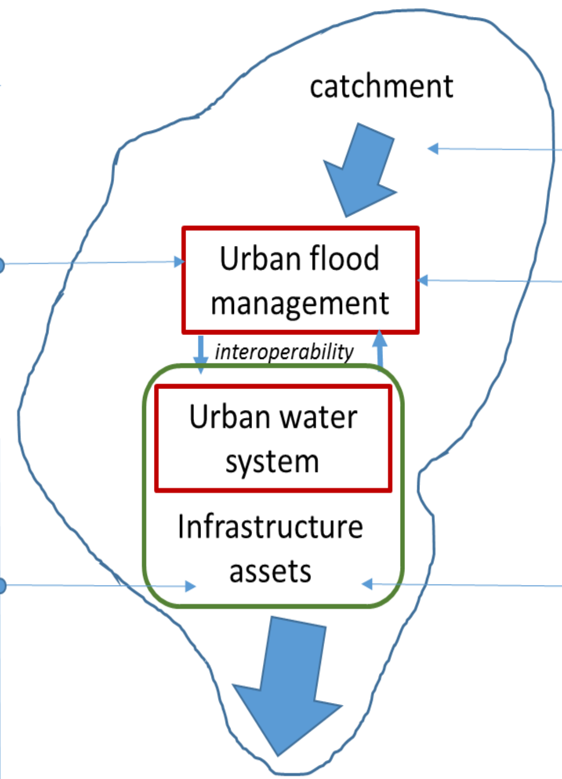
Stakeholder actions and system evaluations:

Participatory Action Research and **Social Practice Theory** to examine relationships between researchers, UFRM practitioners and communities, based on **Local Action Alliances** in locations such as Newcastle and Ebbsfleet. *This will explore tacit knowledge, behaviours and citizen's attitudes with respect to diverse flood mitigation measures and link the desirability of specific asset interventions with wider urban planning.*

Real Options analysis will find the most synergistic mix of B-G and G assets, with new objective functions for option isolation based around maximising multiple benefits and service delivery. *This will apply methods for evaluating the benefits of SUDS-GI developed in the Blue Green Cities project. Optimisation will include Totex (including maintenance liabilities) and monetised benefits (generated using CIRIA's BeST tool).*

System interdependencies will examine interactions with other components of urban fabric including open spaces, highways and buildings. *This will evaluate systemic resilience and the uncertainties arising from climate and socio economic futures to be accounted for in infrastructure planning and decision making.*

GIS visualisation of the flood mitigation performance of potential of Blue-Green & Grey assets and their multifunctional benefits. *This will consolidate the model outputs for use locally to guide development and be up-scaled regionally/nationally to inform policy, and form the basis for a National Assessment of flood resilience.*



Stormwater Hazard + Resource potentials

Urban flood risk
Non-potable use
Irrigation of Blue Green infrastructure
Groundwater and soil moisture recharge
Micro-hydropower
Maintaining urban green spaces and ecosystem services

Physical Models:

SHETRAN handles water, flow multi-fraction sediment transport and multiple, reactive solute transport within a river basin model. *This will couple catchment hydrology and sediment/contaminant inputs to urban systems (simulated using CityCAT and WaterMet2).*

CityCAT models urban flooding to assess pluvial and fluvial flood risk and flood alleviation measures with simulations driven by rainfall, flow and/or water depth time series. Maps of water depths and velocities at different times are combined to animate the flood propagation. *This central tool will simulate how stormwater cascades through urban systems, show where capture and re-use is possible and where its resource potential is constrained.*

WaterMet2 is an urban water system performance model providing flows/fluxes in 4 subsystems: water supply, sub-catchment, wastewater and water resource recovery. *This will be coupled with CityCAT to explore the interconnections between all forms of urban water.*

Eco-hydrological modelling links plant physiology within SuDS to water availability, using a water balance model linking the total water in the rooting zone with rates of rainfall, interception, runoff, evapotranspiration and leakage (in mm/d). *This will apply time series data from CityCAT and WaterMet2 to determine the resilience of vegetation in Blue-Green infrastructure and SuDS systems.*