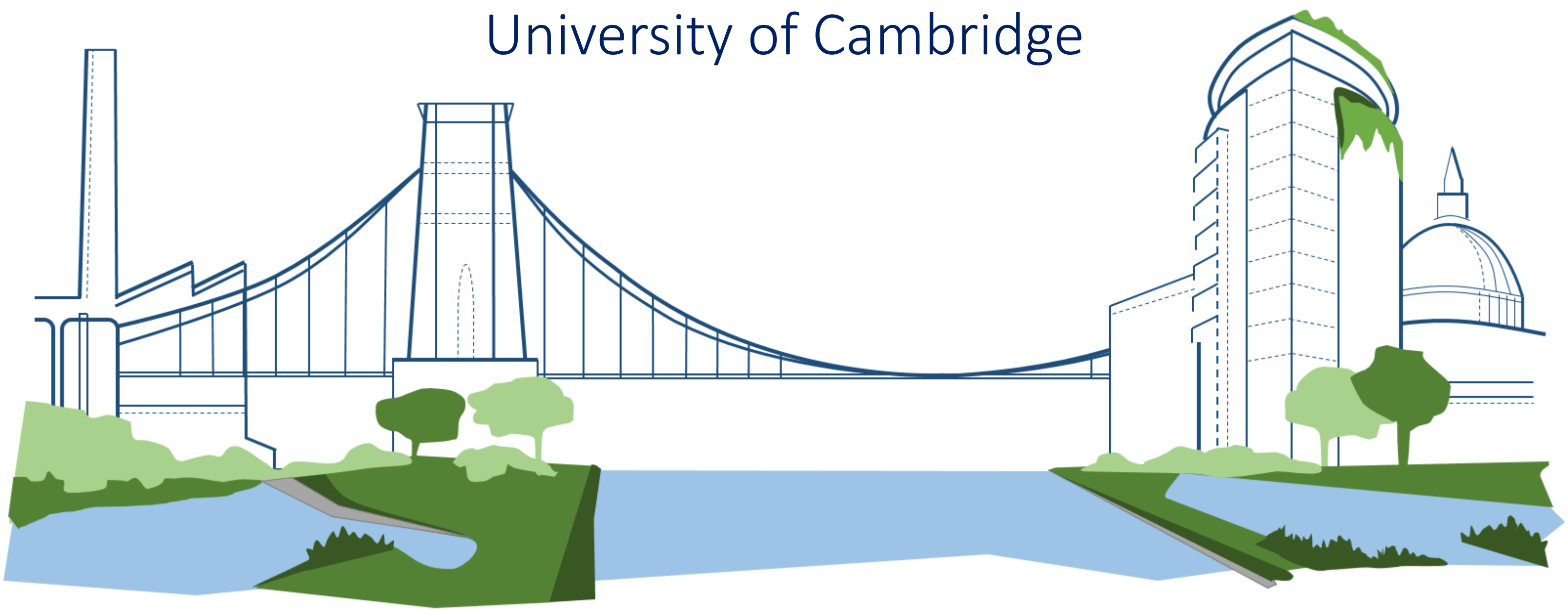
An adaptation pathways approach to deliver multiple benefits of Blue-Green Infrastructure: insights from London Borough of Sutton

Leon Kapetas & Dick Fenner
University of Cambridge



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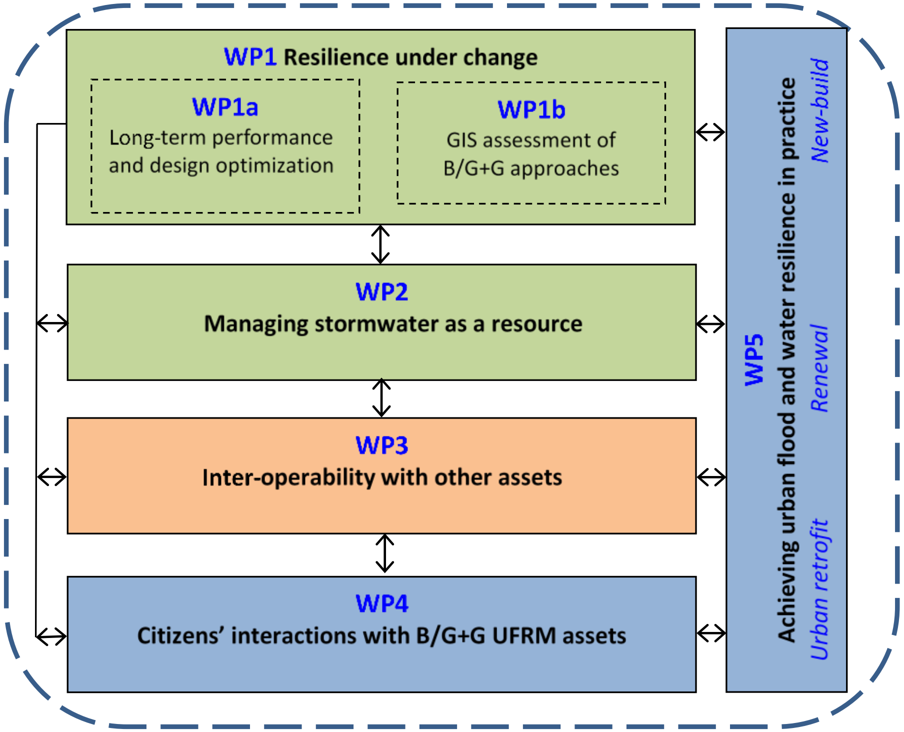
Research streams



1. Adaptation Pathways for long-term drainage infrastructure planning

2. Energy Recovery from urban stormwater

3. Using stormwater in managed aquifer recharge for drought mitigation

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Talk Outline

- Research Questions
- Multiple Benefits (MB)
- MB evaluation and co-design
- Sutton flooding
- Adaptation Pathways for a long-term drainage infrastructure plan
    - Options
    - Modelling
    - Options and pathways appraisal
- Key Deliverables

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Research Questions:

What is the right mix of blue-green and grey infrastructure at any location and time?

When are blue-green interventions necessary under future development and climate scenarios?

How can flexible design approaches be valued incorporating multiple benefit assessments (and real options)?

#blue/green infrastructure #multiple benefits #flexibility

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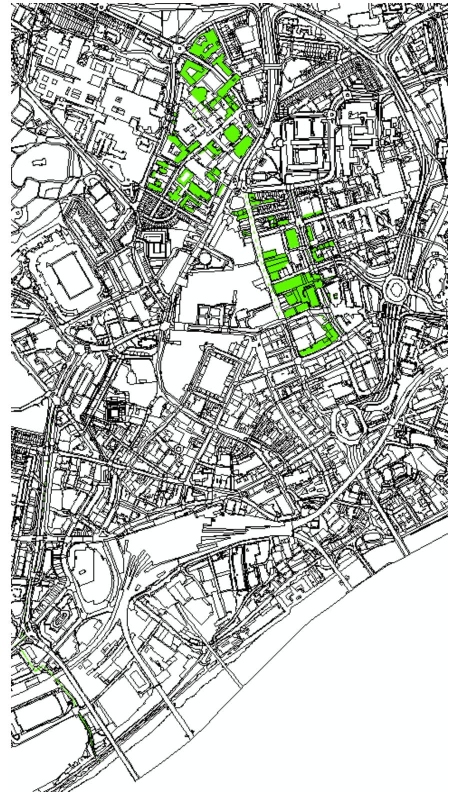
Examples of multiple benefits from SuDS / GI

Potential Benefits from SuDS and Blue Green Infrastructure	Mechanisms
Pollutant trapping	e.g. Adsorption of PM_{10} onto leaf surfaces
Biodiversity	e.g. through habitat creation
Amenity and recreation	e.g. through greater access to green space
Enhanced urban form	e.g. through landscape connectivity into green corridors
Groundwater recharge	e.g. maintenance of natural hydrology
Air temperature	e.g. through mitigating urban heat island effects
Health	e.g. by providing areas for exercise, improving air quality etc
Noise reduction	e.g. where adjacent to major roads
Traffic calming	e.g. by using street gardens as width restrictors
Carbon mitigation	e.g. by sequestering CO_2
Property value uplift	e.g. by proximity to green space

Spatial distribution of benefits: normalised uplift

Access to Greenspace

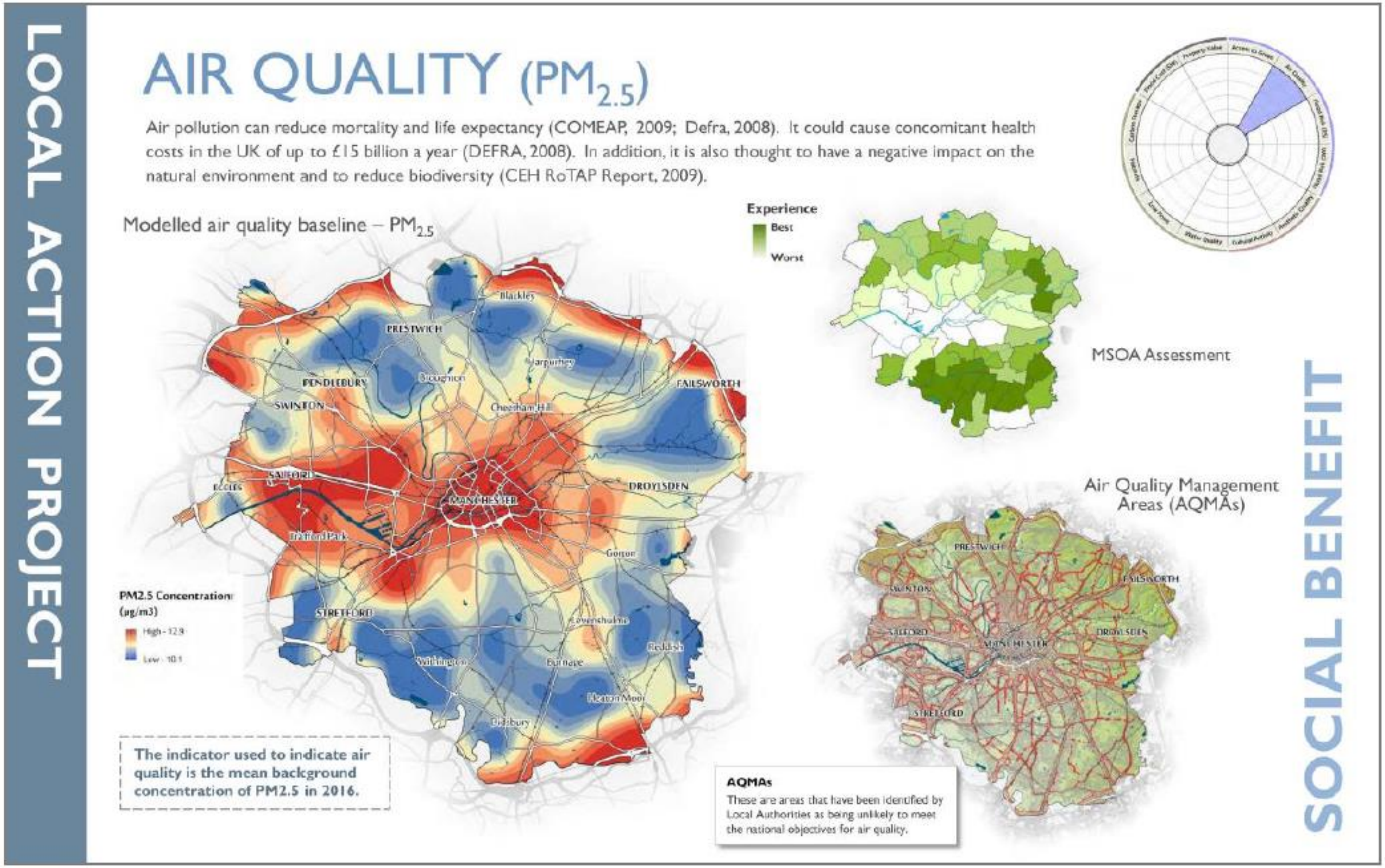
Noise Pollution



Carbon Sequestration

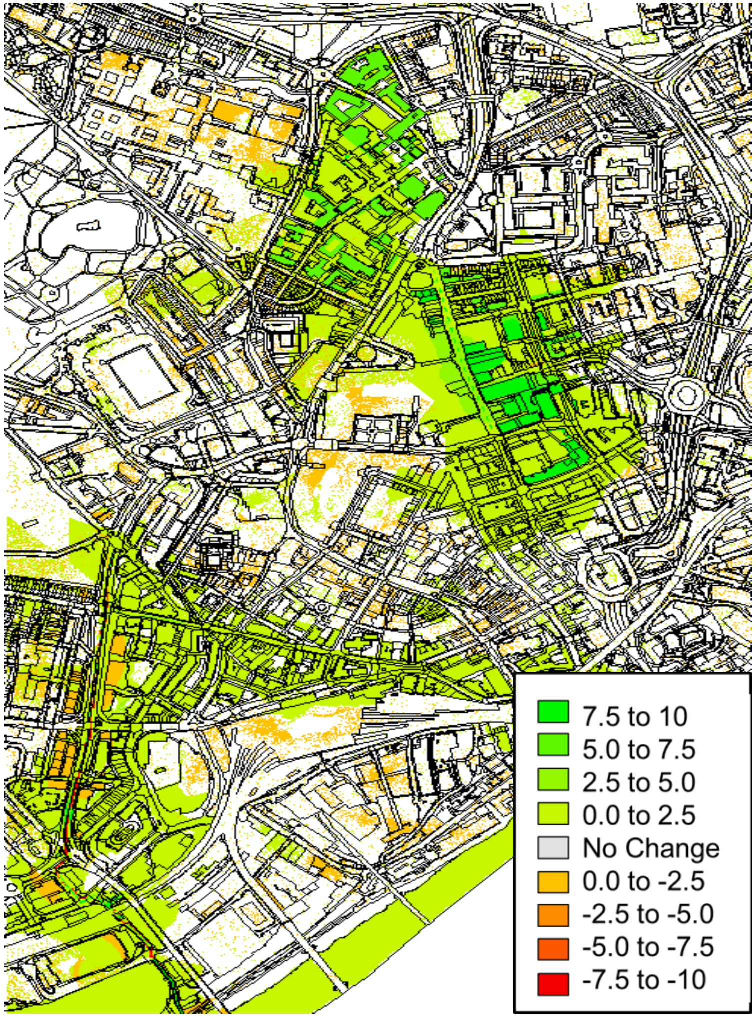
Flood Damage

Background conditions



Defra, 2016, Local Action Project

Cumulative benefit intensity:



Key principles:

1. Benefits are location- and context-specific
2. Simultaneous optimisation of all benefits is not possible
3. The value of each benefit will be dependant on background environmental conditions
4. Benefits develop over time and need to be assessed as an improvement from an initial condition state
5. The spatial distribution of benefits is important and accrue to different stakeholder groups other than the asset owner, and scales from local to regional to global

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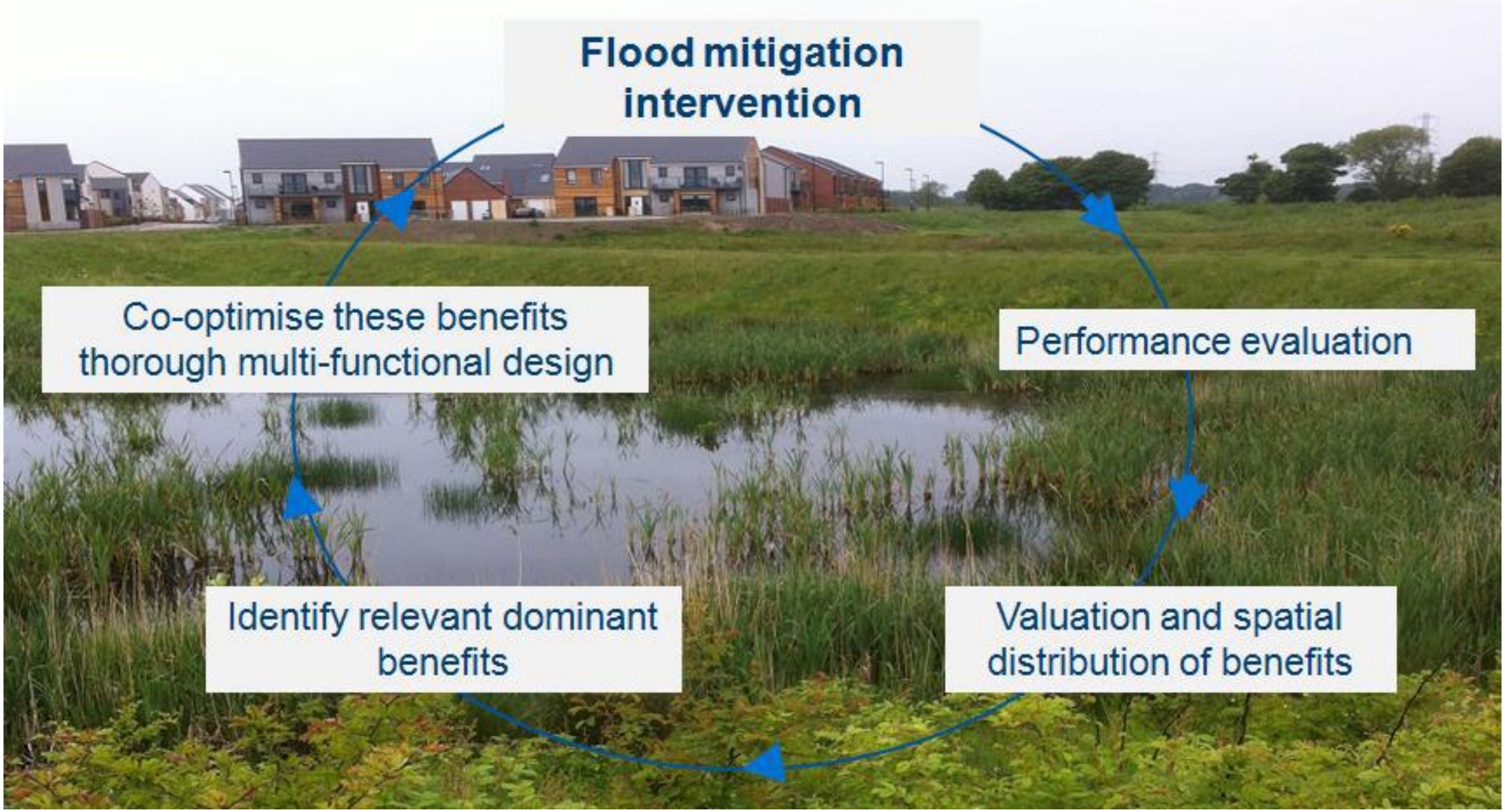
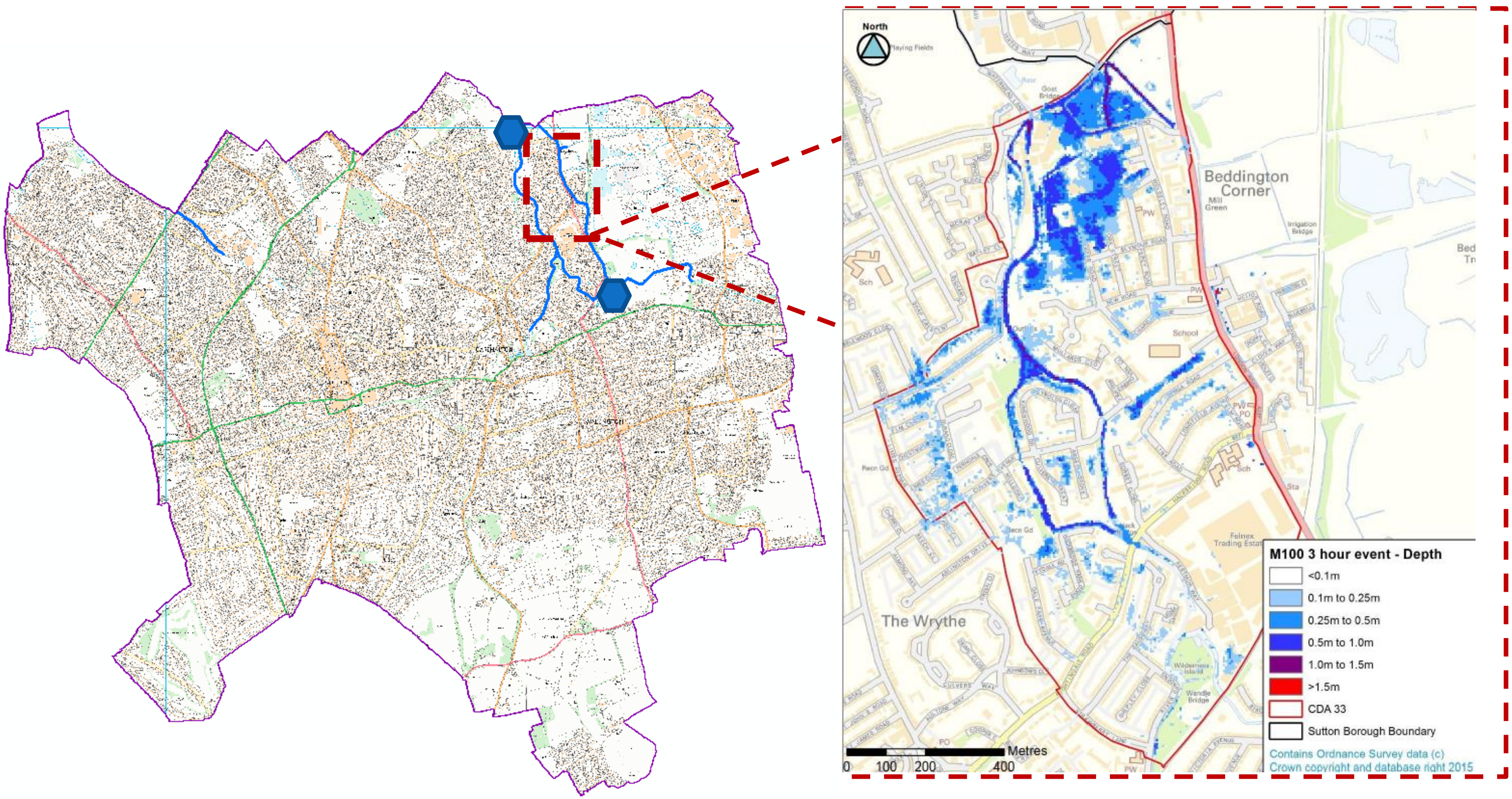
Co-design of SuDS to achieve multi-functionality



What is the right mix of blue-green and grey infrastructure ***IN SUTTON*** *and* ***FOR THE NEXT 40 YEARS****?*



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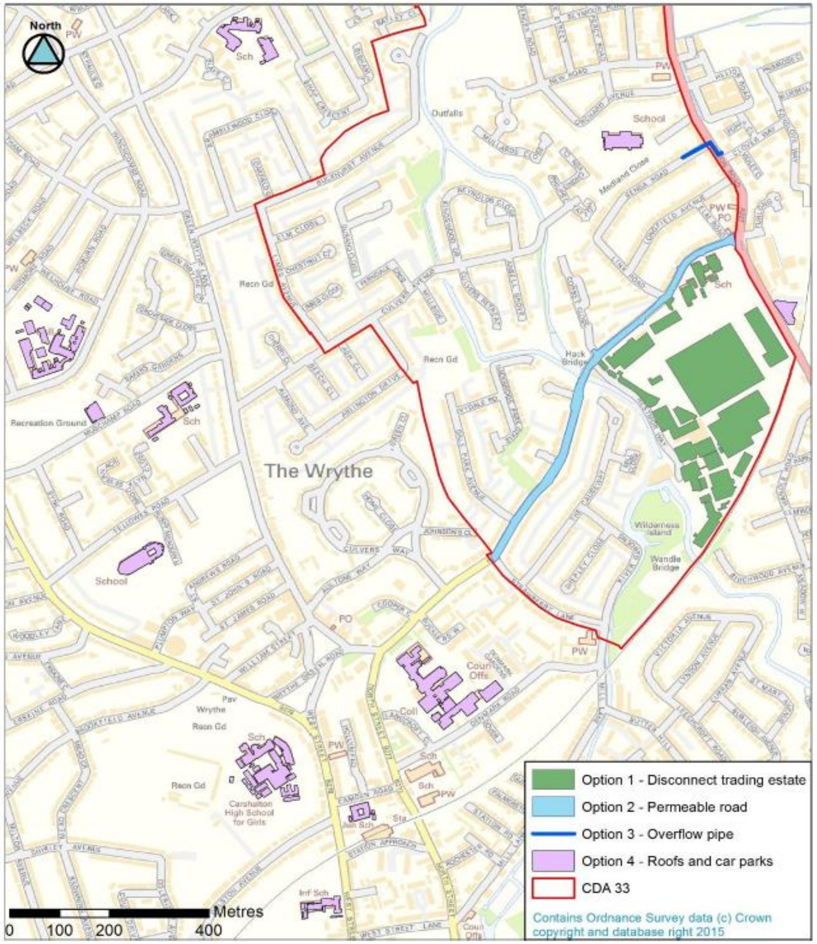
What is the right mix of blue-green and grey infrastructure ***IN SUTTON*** *and* ***FOR THE NEXT 40 YEARS****?*

SuDS in Sutton Schools Project:

- Reduce flooding from 135 to 20 properties for a 1 in 30 years event
- Sutton Council, South East Rivers Trust, METIS ; Thames Water
- SuDS interventions in 07 schools + City Council Estate

Considering climate change and urban intensification

- Pilot as evidence
- Static response to a dynamic problem
- Which intervention comes next?



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SuDS in Sutton Schools: work in progress

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What is the right mix of blue-green and grey infrastructure ***IN SUTTON*** *and* ***FOR THE NEXT 40 YEARS****?*

i. What is the desired performance threshold?

ii. What are the intervention options and how does one combine with the other?

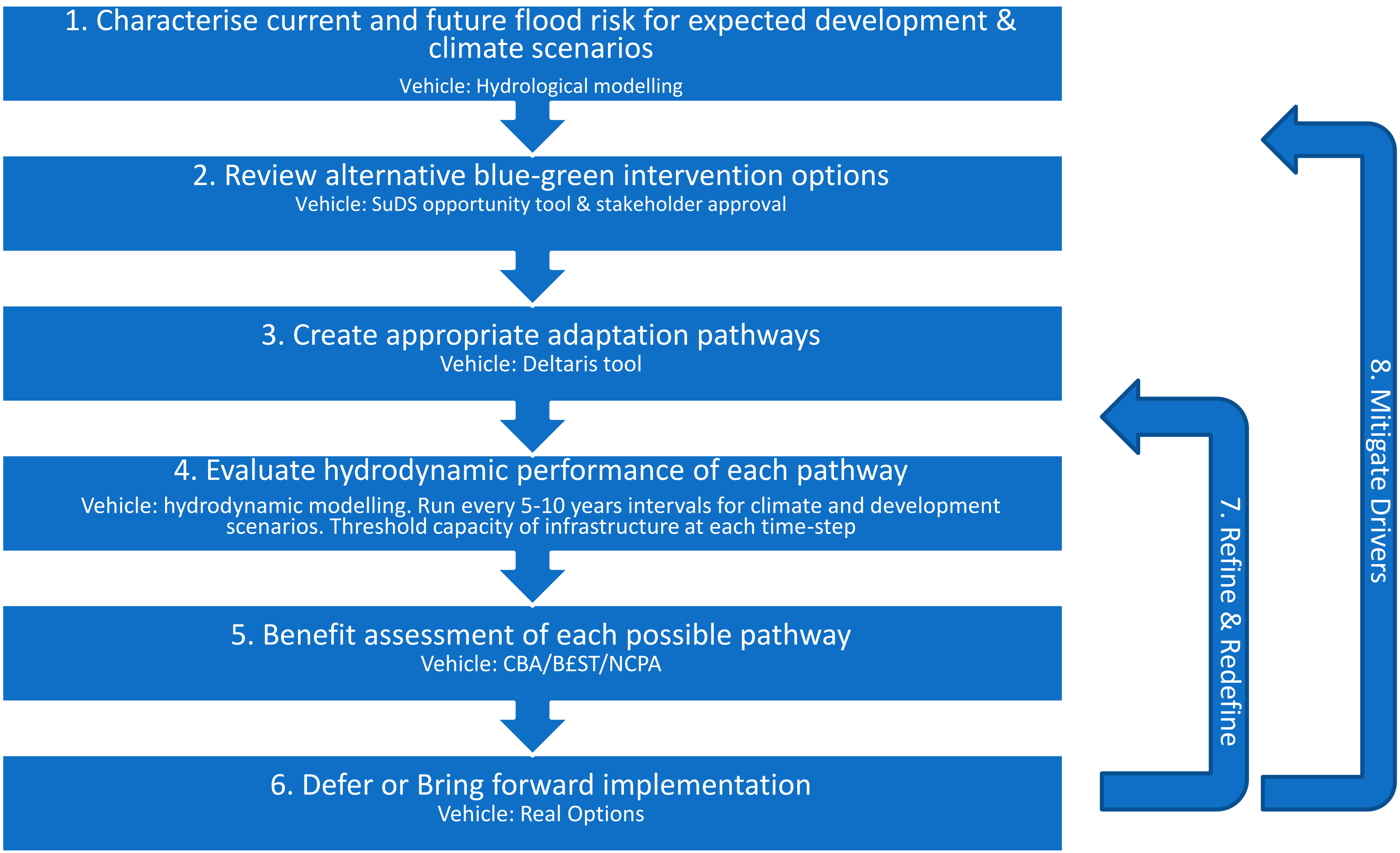
iii. Which intervention should be prioritised?

iv. What is the assessment approach?

v. When should they be implemented?

vi. How do we respond to climate change and urbanisation?

Procedure for the development and assessment of Adaptation Pathways



1a. Understanding Drivers for intervention in Sutton

- Climate Change (expected flood risk increase)
- Population growth: 10,000 households in 30 years.
- AQMA zones with Sutton
- SuDS on streets policy (TFL)
- Water stressed area
- Natural Capital uplift policy – planner's priority

1b. Flood modelling: SWMM model

Model data:

- Subcatchment areas
- Manhole data
- Pipe data
- Permeable area %
- Slope%

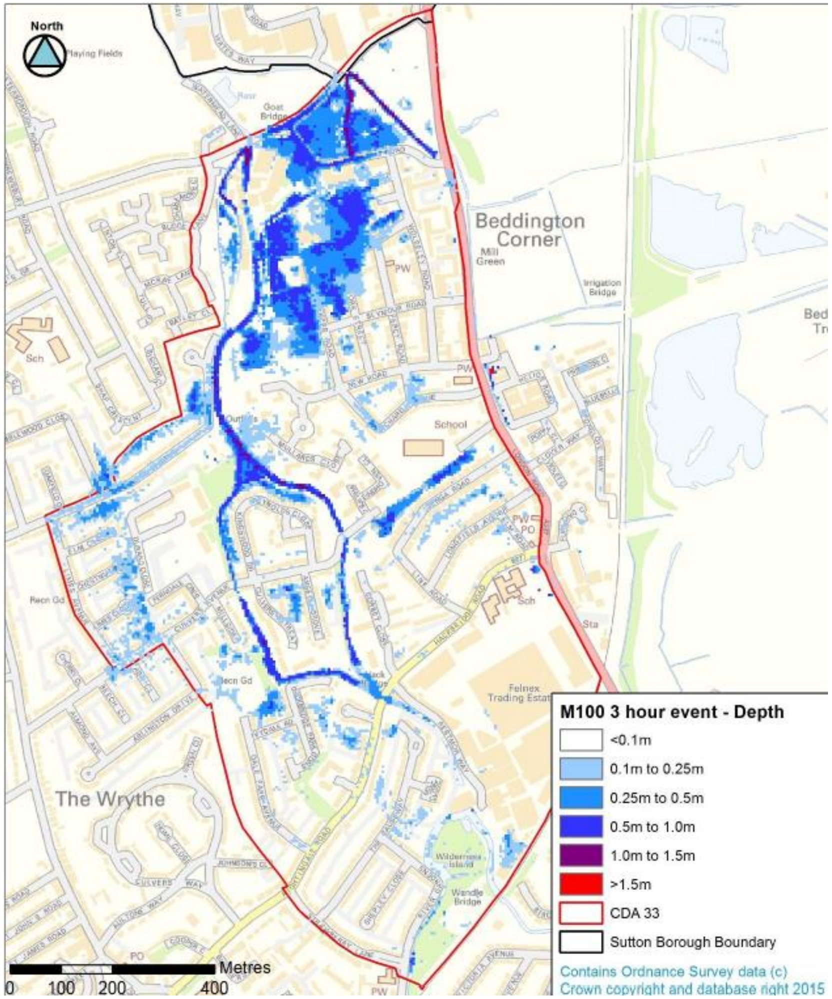
→ Establish **current** flood risk conditions

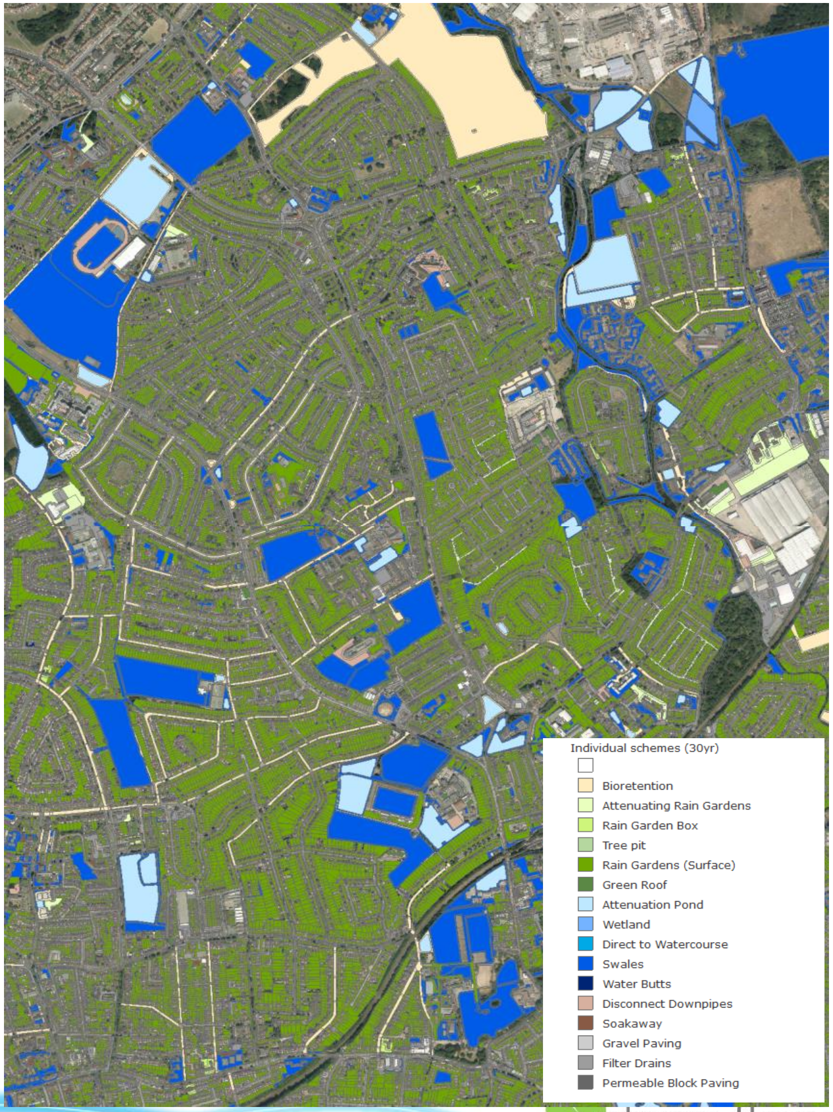
Climate and Intensification scenarios:

- Storm profile increase
- Impermeable area increase

→ Establish **future** flood risk conditions

2. Identifying BG/G intervention options: SuDS opportunity tool





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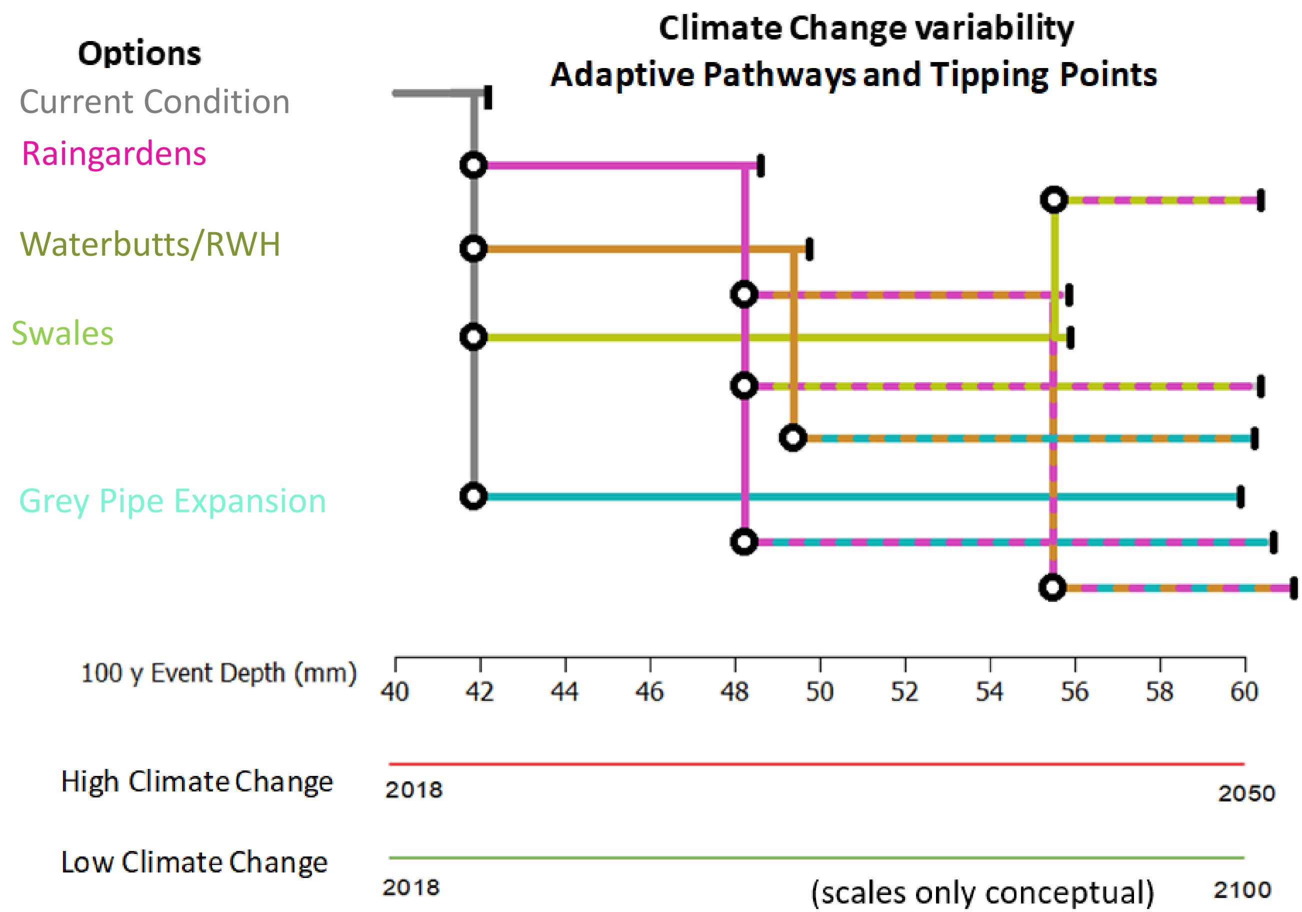
3. Generating the Pathways

Long-term drainage infrastructure planning:

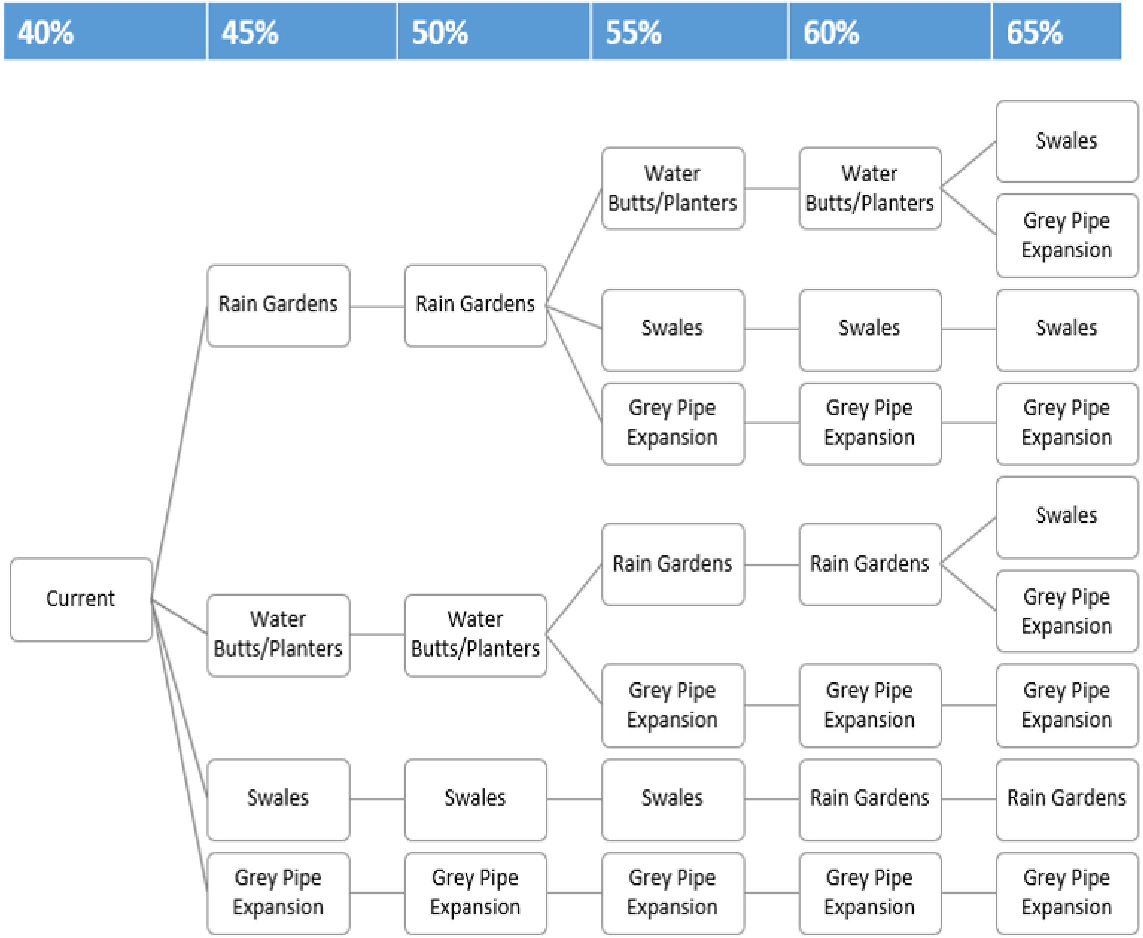
1. Identify Option impact
2. Combine Options in Pathways
3. Appraise Pathways

<u>Implications of Scenarios on NPV?</u>



Pathways generator (Deltaris/Carthago)

Adaptation Pathways approach:
Quantitative CBA and qualitative multi-criteria appraisal



Adaptation pathways tree as a response to urbanisation

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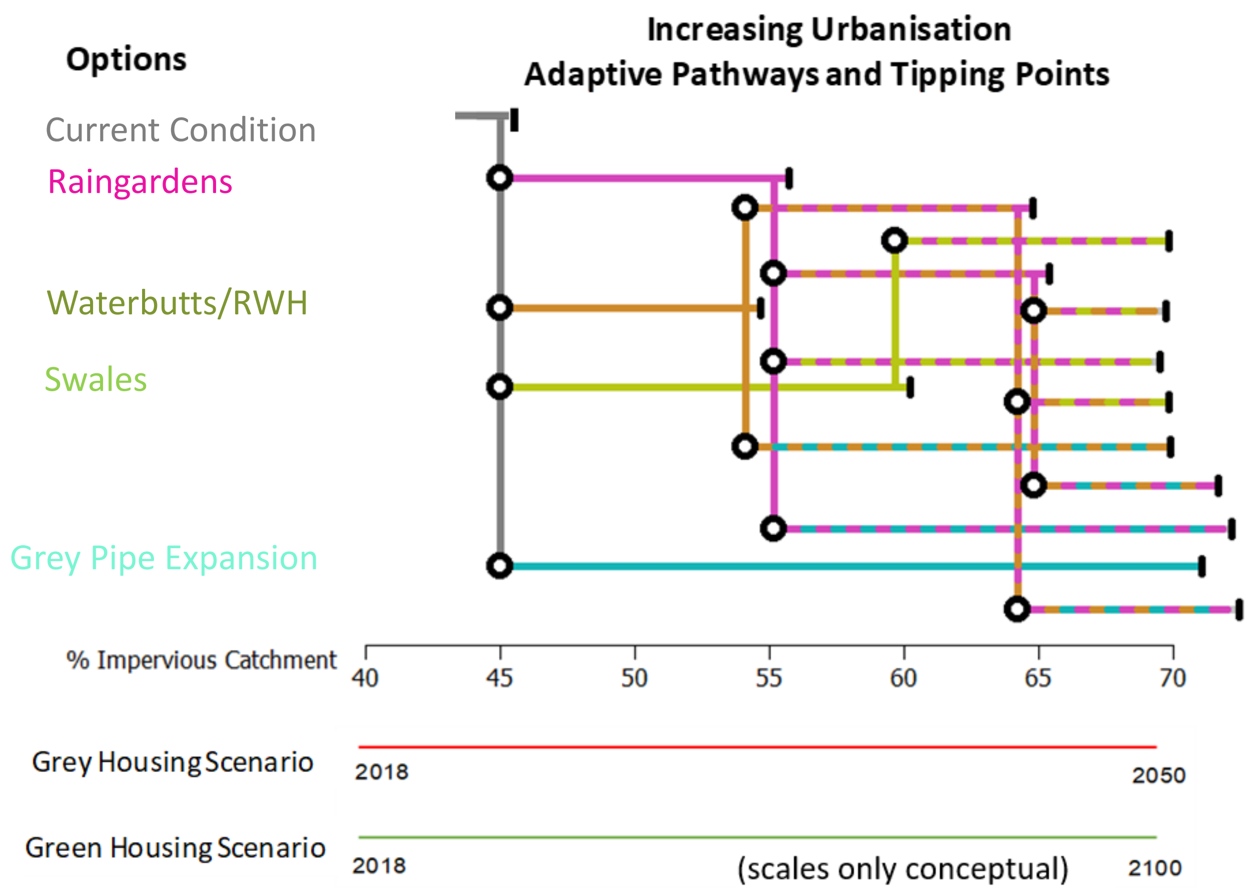
3. Generating the Pathways

Long-term drainage infrastructure planning:

1. *Identify Option's impact*
2. *Combine Options in Pathways*
3. *Appraise Pathways*



Pathways generator (Deltaris/Carthago)

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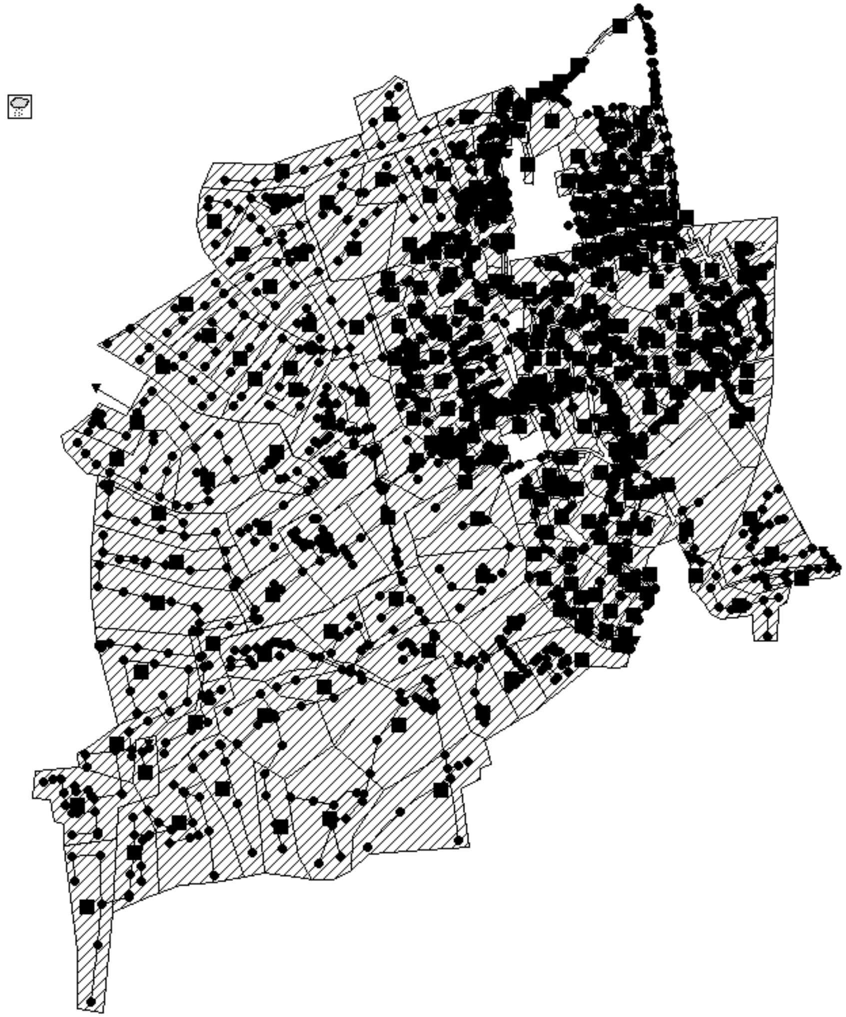
4. Flood modelling to assess option/pathway viability



BG and G Interventions:
Model modification of permeable area and storage volume in specific sub-catchments

Climate and Intensification scenarios:

- Storm profile increase
- Impermeable are increase

Option viable until flooding is observed and tipping point to next step in pathway:
Trigger Point Timing

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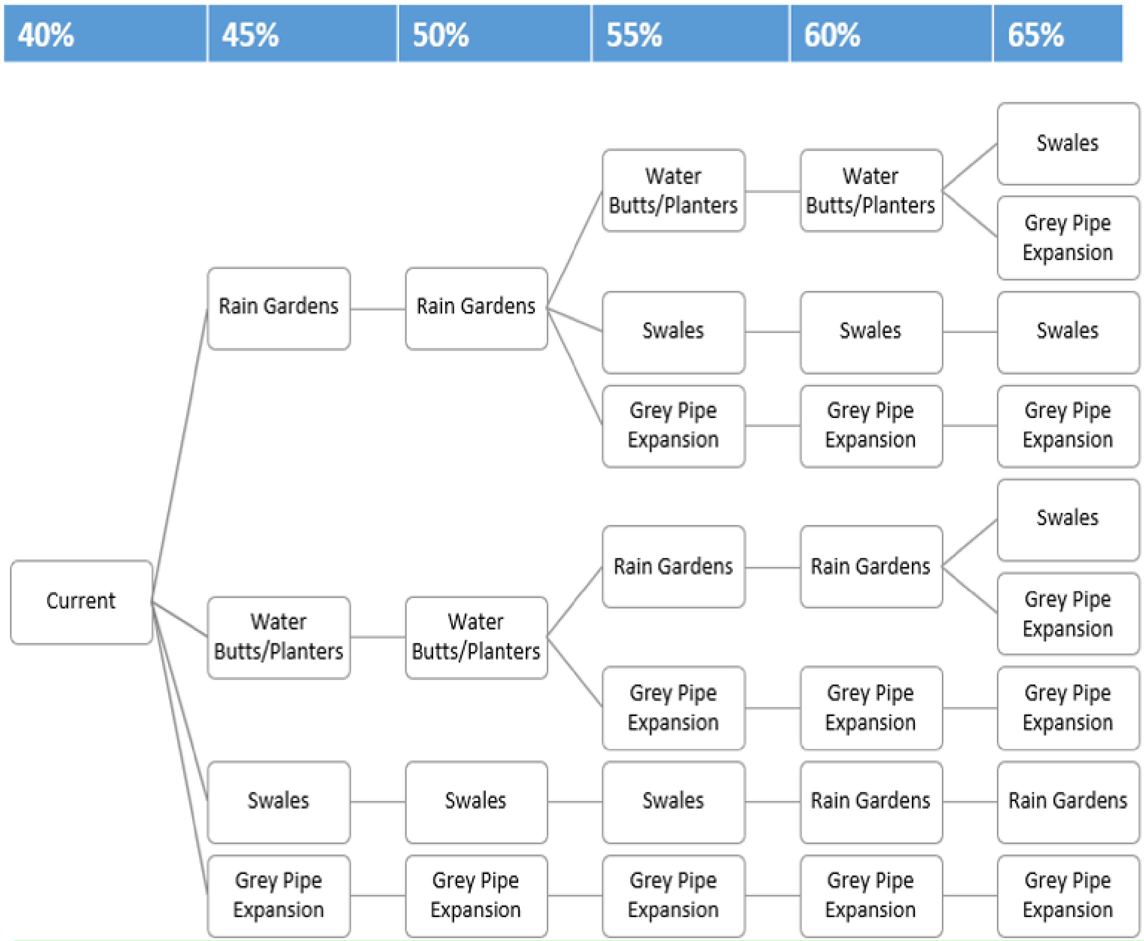
5. Carrying out a Cost Benefit Analysis

Components:

- Flood Damage avoided
- Options costing (HR Wallingford Tool CAPEX/OPEX 40 years)
- Cost of Grey System
- B£ST MB monetisation (currently undertaken)

Pathways appraisal

Quantitative CBA and qualitative multi-criteria appraisal



Pathways	Current Criteria	Additional Criteria		
	Standard CBA	Adaptiveness	Ease of Implementation	Multiple Benefits
1	Medium	High	High	High
2	Medium	Medium	Medium	High
3	High	High	Medium	Medium
4	Medium	Medium	High	Low
5	Medium	Medium	Medium	High
6	Medium	High	Medium	Medium
7	Medium	Low	Medium	Low
8	High	Medium	Medium	High
9	Medium	Low	Medium	None

Adaptation pathways tree and multi-criteria pathway assessment as a response to urbanisation

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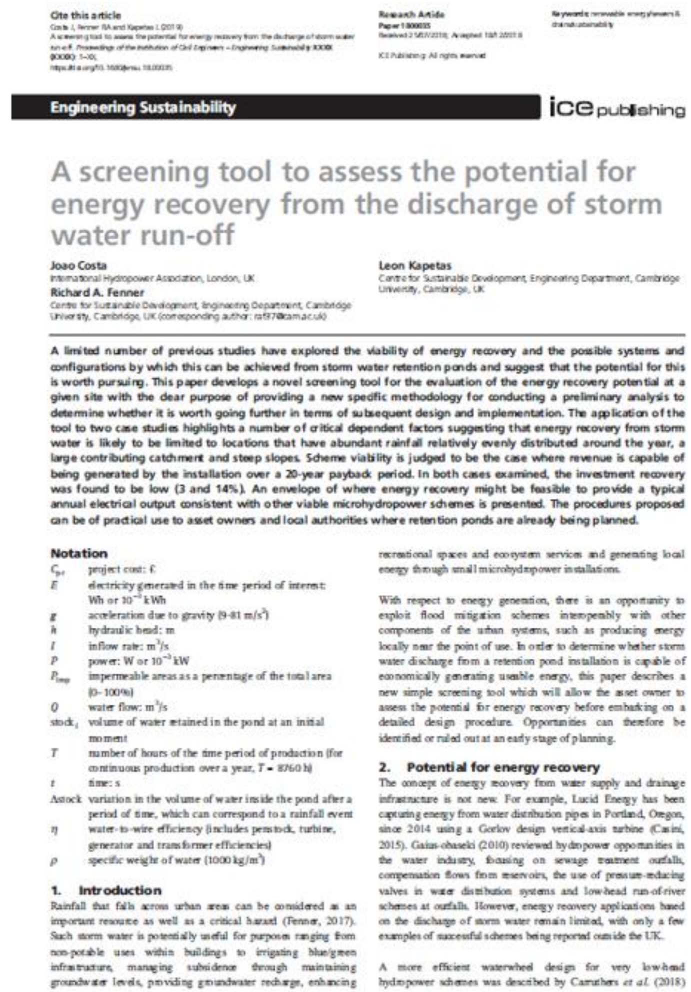
Conclusions

- Identify the right mix of BG/G infrastructure; implications on investment planning
- Include wider criteria in SUDS decision making, particularly Multiple Benefits
- Take uncertainty into account by developing flexible grey/blue-green pathways
- Carry out valuation of flexibility when comparing/combining grey and blue-green options
- Applicable to numerous UK and international urban environments

Key Deliverables at the end of project

- ❑ Methodology to assess energy recovery potential
- ❑ Understanding barriers and opportunities in SuDS/MAR conjunctive systems including cost and quality concerns.
    - ❑ Partnership with Thames Water
- ❑ Practical guidelines on how to incorporate flexibility in drainage infrastructure planning while delivering multiple benefits.
    - ❑ Partnership with Sutton Council and SERT



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A screening tool to assess the potential for energy recovery from the discharge of storm water run-off

Joao Costa
International Hydropower Association, London, UK

Richard A. Fenner
Centre for Sustainable Development, Engineering Department, Cambridge University, Cambridge, UK (corresponding author: raf37@cam.ac.uk)

Leon Kapetas
Centre for Sustainable Development, Engineering Department, Cambridge University, Cambridge, UK

A limited number of previous studies have explored the viability of energy recovery and the possible systems and configurations by which this can be achieved from storm water retention ponds and suggest that the potential for this is worth pursuing. This paper develops a novel screening tool for the evaluation of the energy recovery potential at a given site with the clear purpose of providing a new specific methodology for conducting a preliminary analysis to determine whether it is worth going further in terms of subsequent design and implementation. The application of the tool to two case studies highlights a number of critical dependent factors suggesting that energy recovery from storm water is likely to be limited to locations that have abundant rainfall relatively evenly distributed around the year, a large contributing catchment and steep slopes. Scheme viability is judged to be the case where revenue is capable of being generated by the installation over a 20-year payback period. In both cases examined, the investment recovery was found to be low (3 and 14%). An envelope of where energy recovery might be feasible to provide a typical annual electrical output consistent with other viable microhydropower schemes is presented. The procedures proposed can be of practical use to asset owners and local authorities where retention ponds are already being planned.

Notation

C_{pr}	project cost: £
E	electricity generated in the time period of interest: Wh or 10^{-3} kWh
g	acceleration due to gravity (9·81 m/s^2)
h	hydraulic head: m
I	inflow rate: m^3/s
P	power: W or 10^{-3} kW
P_{imp}	impermeable areas as a percentage of the total area (0–100%)
Q	water flow: m^3/s
stock$_i$	volume of water retained in the pond at an initial moment
T	number of hours of the time period of production (for continuous production over a year, T = 8760 h)
t	time: s
Δstock	variation in the volume of water inside the pond after a period of time, which can correspond to a rainfall event
η	water-to-wire efficiency (includes penstock, turbine, generator and transformer efficiencies)
ρ	specific weight of water (1000 kg/m^3)

1. Introduction

Rainfall that falls across urban areas can be considered as an important resource as well as a critical hazard (Fenner, 2017). Such storm water is potentially useful for purposes ranging from non-potable uses within buildings to irrigating blue/green infrastructure, managing subsidence through maintaining groundwater levels, providing groundwater recharge, enhancing recreational spaces and ecosystem services and generating local energy through small microhydropower installations.

With respect to energy generation, there is an opportunity to exploit flood mitigation schemes interoperably with other components of the urban systems, such as producing energy locally near the point of use. In order to determine whether storm water discharge from a retention pond installation is capable of economically generating usable energy, this paper describes a new simple screening tool which will allow the asset owner to assess the potential for energy recovery before embarking on a detailed design procedure. Opportunities can therefore be identified or ruled out at an early stage of planning.

2. Potential for energy recovery

The concept of energy recovery from water supply and drainage infrastructure is not new. For example, Lucid Energy has been capturing energy from water distribution pipes in Portland, Oregon, since 2014 using a Gorlov design vertical-axis turbine (Casini, 2015). Gaius-obaseki (2010) reviewed hydropower opportunities in the water industry, focusing on sewage treatment outfalls, compensation flows from reservoirs, the use of pressure-reducing valves in water distribution systems and low-head run-of-river schemes at outfalls. However, energy recovery applications based on the discharge of storm water remain limited, with only a few examples of successful schemes being reported outside the UK.

A more efficient waterwheel design for very low-head hydropower schemes was described by Carruthers *et al.* (2018)

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