

Institution: University of Nottingham		
Unit of Assessment: 14 Geography and Environmental Studies		
Title of case study: Changing mindsets, policy and practice towards a Blue-Green approach to urban flood risk management		
Period when the underpinning research was undertaken: 2013-2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Dr Emily O'Donnell (née Lawson) Professor Colin Thorne	Research Fellow Chair of Physical Geography	2013-present 1990-present
Period when the claimed impact occurred: 2016-2020		
Is this case study continued from a case study submitted in 2014? No		
<p>1. Summary of the impact</p> <p>Blue-Green infrastructure is a way of managing urban water and flood risk, while addressing important issues facing the environment and society. Research on urban flood resilience and Blue-Green Cities by Dr O'Donnell and Professor Thorne has engendered a change in mindset, policy and practice among decision makers towards greater support for Blue-Green infrastructure. O'Donnell's establishment and coordination of Learning and Action Alliances in Newcastle, Ebbsfleet and Nottingham has been the driving force behind all impact. Their research has been used by local authorities, water companies and environmental consultancies as evidence of the advantages of Blue-Green (e.g. swales, rain gardens) over traditional grey (e.g. barriers, pipes) infrastructure, leading to greater implementation of Blue-Green systems and widespread utilisation of their concept of a 'Blue-Green City'. Their research also led to the signing of the '<i>Newcastle Blue and Green Declaration</i>' and the subsequent granting of permission for over 90 Blue-Green infrastructure assets in new developments, providing environmental, economic and social benefits to the city.</p>		
<p>2. Underpinning research</p> <p>The term 'Blue-Green infrastructure' is widely understood and acknowledged in relevant literature as an approach to manage water and flood risk; sometimes referred to as 'soft' Sustainable Drainage Systems (SuDS). However, the term 'Blue-Green City' is specifically attributed to Thorne and the Blue-Green Cities research project. As outlined in the findings of Research 1 (R1) (and www.bluegreencities.ac.uk), a Blue-Green City aims to recreate a naturally oriented water cycle while contributing to the amenity of the city by bringing together water management and green infrastructure. The concept of a Blue-Green City moves beyond its constituent infrastructure and embraces the creation of multiple benefits to the environment, society and economy. This is achieved by natural, resilient and adaptive management of water that is equitable and desired by residents and decision makers (R1).</p> <p>Between 2013 and 2020, O'Donnell and Thorne conducted research into urban flood risk and water management as part of two EPSRC-funded interdisciplinary, multi-institution research projects for which Thorne was the PI and O'Donnell lead researcher. The Blue-Green Cities research project (Grant 1 (G1, 2013-2016)) included academics from nine UK Universities and was led by the University of Nottingham (UoN). The project developed new strategies for managing urban flood risk as part of wider, integrated urban planning to achieve environmental enhancement and urban renewal (R1). Within this framework, the multiple benefits of Blue-Green Cities are rigorously evaluated and understood. Thorne and O'Donnell coordinated research across five work packages and led research in the case study cities. They translated the technical research outputs (from other Universities) and demonstrated how they could be used to meet the strategic objectives of practitioners and policy makers in the demonstration cities to facilitate a move towards becoming a Blue-Green City. O'Donnell established and led the Newcastle Learning and Action Alliance (LAA) which galvanised professional stakeholders to overcome the barriers to Blue-Green infrastructure and increase delivery (R2).</p> <p>Research focused first on Portland, Oregon USA, recognised as an international leader in using Blue-Green infrastructure to manage urban stormwater and improve water quality. Despite Portland's progression towards becoming a Blue-Green City, Thorne and O'Donnell's research found that widespread delivery was limited by uncertainty regarding the hydrologic performance</p>		

of Blue-Green infrastructure and lack of confidence that it would be publicly accepted (R3). Notably, the socio-political barriers were shown to exert the strongest negative influence on the implementation of Blue-Green approaches to manage water (R3). Research in Portland provided a stepping stone for subsequent research in Newcastle, UK, where best practice in Blue-Green infrastructure governance from the USA was explored in a UK context. Newcastle was selected as flood risk management was high on the political agenda following an extreme rainfall event on 28 June 2012 where 50mm rain fell in 2 hours, flooding over 1,200 properties (500 internally) and impacting most of the city's transport system (R3). Thorne and O'Donnell's research identified barriers to the delivery of Blue-Green infrastructure to address future flood risks (R4) and recommended strategies for overcoming these barriers (R3-5). They recommended collaborative, inter-agency and inter-departmental working (R4) and identification and evaluation of the multiple benefits, and beneficiaries, of Blue-Green infrastructure through Geographical Information Systems (GIS) and other accounting tools (R5). Their research showed that challenges with governance of Blue-Green infrastructure (e.g. limited multi-agency working and poor inter-departmental communication) can be overcome through social learning initiatives such as LAAs (R2, R6).

In 2014, O'Donnell (with members of the Blue-Green Cities research project) established the Newcastle LAA, which O'Donnell continues to lead. The LAA enables effective engagement through social learning and facilitates targeted action, which is needed to deliver innovative solutions to Newcastle's flood and water management challenges. Thorne and O'Donnell's research into the multiple benefits and beneficiaries of Blue-Green infrastructure (R1, R5) demonstrated the need for including a wider range of stakeholders in Blue-Green infrastructure discussions, which would typically have been limited to engineers and flood managers. The Newcastle LAA, (including Newcastle City Council, Northumbrian Water, the Environment Agency (EA), industry, local environmental groups and academics), brought together disparate city stakeholders and co-produced new knowledge, negotiated innovative actions and developed a Vision for Newcastle to become a Blue-Green City (R2).

Research in Newcastle continued under the subsequent Urban Flood Resilience research project (2016-2020), led by UoN and including eight additional UK Universities. This project aimed for transformative change in urban flood risk and water management through co-ordinated planning, design and operation of closely coupled urban water systems (G2). Thorne and O'Donnell led the case study research, translating the technical research and demonstrating to practitioners and policy makers how innovative Blue-Green approaches to flood and water management can help build cities resilient to climate and environmental change. This has enabled O'Donnell to further develop the LAA framework to improve capacity building amongst stakeholders and facilitate action and policy change (R6). A second case study, the Ebbsfleet Garden City, explored Blue-Green infrastructure opportunities in a new build context. Ebbsfleet is sponsored by the UK Government to become a 'Garden City of the 21st Century', and there was opportunity to influence the development plans for this 1,026 hectare site and embed sustainable urban water management at the heart of the planning process. O'Donnell established and co-led the Ebbsfleet LAA. O'Donnell and colleagues' research has demonstrated that LAAs must employ a range of capacity building elements (e.g. material and human resources, new structures and processes) to maximise action and move beyond individual levels to reach organisations and wider society (R6).

3. References to the research

1. **Lawson, E. C., Thorne, C. R., et al.**, (2014) 'Delivering and evaluating the multiple flood risk benefits in Blue-Green Cities; an interdisciplinary approach', In: *Proverbs, D., Brebbia, C.A. (eds.), Flood Recovery, Innovation and Response IV. WIT Press, 113-124*. Book chapter. [DOI:10.2495/FRIAR140101](https://doi.org/10.2495/FRIAR140101).
2. **O'Donnell, E. C.**, Lamond, J. E. and **Thorne, C. R.**, (2018) 'Learning and Action Alliance framework to facilitate stakeholder collaboration and social learning in urban flood risk management', *Environmental Science & Policy*, 80, 1-8. Refereed Journal paper. [DOI:10.1016/j.envsci.2017.10.013](https://doi.org/10.1016/j.envsci.2017.10.013).
3. **Thorne, C. R., Lawson, E. C., Ozawa, C., Hamlin, S. and Smith, L. A.**, (2018) 'Overcoming uncertainty and barriers to adoption of blue-green infrastructure for urban flood risk

management', *Journal of Flood Risk Management*, 11(S2), S960-S972. Refereed Journal paper. [DOI:10.1111/jfr3.12218](https://doi.org/10.1111/jfr3.12218).

4. **O'Donnell, E. C.**, Lamond, J. E. and **Thorne, C. R.**, (2017) 'Recognising barriers to implementation of Blue-Green infrastructure: a Newcastle case study', *Urban Water Journal*, 14(9), 964-971. Refereed Journal paper. [DOI:10.1080/1573062X.2017.1279190](https://doi.org/10.1080/1573062X.2017.1279190).
5. **O'Donnell E. C.**, Woodhouse, R. and **Thorne, C. R.**, (2018) 'Evaluating the multiple benefits of a Newcastle surface water management scheme', *Proceedings of the ICE – Water Management*, 171(4), 191-202. Refereed Journal paper. [DOI:10.1680/jwama.16.00103](https://doi.org/10.1680/jwama.16.00103).
6. Maskrey, S., Vilcan, T., **O'Donnell, E. C.**, and Lamond J. (2020) 'Using Learning and Action Alliances to build capacity for local flood risk management', *Environmental Science and Policy*, 107, 198-205. Refereed Journal paper. [DOI:10.1016/j.envsci.2020.02.012](https://doi.org/10.1016/j.envsci.2020.02.012).

Grants and commissioned research (G)

1. PI: **Prof Colin Thorne**. Delivering and Evaluating Multiple Flood Risk Benefits in Blue-Green Cities. 2013-2016. EPSRC, GBP1,434,824 plus GBP75,000 from DAERA (Northern Ireland).
2. PI: **Prof Colin Thorne**. Achieving Urban Flood Resilience in an Uncertain Future. 2016-2019. EPSRC, GBP511,139.
3. PI: **Dr Emily O'Donnell**. Research project commissioned by Northumbrian Water Ltd., to evaluate the multiple benefits of Blue-Green Infrastructure in Newcastle. GBP26,388.
4. PI: **Dr Emily O'Donnell**. Delivering Blue-Green Infrastructure to Drive Economic Growth and Place Making: A Case Study of the River Leen, Nottinghamshire. 2020-2021. UoN Interdisciplinary Research Clusters (IRC) Initiative. GBP59,432.

4. Details of the impact

O'Donnell and Thorne's research into Blue-Green Cities and urban flood resilience (R1-6) has raised awareness of the multiple benefits of Blue-Green infrastructure and how barriers to delivery can be overcome by knowledge co-production and interdisciplinary collaboration. Their research has influenced flood and water management policy and practice in Newcastle, e.g. the Newcastle City Council Local Flood Risk Management Plan (2016) (Impact a, b (1a, 1b)) and Northumbrian Water's Rainwise initiative (1c), and led to several related projects in the UK (e.g. Ebbsfleet, Nottingham). Their work, and O'Donnell's coordination of the LAAs, has engendered a change in mindset to managing urban water through the identification of the multiple co-benefits that Blue-Green infrastructure can provide (R1, R5) and development of strategies to overcome the socio-political barriers to widespread implementation (R2-4). As a result, Newcastle stakeholders have adopted new flood risk management strategies and a range of schemes have been completed across the city (1a, 1b, and 1c).

4.1. Newcastle Blue and Green Declaration

The change in mindset of Newcastle stakeholders is illustrated by their support for a Blue-Green Vision, co-produced by O'Donnell and the Newcastle LAA in 2016 (1a). The 'Newcastle Blue and Green Declaration' was signed by senior stakeholders from Newcastle City Council (the Cabinet Member for Investment and Development), Northumbrian Water, the EA, Newcastle University, and two international environmental engineering consultancies working on Blue-Green projects in Newcastle (Arup and Royal HaskoningDHV). The Declaration commits organisations to greater implementation of Blue-Green infrastructure and collaborative working. In 2019, commitment to the Blue-Green Declaration was reaffirmed when the six founding signatories and four new signatories [the Royal Town Planning Institute (RTPI), Groundwork NE & Cumbria (charity working to transform disadvantaged UK communities), and two international engineering consultancies (Stantec and Sweco)] pledged their support. Commitment to the Blue-Green Declaration by organisations not solely involved in flood risk management, such as RTPI and Groundwork, illustrates greater recognition of the wider environmental and social co-benefits of Blue-Green infrastructure, as advocated in R1 and R4-5. The Principal Engineer for Newcastle City Council states "*The Declaration currently provides the framework for much of our work locally, including new flood alleviation work and assessing planning applications, and has been influential in shaping the culture of surface water management in Newcastle*" (1a).

4.2. Newcastle Blue-Green infrastructure projects and plans

The commitments in the Declaration have been actioned by stakeholders leading to an increase in the number of Blue-Green infrastructure projects in the North East since 2016 (1a, 1d). As a

designated Lead Local Flood Authority, Newcastle City Council acts as a statutory consultee to the Local Planning Authority in relation to surface water management on all major planning applications. It works with developers on drainage strategies and promotes the delivery of multiple benefits through Blue-Green infrastructure. Since 2016, 90 Blue-Green infrastructure assets have been included in completed new developments within the Newcastle city boundary to minimise and control surface water runoff (Id). This includes green roofs, swales, ponds and rain gardens that provide environmental, economic and social benefits to Newcastle's residents. Such practices deliver co-benefits to a range of organisations, as recommended in R2-5.

The Newcastle Local Flood Risk Management Plan (March 2016) cites the LAA, Blue-Green Cities project and Declaration when stressing a change in mindset to managing flooding: *"we have recently signed up to the Blue Green pledge which commits the city to managing flooding in a more natural way whilst still obtaining the benefits from using green infrastructure for the benefit of the environment, our residents and visitors and the economy"* (Cabinet Member for Investment and Development, Newcastle City Council) (Ib). Furthermore, *"Her [O'Donnell's] knowledge, and that of the wider Blue-Green Cities research project, of the multiple benefits of Blue-Green infrastructure has directly informed strategic decision makers within Newcastle City Council when preparing the city's Core Strategy and Urban Core Plan 2015 and Surface Water Management Plans in the Ouseburn and city centre"* (Ia; Principal Engineer, Newcastle City Council).

Changes in mindset of other LAA members, including Northumbrian Water and the EA, have led to changing practices towards more collaborative Blue-Green infrastructure projects; *"work undertaken by Dr O'Donnell and the Blue-Green Cities project has also been an enabler for Northumbrian Water's 'Rainwise' initiative by providing further evidence for the benefits of combining grey with multifunctional Blue-Green infrastructure and highlighting the advantages of collaborative partnerships"* (Ic; Sustainable Sewerage Manager, Northumbrian Water). For example, the Rainwise initiative in Brunton Park (including realignment of the Ouseburn and modifications to the river channel to increase surface storage) reduced flood risk to over 100 residential properties while improving biodiversity and creating habitat for otters (Ie).

As another example, in 2016 Northumbrian Water, the EA and North Tyneside Council invested over GBP5,000,000 in three sites in North Tyneside (Longbenton High School, Killingworth Moor and Killingworth Lake), including five attenuation basins and disconnection of Longbenton Letch from the combined sewerage network (Ic). As part of this, Northumbrian Water commissioned O'Donnell in May 2016 to conduct a 3-month research project to evaluate the multiple benefits of Blue-Green infrastructure for planned and visionary projects, including the Killingworth and Longbenton scheme, using recent evaluation toolkits produced in academia and industry (G3). This further supports a change in practice from solely considering the flood risk management benefits in options appraisals towards greater inclusion of monetised benefits that Blue-Green infrastructure delivers to the environment and society (Ic). O'Donnell used the B£ST (Benefits Estimation Tool), CIRIA (Construction Industry and Research Information Association) and calculated that this scheme generates flood damage reduction benefits of circa. GBP50,000,000 over a 100-year period (2017-2117; the typical timeframe for evaluating flood risk). The scheme further provides over GBP1,000,000 of benefits due to improvements in local water quality; GBP241,000 of benefits from increased recreational opportunities; GBP100,000 from improved amenity and GBP33,000 from enhanced biodiversity and ecology (R4; calculated over a 38-year period, If). Flood risk to 3,500 local properties and three key transit roads has been reduced, and a dry weather amphitheatre and wetland viewing platform have increased local awareness and educational opportunities (If). The GBP5,000,000 spent on this project will mitigate potential harm caused by future flooding, creating a legacy impact and saving money.

4.3. Multiple benefits of Blue-Green infrastructure

O'Donnell and Thorne's research (R2, R4) has contributed to the growing evidence base that demonstrates the multiple benefits of sustainable drainage systems (SuDS) that utilise Blue-Green infrastructure. In addition to reducing flood risk, Blue-Green infrastructure in Newcastle effectively traps contaminants (e.g. heavy metals) that are attached to fine sediment particles (Ig). By trapping contaminated sediment, Blue-Green infrastructure removes it from local watercourses connected

to these features (such as the Ouseburn), thus reducing pollutant concentrations and improving water quality. For example, concentrations of Fe, Ca, Al, Ba, Cr, Ni, Cu, Mg, Pb and K in Newcastle Blue-Green infrastructure exceeded those in the adjacent Ouseburn stream (lg). Local environmental benefits include a 3-fold increase in macrophyte taxon between 2012 and 2018 (5 to 15 species), and an increase in 3-spined Stickleback from 26 in 2017 to 87 in 2019 (lg). This increase in different aquatic species highlights improved biodiversity, a consequence of the improved water quality in the Ouseburn since the Blue-Green infrastructure ponds were installed. The 166,000 residents in the catchment also benefit from the creation of more attractive recreational Blue-Green space.

4.4. Ebbsfleet Garden City (delivery of homes and infrastructure began in 2015)

O'Donnell and Thorne's research in Ebbsfleet, Kent (2016-2020) investigated how integrated water management can be achieved in the context of a new build 'Garden City' (G2). O'Donnell was fundamental in establishing the Ebbsfleet LAA in 2017, based on the framework successfully developed in Newcastle (R5), and this has played a pivotal role in the collaborative design of the Ebbsfleet Garden City's core facilities and infrastructure. The LAA has strengthened relationships between the Ebbsfleet Development Corporation and key stakeholders by regularly bringing together representatives from Southern Water, Thames Water, Kent County Council, Dartford Borough Council, Kent Wildlife Trust, the EA, and the SE Rivers Trust. O'Donnell and Thorne's research (R1-3) has also "*illustrated how sustainable water management could be achieved in the Ebbsfleet Garden City, and provided recommendations for overcoming some of the socio-political barriers to greater implementation of blue-green infrastructure*" (lh; Head of Design, Ebbsfleet Development Corporation). O'Donnell and Thorne have strongly informed the development of the Ebbsfleet Water Strategy (2019) that guides planning and development in the Garden City (lh, li). The Ebbsfleet Water Strategy is one of five key environmental design areas that together form Ebbsfleet Development Corporation's Sustainability Performance Framework (2020). All organisations working in the Ebbsfleet Garden City must adhere to this framework which monitors the Garden City's environmental sustainability (li).

4.5. Nottingham Climate Change Resilience and Adaptation

Building on learning from both the Newcastle and Ebbsfleet LAAs, O'Donnell established an LAA in Nottingham in 2019, and leads a project exploring how Blue-Green infrastructure can be used to drive economic growth and place making along the River Leen, Nottinghamshire (G4). O'Donnell's research (R2, R4) has led to increased awareness among city stakeholders (Nottingham City Council, the EA, and local environmental consultancies) of the multiple benefits of Blue-Green infrastructure and has influenced local policy: "*it was Dr O'Donnell's ability to assist me in steering a discussion towards how the city can best design for, and capture the multiple environmental, social and economic benefits of Blue-Green infrastructure that has influenced local policy around resilience and adaptation*" (lj; Principal Energy Policy Officer, Nottingham City Council). Specifically, O'Donnell's input has led to the acknowledgement of the benefits of a 'Blue-Green Nottingham' in the Carbon Neutral Nottingham: 2020 Action Plan (lk, p. 50) and engagement with local policy makers around the importance of Blue-Green infrastructure in creating a city that is resilient and adaptable to climate change.

5. Sources to corroborate the impact

- a. Newcastle City Council Testimonial
- b. Newcastle City Council Local Flood Risk Management Plan
- c. Northumbrian Water Testimonial
- d. Newcastle City Council Annual Monitoring Reports
- e. Northumbrian Water Rainwise Initiative
- f. Killingworth and Longbenton Surface Water Management Scheme
- g. Ouseburn Water Quality and Biodiversity Evidence
- h. Ebbsfleet Development Corporation Testimonial
- i. Ebbsfleet Development Corporation Water Strategy
- j. Nottingham City Council Testimonial
- k. Nottingham City Council, Carbon Neutral Nottingham 2020 Action Plan