02
2016

Urban rainwater. A liquid asset

Johanna Gibbons
J & L GIBBONS, London johanna@jlg-london.com

Abstract

Climate change is a reality. Rainwater is essential to our survival. However, with intensification of the already highly modified environment of the city and rising temperatures, more frequent intense rainfall is affecting not only water quality but also basic quality of life. Sustainable drainage is not only the solution but a fundamental philosophy to do with nurturing our sense of identity and re-connection with nature. It offers the potential for transforming the way we read the urban environment, and also the potential for re-thinking what infrastructure means, how engineering interfaces with community, and the great opportunity for landscape architects to step up to the challenge.

Keywords

Climate change, SuDS – Sustainable (urban) Drainage Systems, green infrastructure, well-being.

Received: July 2016 / Accepted: September 2016

DOI: 10.13128/RV-19371 - www.fupress.net/index.php/ri-vista/

Context

Climate change is the critical issue of our time.

The Intergovernmental Panel on Climate Change (IPCC) report 2014 gave unambiguous evidence that climate change is set to inflict "severe, widespread and irreversible impacts" on people and the natural world, unless action is taken. The Paris Climate Agreement December 2015 secured for the first time full agreement from 195 nations on the science of climate change, acknowledged collective responsibility for addressing the problem and also agreed to 'ratchet-up' provision whereby their commitments are reviewed and reinforced every five years with regular reporting of progress by each nation to incentivise improved results.

Water management is at the heart of adaptation to changing conditions. Climate change compounds the pressures on water resources and water quality, likewise so does population increase, vulnerability to pollution, increased flooding events and droughts.

> Water resources are directly impacted by climate change, and the management of these resources affects the vulnerability of ecosystems, socio-economic activities and human health. Water management is also expected to play an increasingly central role in adaptation. Climate change is projected to lead to major changes in water availability across Europe with increasing water scarcity and droughts mainly in Southern Europe and increasing risk of floods throughout most of Europe. (European Climate Adaptation Platform).

Vulnerability and adaptation capacity affects the potential quantum of change or degree to which a system is susceptible as a consequence of climate change. Climate change affects the hydrological cycle. The impacts are measured in terms of extreme rainfall, river flood flow, sea level rise and storm surge, and the consequences to people and wildlife. The threat is enormous.

Stemming the flow of impending disaster becomes the opportunity for an innovative and inspired approach to urban infrastructure planning that acknowledges the potential of the biophilic city. It values the free and adaptive ecosystems nature provides, to take a catchment based approach to water management, and reap the multiple benefits for the environment and community well-being (fig. 1).

The evolution of sustainable drainage systems (SuDS) can be traced back to the Cuyahoga river fire of 1952 in Cleveland that featured on the cover of Time magazine. This image became the symbol of environmental degradation, throwing a spot light on water pollution and igniting the rise of environmentalism. Since then SuDS has gradually gained ground in the USA with many exemplary case stud-

Fig. 1 – Community well-being is one of the multiple benefits of SuDS. Large specie trees intercept rainfall and provide biodiversity and reinforce a sense of place (photo: J. Gibbons, J & L Gibbons).

ies particularly in Portland Oregon. In the UK early schemes that focused on water quality were adopted in Scotland[1] in the 1990s which developed guidance (CIRIA, 2000) for practitioners on technical and planning considerations. However, the first scheme to pioneer an integrated system approach to SuDS was at the Oxford Service Station designed by Robert Bray in 1996 which collected, treated and recycled surface water.

Liquid Asset

Surface water is the rainwater that falls on any city's surfaces; on the ground, street and roofs (fig. 2). Traditional methods of draining surface water runoff from built-up areas has been through underground pipes and tank storage systems. Sustainable drainage systems (SuDS), however, is an approach to drainage that uses natural hydrology as the baseline against which system performance is evaluated. SuDS redefines drainage, brings it to life, in terms of a philosophical, cultural and practical shift in attitude to rainwater as a valuable resource and a conservation opportunity, for the multiple benefits of water quality, quantity, amenity and biodiversity (fig. 3).

"Water is a heritage which must be protected" (Water Framework Directive, 2000).

Outmoded are 'end of pipe' solutions of filtering and purifying rainwater that are energy intensive and require chemical treatment. Instead SuDS advocate flexible strategies applicable to specific locations defined by landscape character, topography, soils, development pattern, and existing green and grey infrastructure. SuDS smooth out localised peak flows and extreme weather events. Sustainable drainage manages surface water using trickle filters that mimic natural systems, storing water and allowing infiltration, while enhancing the urban landscape. There is no reason why SuDS cannot be integrated into highways, parks, gardens and public realm as readily as conventional drainage to create innovative, beautiful and multifunctional urban green infrastructure (fig. 4). Early consideration in either retrofitting or redevelopment will ensure decentralised and localised solutions which mitigate and distribute the risk of high intensity rainwater events. This will enhance the adaptive capacity and climate resilience (the ability of a system to return to equilibrium after flooding). A long-term management approach, should be able to demonstrate cost-benefits as part of the green infrastructure framework. It is important that management and maintenance do not be accepted as an excuse for lack of action. Equally, that responsibility for maintenance is undertaken effectively throughout the life-cycle of a drainage system with mainte-

Fig. 2 – Intense rainfall on 23rd June 2016 in London, where a month rainfall fell in certain areas in one day (photo: A. Ferguson, The New York Times).

nance contracts that might well span over decades. All sites require maintenance whether they feature SuDS or not. If well designed and integrated from the start of a project, sustainable drainage optimises funding by delivery of greater multiple benefits and outcomes, in a way that is unachievable with traditional piped drainage. The operations specifically related to SuDS maintenance rather than site maintenance actually only amount to the inspection of control structures, outlets and inlets. The advantage of SuDS is due to the drainage components being on or near the surface (and more visible) maintenance can be facilitated in a more timely fashion resulting in long-term cost benefits. Demonstrating compatibility with the local authority's adoption procedures, methods and cost structures from the outset can build confidence and knowledge in the delivery. Best overall value is not about cheapness, but more to do with 'capacity building' (UNCED, 1992)[2]. Community engagement is a vital part of a successful project. It should inform and empower communities through the design, planning and delivery processes. It is an essential ingredient in finding the best design solution, and to building popular support for the project. In addition, community engagement can act as a catalyst for partnership working that can benefit long-term management and maintenance mechanisms, as well as funding regimes. Underpinning all the technical work with a process of community engagement, involving the ultimate beneficiary (the 'ordinary person') in decisions of urban planning reinforces a sense of ownership and identity and assist in mutual understanding by advocating a change of attitude to rainwater, as a resource rather than a problem.

Natural or greenfield runoff rates of 3-8litres/second can increase to greater than 200 litres/second in an impermeable urban context. This can place an unpredictable burden on a drainage system. Sustainable drainage is therefore not an option, but a requirement in the face of adaptation to climate change. London is particularly vulnerable due to its density, location and complexity with a projected increase in winter rainfall of 6% by 2020 and 15% by 2050, and a population increase from 8.6 million to 11 million by 2050. Almost a fifth of London lies in the floodplain, defended by traditionally engineered flood defences that protect the city from fluvial flooding. However, this does not account for urban run-off problems from the increasingly frequent return events of heavy rainfall that makes the city vulnerable to surface water and sewer flooding. The situation is compounded by the capital's Victorian legacy of a combined sewer system, designed 150 years ago for a city of less than half its current population means that rainwater runoff mixes with sewage. In addi-

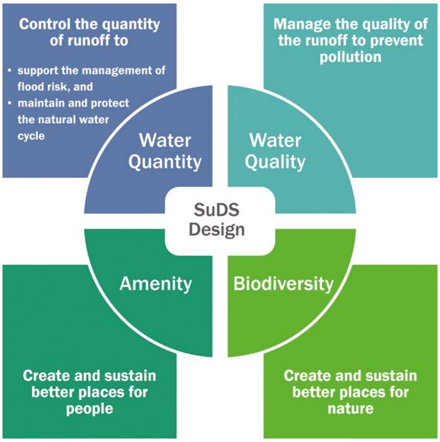

Fig. 3 – The four pillars of SuDS. CIRIA, *The SuDS Manual*, Figure 2.1 (Courtesy of CIRIA).

opposite page
Fig. 4 – St James's Park London provides multifunctional green infrastructure and forms part of London's All London Green Grid (photo: S. Blee, J & L Gibbons).

Fig. 5 – Designing for sustainable drainage at Canal Park Queen Elizabeth Olympic Park to underpin landscape character and community identity (Image credit: J & L Gibbons).

tion, 40% of the surface area of London has been rendered impermeable, and the rate of paving over front gardens is alarming, contributing to increased impermeability and risk of surface water flooding. To deal will this growing problem, the London Sustainable Drainage Action Plan (GLA, 2015a) sets out the city's overall ambition with regard to long-term integrated water management. While considerable achievements have been delivered in recent years, it is vital that with London's population set to grow, there is a need for greater innovation and action in public and private parks, gardens, schools, institutions, streets and squares. This more radical approach will rely on London's Boroughs, Transport for London (TfL), central government, businesses and other stakeholders working together imaginatively and collaboratively. SuDS is a key part of green infrastructure policy, embedded in the London Plan as the *All London Green Grid Special Planning Guidance* (GLA, 2012). It aims to elevate the status of green infrastructure to become a fundamental part of London's long-term infrastructure vision. The recently published Green Infrastructure Task Force report, *Natural Capital*, further underpins the potential for economic and social improvement and for green infrastructure to be considered "as integral to the capital's metabolism as its roads, rail lines or water pipes" (GLA, 2015b).

The streetscapes of London, in particular, provide widespread opportunity in the capital for SuDS. Over 80% of the public realm of the capital is formed of streets and squares. These are the conduits for city living and a barometer for the health of Londoners. Transport for London recognises that a 'whole-street' approach is required to capture the health benefit of encouraging more walking and cycling (TfL, 2014). Sustainable drainage has a big part to play in reinforcing a fundamental connection with nature. The 'soft engineering' of water on the surface where it can be seen, to alleviate flooding, to filter through vegetation, provide integrated play and biodiversity, has a direct positive impact on how we perceive our environment, our sense of place and identity (fig. 5).

SuDS can be achieved at every level. The cumulative impact of empowering 8 million Londoners to do their bit could be significant, and is equally important as the integrated surface water management planning for large developments. Every citizen should be encouraged to take action to make a difference. This might be disconnecting a downpipe and diverting rainwater to the garden rather than the sewer (fig. 6), laying permeable paving in the garden (fig. 7), de-paving a front garden, or installing a green roof on the garden shed or back extention. Many, many incremental actions can be

opposite page
Fig. 6 – Rainwater butt intercepting rainwater from the roof to store for irrigation (photo: J. Gibbons, J & L Gibbons).

pages 62-63
Fig. 7 – Permeable paving with grit jointed granite paving and self seeded *Lotus corniculatus* providing biodiversity with source control of surface water at Alnarp Sweden (photo: J. Gibbons, J & L Gibbons).

more effective, more economic, more resilient, but can also engage citizens in a rapid culture change to underpin the fact that we are all part of the ecosystem, and it is actually within our individual and collective ability to influence the outcome, and feel good about it.

Natural signature. Anthropogenic condition

Cities are lost landscapes. Urbanisation has a significant impact on natural flow rate, runoff, infiltration, and groundwater re-charge. London's urban environment is particularly challenging due to the level of impermeability and degree of modification of natural systems (fig. 8). To re-engage with the underlying heritage of the natural system, sustainable drainage gives the opportunity to peel back the surface of the city and express the management of surface water. This can be done by dealing with water when and where is falls (source control), through interception, collection and recycling of rainwater; through planting large specie trees to mark natural ground; retrofit impermeable surfaces with permeable constructions; de-culverting water courses and using the visible flow of surface water to articulate threshold, movement and space (fig. 9).

The natural signature of the capital is the framework that re-establishes the relationship between the built and the natural aspects of London (Natural England, 2011). London's soils, geology and hydrology have been heavily modified with culverts, raised levels, basements and traditional piped drainage. Only remnants of the 'natural' hydrology are left. Culverted watercourses belie the natural pattern of the Thames Basin. The Fleet River, for instance, lies hidden beneath Farringdon Road, incarcerated in its beautifully detailed Victorian brick culvert, a distant memory of Bazelgette's vision for the health and wellbeing of Londoners.

The Thames Tideway Tunnel is a project shortly to be under construction. It is a major undertaking, which will sink shafts 70m below the Thames and tunnel a 'super sewer'. This will run east-west to connect with Bazelgette's Northern Outfall Sewer to alleviate the issues of a combined sewer whereby intense flood events cause outflow into the Thames with consequential unacceptable levels of pollution (contravening the European Water Directive). However, this will not solve localised flooding, as the sewer infrastructure between the new big pipe and local communities north and south of the Thames will generally not be upgraded. Yet the volume of rainwater entering those local sewers will only increase with intensification of density.

SuDS therefore provides the only solution. Yet as the thirty-three London Local Authorities take on the responsibility of delivering and maintaining

02
2016

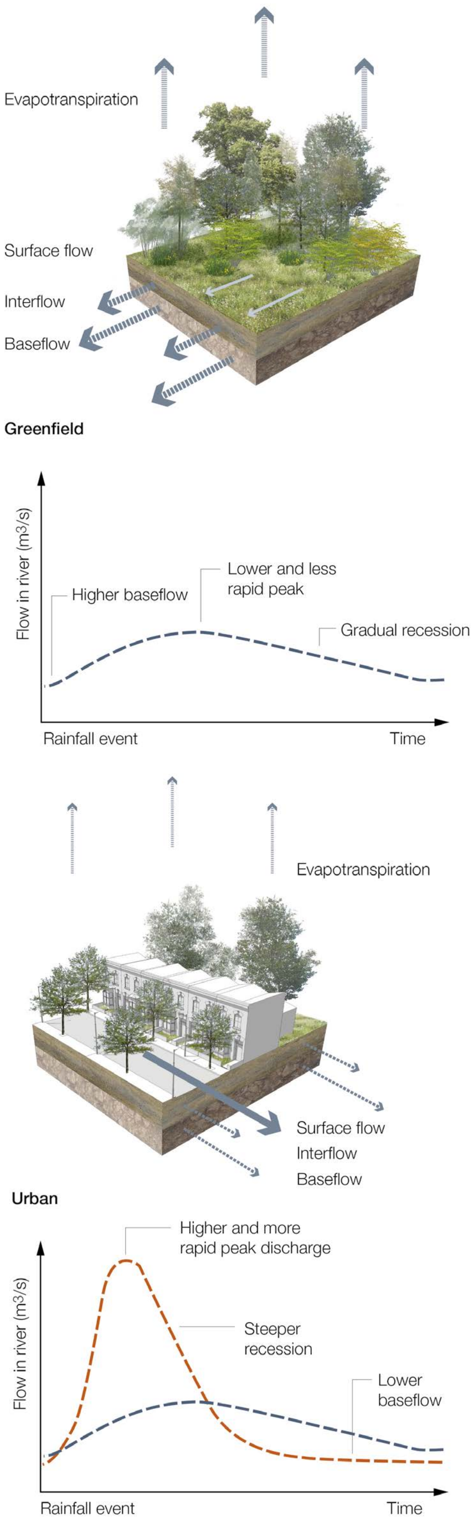

Fig. 8 – Comparison of runoff from greenfield and urban environments (taken from TfL 2016, p. 20, <https://consultations.tfl.gov.uk/policy/suds-guidance>).

opposite page
Fig. 9 – Articulation of threshold, movement and space: An example of SuDS retrofit in London (taken from TfL 2016, pp. 106-107, <https://consultations.tfl.gov.uk/policy/suds-guidance>). Potential SuDS components illustrated:
1. Existing trees provide interception
2. Tree trenches for attenuation
3. Bioretention planters to the base of disconnected downpipes
4. Channel to bioretention gardens
5. Traditional London stone slab paving
6. Permeable paving to discrete areas for source control
7. Porous bound surfaces over existing trees rooting zones
8. Bioretention gardens for attenuation
9. Street furniture aligned with SuDS components to reduce clutter
10. Below ground services and utilities
11. Cellular systems for attenuation
12. Soil and drainage materials
13. Living roofs provide source source control

sustainable drainage, the art and science of SuDS is very much an evolving one, with a few enlightened flood risk officers pioneering the way. The recently published CIRIA *SuDS Manual* (CIRIA, 2015) which provides industry standards in the UK. The guidance recognises that sustainable drainage systems are relevant to urban, suburban and rural environments. For that reason, the 'u' of SuDS has been de-capitalised to reflect a shift to a broader relevance, not just urban.
The Manual is a hefty tome, evidence that the topic requires extensive collaborative technical know-how that crosses disciplines, as well as common sense. Common sense that water flows with gravity, that it will be absorbed by soil, that it will flow faster over hard surfaces, and that when it rains, that rain mixes with whatever is on the surface (soil, oil, dust, litter) to affect the quality of the water. Common sense that rainwater is a precious resource, not a waste product. It is, after all, what defines our climate and vegetation, give us our 'green and pleasant land', provides us with essential drinking water and irrigation. Yet traditionally we have tended not to treat it as such, seeking to put it

down the drain as directly as possible. The manual explores how to reintroduce 'hydraulic roughness', how to capture, hold and absorb, rather than accelerate and compound the cumulative impact.

London presents very many townscape and landscape conditions within conservation areas, major growth and opportunity areas, areas of re-development, retrofit or upgrade. SuDS calls for a close appreciation of locality. It is not sufficient to say, for instance, that London is on clay and therefore filtration is not an option. The anthropogenic conditions of the city environment are complex, and there is a multiplicity of soil profiles, one overlaying the other (fig. 10). Some soils have been aggregated over the last two millennia of occupation since the Romans, in some places many meters deep of burial ground, bomb damage rubble, industrial activity or land fill. The complexities of the below ground environment may also include the presence of sub surface structures, transport infrastructure, basements, utilities and tree roots. In the design of SuDS it is the context that will define the components of the system, according to assessment of long-term viability, and character. The design and technical detail being as important as the strategic vision.

Puddles and strategic partnerships

No single discipline, stakeholder or profession has a monopoly on realising the optimum outcome when confronted with an array of technical, political and regulatory requirements. Properly appraising these factors requires a collaborative approach across a wide range of professions depending on the location. This will include drainage engineers, local authority officers, landscape architects, urban designers, highways engineers, ecologists, arboriculturalists, soil scientists, land managers, land owners, community leaders and residents amongst others. There is a growing resource of case studies and progressive reference material already available to help

opposite page
Fig. 10 – Anthropogenic soils at Ruskin Square London East Croydon (photo: J. Gibbons, J & L Gibbons).

project sponsors to begin to appreciate best practice, SuDS is an ever evolving case of technical improvement, responding to emerging empirical data from completed schemes in operation.
Crucial to the successful adoption of SuDS techniques is public engagement and partnership working. In particular, the dissemination of technical information in a way that enables information and vocabulary to be shared and local communities to take ownership, participate and appreciate the strategic and local green infrastructure impacts of SuDS.
Research and monitoring of structural soils, long-term health and root growth of street tree planting for SuDS are also essential. In engineered environments, seasonal demands and planting specifications need to be monitored to inform long-term asset management planning. Last year iTree Eco London (Treeconomics London, 2015), a survey and evaluation of the performance of the urban forest in London, estimated that the capital's 8.5 million trees create a leaf area that intercepts some 3.4million m^3 of rainwater per annum. This avoids run-off that can quickly become polluted as the rain washes the streets picking up pollutants that eventually end up in the Thames or its tributaries. London has targeted 25% reduction in surface water flows by 2040. London is at the threshold of a significant culture change, lead by the Greater London Authority organisation including TfL long after cities in USA and Europe have embraced the theory and practice, and it's about time. Heavy rainfall in the summer is a more frequent occurrence. On 23rd June 2016, for instance, red flood warnings were issued for parts of south-east London as double the average rainfall fell on one day, in isolated intense thunderstorms.
The city is in a continual state of cultural change. As cities intensify, especially London, the recognition that contact with nature is an essential indicator of quality of life comes more into focus in terms of positively supporting mental well-being and stress reduction. Just as the slow food movement initiated in Italy in the 80s created a greater appreciation of traditional cuisine related to the specifics of soil or 'terroir', so slowing the flow of rainwater in the urban environment will allow a more multi-functional environment to evolve, tuned to its urban, social and physical geography. 'Drainage' is being re-defined from a singular perspective of conveyance to the multiple perspective of clean water, beauty, amenity, biodiversity and long-term health benefits.
We have a new Mayor at the helm in London, who has announced that 'puddles' are a priority! Most children would agree that puddles are fun to play in, but evidently they have a serious side too, where they can cause structural failure of pavements and compromise safety on the road. So perhaps it is ap-

propriate to put the spotlight on puddles, as everyone knows what a puddle is. Perhaps puddles is the password and subliminal acknowledgement that more fundamental Mayoral priorities of health, walking and cycling and improving air quality are all connected, and can all be addressed by an integrated approach to SuDS and green infrastructure planning. To this end, the momentum for change will, I believe, be driven as much from grass roots as City Hall, by those who do not have their heads in the clouds over climate change.

Note

[1] Scottish Environment Protection Agency (SEPA) <https://www.sepa.org.uk> (08/2016).
[2] Capacity building is a conceptual approach to social or personal development that focuses on understanding the obstacles that inhibit people, governments, international organizations and non-governmental organizations from realizing their development goals. See <http://www.gdrc.org/uem/capacity-define.html>.

Web sites

European Climate Adaptation Platform, <http://climate-adapt.eea.europa.eu/water-management> (08/2016).

United Nations Conference on Environment and Development (UNCED) 1992, *Agenda 21*, Chapter 37, Definition: Capacity building, <http://www.gdrc.org/uem/capacity-define.html> (08/2016).

Bibliographic references

CIA/CIRIA 2000, *Sustainable Urban Drainage Systems-Design manual for Scotland & Northern Ireland* (C521), CIRIA, London UK.

CIRIA 2015, *The SuDS Manual* (C753), CIRIA, London UK, <http://www.ciria.org/Memberships/The_SuDs_Manual_C753_Chapters.aspx> (08/2016).

European Parliament & Council 2000, Water Framework Directive 2000/60/EC, *Establishing a framework for Community action in the field of water policy*, 23 October 2000.

Greater London Authority (GLA) 2012, *All London Green Grid, Special Planning Guidance*, <https://www.london.gov.uk/sites/default/files/algg_spg_mar2012.pdf> (08/2016).

Greater London Authority (GLA) 2015a, *London Sustainable Drainage Action Plan*, consultation draft October 2015, <https://www.london.gov.uk/what-we-do/environment/environment-publications/draft-lsdap> (08/2016).

Greater London Authority (GLA) 2015b, *Natural Capital: Investing in a Green Infrastructure for a Future London*, report December 2015, Green Infrastructure Task Force, <https://www.london.gov.uk/sites/default/files/gitaskforcereport.hyperlink.pdf> (08/2016).

Natural England 2011, *London's Natural Signatures: The London Landscape Framework*, January 2011, <http://publications.naturalengland.org.uk/publication/6540238365130752> (08/2016).

Transport for London (TfL) 2014, *Improving the Health of Londoners*, transport action plan, February 2014, <http://content.tfl.gov.uk/improving-the-health-of-londoners-transport-action-plan.pdf> (08/2016).

Transport for London (TfL) 2016, *SuDS in London: A Design Guide*, consultation draft August 2016, <https://consultations.tfl.gov.uk/policy/suds-guidance> (08/2016).

Treeconomics London 2015, *Valuing London's Urban Forest. Results of the London iTree Eco Project* <http://www.forestry.gov.uk/london-itree> (08/2016).