# SuDS as Solutions for Flood Risk Reduction and Climate Change Resilience: London Case Study

## SuDS : des solutions pour réduire le risque d'inondation et répondre au changement climatique. Le cas de Londres

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## RÉSUMÉ

Il est présumé qu'1,4 million de propriétés à Londres, y compris de nombreuses infrastructures sociales, de transport, d'urgence et services publiques londoniens, sont exposées à un risque d'inondation pouvant être causé par des pluies abondantes. Les vastes zones imperméables à travers Londres et la perte de surfaces perméables en faveur d'espaces de stationnement et de lotissement font pression sur le système de drainage londonien et augmentent le risque d'inondation. L'ampleur et la fréquence de la situation risquent de s'aggraver face au changement climatique. Cette communication identifie et évalue le potentiel de la mise en place de systèmes de drainage urbain durable (Sustainable Drainage Systems - SuDS) à travers Londres, permettant une résilience vis-à-vis des différentes hauteurs de précipitations, en utilisant un outil de SIG fait sur mesure, SuDS Studio™. L'approche a utilisé des données standards afin d'identifier des solutions pour chaque site de Londres, pour différentes hauteurs de précipitations. L'outil a évalué la faisabilité d'introduire les systèmes SuDS au cas par cas. Les résultats sont ensuite discutés à l'échelle des quartiers (London Boroughs) et de la ville (Greater London).

## ABSTRACT

A predicted 1.4 million properties in London are at risk from surface water flooding caused by heavy rainfall, including much of London's social, transport, emergency and utility infrastructure. Large impermeable areas across London and the loss of permeable surfaces to parking and development are putting pressure on London's drainage system and increasing flood risk. The situation is projected to worsen in magnitude and frequency with predicted climate change.

The paper identified and assessed the potential for Sustainable Drainage Systems (SuDS) to be retrofitted across London to provide resilience to different rainfall depths, using a bespoke GIS tool, SuDS Studio™. The approach utilised standard datasets to identify solutions for each site across London for different rainfall depths. The tool assessed the feasibility of SuDS retrofit on a site by site basis. The results are then discussed at the London Borough and Greater London (London-wide) basis.

## KEYWORDS

Climate Change Resilience, Planning, Retrofit, SuDS

# 1 INTRODUCTION: BACKGROUND AND AIMS OF THE WORK

A predicted 1.4 million properties in London are at risk from surface water flooding caused by heavy rainfall, including much of London's social, transport, emergency and utility infrastructure. Large impermeable areas across London and the loss of permeable surfaces to parking and development are putting pressure on London's drainage system and increasing flood risk. The situation is projected to worsen in magnitude and frequency with predicted climate change.

The Greater London Authority (GLA) plans to develop a strategic-level framework to deliver actions that better quantify what sustainable drainage could achieve in terms of reducing the burden on existing drainage infrastructure and where it would be most effective. It will promote retrofit of sustainable drainage (SuDS) in addition to supporting London Boroughs in encouraging use of SuDS through planning. The understanding was developed with key stakeholders from the London Boroughs, Environment Agency (environmental regulator) and Thames Water (sewerage undertaker for the area).

# 2 METHODS: A BRIEF DESCRIPTION OF THE METHODS / TECHNIQUES USED

The whole area of the Greater London Authority area was screened using the GIS tool. The method took a source-pathway-sink approach to assessing options. Importantly, the tool assessed and reported connectivity of each option prioritising solutions following the building regulations hierarchy: infiltration, discharge to a waterbody, or reconnection to a pipe (HM Government, 2013).

Each polygon in the study area was assessed to identify whether it could be considered as a source of runoff, or a sink where solutions could be implemented, or in some cases both. Once sources and sinks were defined, routes were identified to relate the source of runoff to the location of the sink, where the solution would be located. A summary of different types of SuDS that are analysed for feasibility for each sink evaluated by SuDS Studio™ (Breton *et al*, 2013) is presented in Table 1.

Considering constraints is crucial to developing meaningful and realistic options, and this functionality is already included in the tool, as a key component of the analysis. A large number of constraints were considered, based on datasets that were freely available to the GLA and other stakeholders.

Contextual constraints and opportunities included geology, listed buildings, priority habitats, traffic calming measures, LiDAR data, distances from waterbodies govern potential for connection to these features. The size of a sink relative to the size of the source area is a constraint on whether a large enough solution can be installed there to deal with all the runoff from the source.

Table 1: SuDS considered in the assessment

| **SuDS considered** | | | |
|---|---|---|---|
| Attenuating rain gardens | Bioretention | Direct discharge to Thames | Disconnect downpipe |
| Filter drains | Gravel paving | Green roof | Permeable paving |
| Pond | Rain garden (box) | Rain gardens (surface) | Soakaway |
| Swales | Tree pit | Water butts | Wetland |

A baseline of current runoff rates was generated by applying a design rainfall event depth to the study area. This was taken from hydraulic models to ensure compatibility with existing drainage and volume reduction estimates during significant rainfall events. Design rainfall depths for 2 year storms, 30 year storms and a predicted 30% increase in rainfall depth were used for the climate change scenario runs. The solutions are reported based on land ownerships where the SuDS solutions will be placed (private (residential or not residential) or public spaces). The 30 year rainfall event response has been used as a baseline scenario.

The feasibility of every SuDS option was assessed for each and every site in the study area. The process moves from the long list of assessed SuDS (Table 1) to a short list of feasible SuDS at every site. The list of feasible options is permanently stored, allowing all feasible solutions to be reported and considered at any point in the future. In addition, the constraints applied to each site were also recorded and reported. The tool then selected the most cost effective solution based on a cost database agreed with project stakeholders.

The results were extensively validated across the area. The purpose of the extended exercise was to improve confidence in the outputs generated.

# 3 RESULTS AND DISCUSSION: A CLEAR PRESENTATION OF THE RESULTS OBTAINED, HIGHLIGHTING ANY TRENDS OR POINTS OF INTEREST

Having successfully undertaken the validation exercise at a site scale, the proven results were then used as the basis of analysis at Borough and London-wide scales. Solutions were plotted and tabulated at a Borough and London-wide scale to investigate the opportunities at each level of study.

As shown in Table 2, as rainfall volumes increase, so the proportion of runoff captured by attenuating rain gardens, disconnection of downpipes and swales increases. Bioretention, filter drains and surface rain gardens, however, decrease in significance by proportion of runoff captured, due to the limited maximum capacity of these solutions.

The effectiveness of solutions for different rainfall events showed only minor variability in performance. Performance decreased from 75% water addressed under the 2 year storm, down to 73% water addressed for the 30 year plus climate change scenario, a remarkably consistent performance.

When surface rain gardens and water butts are removed, to leave only larger scale non-private residential solutions, the overall proportion of runoff removed drops to around 55% for the three scenarios.

Table 2: Breakdown of solutions selected (by type) for anexample Borough

| SuDS type | 2yr | Baseline | CC |
|---|---|---|---|
| Attenuating Rain Gardens | 3.0% | 6.6% | 7.2% |
| Attenuation Pond | 0.6% | 0.5% | 0.5% |
| Bioretention | 3.3% | 1.1% | 0.9% |
| Direct to Watercourse | 0.0% | 0.0% | 0.0% |
| Disconnect Downpipes | 12.3% | 16.6% | 17.9% |
| Filter Drains | 8.8% | 5.9% | 5.3% |
| Gravel Paving | 0.0% | 0.0% | 0.0% |
| Green Roof | 0.4% | 0.2% | 0.2% |
| Permeable Block Paving | 0.0% | 0.0% | 0.0% |
| Rain Garden Box | 0.4% | 0.3% | 0.3% |
| Rain Gardens (Surface) | 26.8% | 24.7% | 23.8% |
| Soakaway | 4.4% | 2.5% | 2.1% |
| Swales | 40.1% | 41.6% | 41.9% |
| Tree pit | 0.0% | 0.0% | 0.0% |
| Water Butts | 0.0% | 0.0% | 0.0% |
| Wetland | 0.0% | 0.0% | 0.0% |

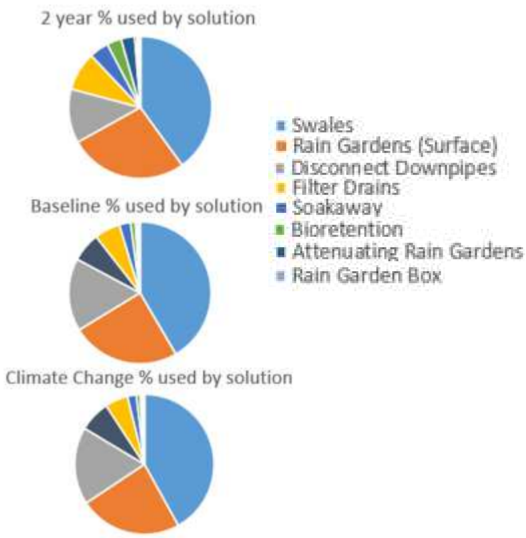


Figure 1 shows the amount of runoff addressed by SuDS across London for the baseline scenario. Central London around Westminster is shown to resolve less runoff (under 50%) than other areas, with the urban fringe having the highest percentage removal, due to the increased number of opportunities for larger solutions such as ponds and swales, where land use is less intense.

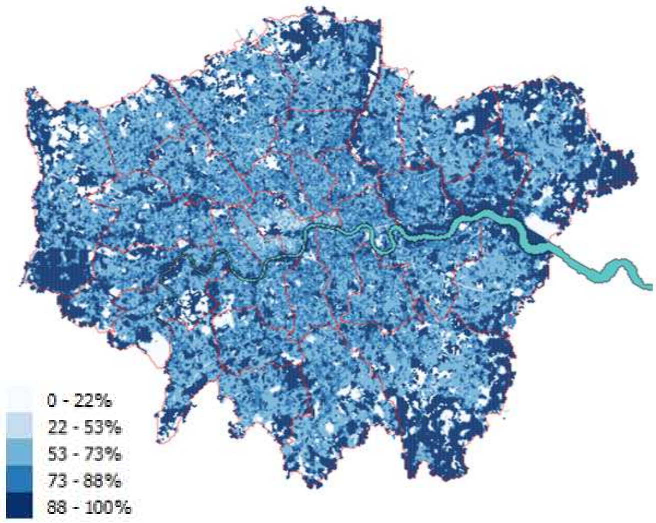


Figure 2: Effectiveness of solutions across London

## 4 CONCLUSION: A BRIEF EXPLANATION OF THE SIGNIFICANCE AND IMPLICATIONS OF THE WORK REPORTED

The paper demonstrates the variability in solutions required to meet the requirements of different design rainfall event depths at scales from source to city-wide level. The capability of SuDS to provide resilience to climate change is demonstrated, and the effectiveness of SuDS to provide solutions to reduce flood risk established. This is of significance in establishing the suitability of SuDS to provide solutions to reduce flood risk from surface water and under capacity pipe networks, as well their potential effectiveness in providing resilience to climate change. The results of this analysis will be used to inform future planning and regeneration plans for the areas. Analysing clusters of different SuDS solutions would inform future policies. Solutions that are related to green infrastructure could be mapped to provide basis for eco-system service assessments.

## LIST OF REFERENCES

Breton, N., Todorovic, Z. & Crayston, F. (2013) *Screening tool for water quality improvements, flood risk management and urban regeneration through surface water flood reduction at a regional scale*. Novatech 2013 Proceedings (J. L. Bertrand-Krajewski & T. D. Fletcher, eds), GRAIE, Lyon, France.

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