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Retrofit SuDS—cost estimates and decision-support tools

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Many urban water quality and flooding problems may potentially be addressed by disconnecting stormwater from the formal drainage system and installing source control sustainable drainage systems (SuDS) instead. This approach is referred to as SuDS retrofit. This paper focuses on the construction costs associated with a range of SuDS devices likely to be implemented in a retrofit context. Three distinct types of costs have been prepared. The costs of construction per device are provided as unit costs. This approach does not, however, enable devices to be compared in terms of an area served. For this reason, schemes have been designed and costed according to representative contributory areas, such as a residential roof or a small car park. These contributory area-based cost comparisons are embodied within a decision-making framework for retrofit SuDS. A case study highlights how secondary costs need to be combined with device unit costs accurately to cost the construction of a whole scheme. The evaluation indicates that infiltration basins represent the cheapest form of SuDS to construct, followed by soakaways, ponds, infiltration trenches and porous pavements. This ranking does not, however, take account of land purchase or sterilisation costs, potential conflicts with requirements for high-density developments or other life-cycle costs—these could alter this preference ranking significantly.

1. INTRODUCTION

Many urban areas experience problems with excessive combined sewer overflow (CSO) discharges and/or flooding (from the sewer network), with consequent aesthetic and water quality impacts. These problems are frequently associated with inadequate capacity in the stormwater management system. Improving upon these discharges is a key aspect of present and future legislation aimed at water quality improvements.

Sustainable drainage systems (SuDS) is a generic term that refers to various measures aimed at managing surface water runoff (and consequent flooding and pollution problems) from urban catchments. SuDS may be ‘non-structural’ or ‘structural’. Non-structural SuDS include the use of education and/or incentives to modify human behaviour. Structural SuDS include, among others, green roofs, soakaways, swales, infiltration trenches and balancing ponds. Because of their reliance on natural catchment processes (i.e. infiltration, attenuation, conveyance, storage and treatment) these technologies are viewed by many to constitute a ‘more sustainable’ approach to the management of urban storm runoff than conventional underground pipe and storage-based solutions.

The Environment Agency (EA) and the Scottish Environment Protection Agency (SEPA) are both actively promoting the increased use of SuDS in order to ensure that new development effectively mitigates for its associated environmental impacts. There is considerable international evidence of the successful incorporation of SuDS technologies into new developments, and the approach has been endorsed by the UK Government’s Planning Policy Guidance Note 25 (PPG 25) and Planning Policy Statement 25 (PPS25) on Development and Flood Risk. The current authors believe, however, that the potential to make use of SuDS within existing urbanised areas has been under exploited.

The term *retrofit* is employed when SuDS-type approaches are intended to replace and/or augment an existing (combined or separate) drainage system in a developed catchment. Retrofit SuDS may be relevant in any situation where insufficient stormwater management capacity leads to poor performance of the urban drainage system. This includes problems associated with excessive CSO discharges, separate storm sewer outfalls, flooding of urban watercourses and/or restrictions to further development imposed directly as a result of insufficient spare capacity in the existing drainage system. Examples of retrofit SuDS might be the installation of green roofs, the diversion of roof drainage from a combined sewer system into a garden soakaway or the conveyance of road runoff via roadside swales into a pond sited in an area of open space.

Feasibility studies relating to the potential usage of retrofit SuDS in two UK catchments[1] have suggested that SuDS could provide cost-effective hydraulic improvement, either as fully SuDS-based or partially SuDS-based rehabilitation strategies. In one case it was found that a SuDS-based solution could provide the necessary hydraulic control (in terms of reduced spill volumes) at 50% of the construction cost of a conventional storage-based solution. In a separate study of options for alleviating inner-city sewer flooding and reviewing urban expansion needs,[2] it was found that a mixed SuDS/conventional solution would be more cost-effective and less disruptive during construction than a simple conventional approach. Although these UK proposals have not yet been implemented, there are several international examples of this type of approach being successfully implemented, including the

Portland (Oregon, USA) downspout disconnection programme,[3] the extensive SuDS retrofit undertaken in Malmö (Sweden)[4] and advanced proposals for the Emscher basin in Germany.[5]

Although retrofit SuDS-based approaches appear (on paper) to represent a viable and cost-effective alternative, English and Welsh water utility companies have been slow to implement them. This reflects a series of legal and regulatory constraints, in addition to the relative novelty of the technologies. A major legal hurdle relates to the issue of adoption. Water utilities are currently unable to build/adopt SuDS because they are not legally described as 'sewers' in *Sewers for Adoption* (5th edn).[6] The National SuDS Working Group in England and Wales has, however, produced an '*Interim Code of Practice for Sustainable Drainage Systems*',[7] in association with model maintenance agreements,[8] and it is likely that mechanisms will increasingly be found to overcome these obstacles.

It is worth noting that at the time the research described in the present paper was undertaken, very little information was available on the design of retrofit SuDS, SuDS maintenance requirements or construction and operational costs of SuDS within the UK. The costing approach described in later sections of this paper was developed as an interim measure to bridge that gap, ahead of more robust cost data becoming available. A number of subsequent publications have provided very valuable insights into 'real' construction and maintenance costs, and more data will become available as experience with SuDS increases. The Construction Industry Research and Information Association (CIRIA) SuDS design manual[9] discusses the construction, maintenance and whole-life costs of SuDS devices. More detailed guidance on the costs associated with SuDS technologies is presented in other literature.[10]

It should also be appreciated that retrofit SuDS have the potential to assist urban planners meet their sustainability objectives by providing amenity, community and biodiversity benefits in tandem with stormwater management. This approach is therefore in harmony with '*Making Space for Water*'.[11]

In Scotland, the 2003 Water and Environment and Water Services Bill gave Scottish Water statutory powers to adopt and maintain all public SuDS (from 2005). These legislative changes suggest that guidance on the use of SuDS—including retrofit applications and with reference to cost issues—is required. Scotland and Northern Ireland Forum for Environmental Research (Sniffer) has recently published a report to help address the lack of UK design guidance for retrofit SuDS.[12] The Sniffer approach builds upon a decision-making framework for the identification and evaluation of retrofit SuDS-based candidate solutions for sewer rehabilitation proposed by Swan and Stovin.[13] The original framework is briefly described in the following section, while the methodology used to derive comparative costings for retrofit SuDS is considered in the remainder of this paper.

2. A DECISION-SUPPORT SYSTEM FOR RETROFIT SUDS

The decision-support framework presented by Swan and Stovin[13] was aimed at efficiently identifying retrofit SuDS options that will deliver hydraulically effective solutions and that are straightforward and cost-effective to implement. Flowcharts were prepared to direct the engineer to consider the range of options in a logical and efficient manner. The flowcharts embody four hierarchies (see Table 1) constructed around urban surface type, the surface water management train concept, the mode of operation of the device and cost. Further work is currently underway[14,15] to extend the scope of this framework to deliver solutions that offer water quality improvements.

The flowcharts direct the user to consider institutional roofs before residential roofs, source controls before off-site controls and infiltration systems in preference to storage-based systems; the cheapest options within each category are highlighted. This framework has been applied to derive a potential retrofit SuDS scheme for the Meanwood catchment in Leeds.[16] The present paper focuses on the way in which the comparative costings embodied within the framework were derived.

3. COST MODELS FOR RETROFIT SUDS

3.1. Introduction

Unit construction costs were developed for a range of potential retrofit SuDS technologies. These unit costs were largely based upon basic cost data from the Spon publications *Civil Engineering and Highways Works Price Book*[17] and *Landscape and External Works Price Book*.[18] Both publications present costs for a wide range of basic civil engineering work items such as excavation, backfilling and re-grassing (it should be noted that the costs presented exclude value added tax (VAT), land take costs, contractor's profit margins, design or supervisory works). All cost estimates presented within this paper include a contractor's profit margin of 10% and VAT at 17·5%, but exclude additional costs such as those associated with design, supervision and compensation payments to injured parties. Reference was also made to the water services regulation authority (OFWAT)'s unit costs for capital works in the water industry.[19] Specific details on how all costs presented in this paper were compiled can be found in Swan.[20]

	Increasing complexity (in terms of detailed design work required) →			
	Urban surface type	Surface water management train	Mode of operation	Cost
Deceasing order of preference ↓	• Institutional roofs • Car parks • Residential roofs • Highways	• Source control • Conveyance and off-site control	• Infiltration • Disposal • Storage • Reuse	• Cheapest • Most expensive

Table 1. The four hierarchies of the retrofit SuDS decision-making framework[12]

3.2. Unit costs for retrofit SuDS

Table 2 presents unit construction costs for a number of retrofit SuDS technologies that were selected because they were considered to represent appropriate design dimensions for typical urban applications. For example, the infiltration trench and soakaway examples correspond to the design examples adopted in Building Research Establishment (BRE) guidelines.[21] When high and low unit costs are presented for a specific technology, these correspond to cost differences that result from different site characteristics (e.g. soil conditions) or construction materials. These values do not include unforeseen risks that—for retrofit SuDS—might include the unanticipated need to move or work around unmapped services, or contaminated land. These risks will generally be higher for urban retrofit applications than for new 'greenfield' SuDS. The costs for ponds/basins do not include landscaping/vegetation because there was virtually no relevant information in the public domain pertaining to these costs at the time this research was undertaken. Storage tanks were assumed to be reinforced concrete units rather than the modular plastic systems that have become more commonplace in recent years. The latter would be expected to represent a significant cost saving.

Many of the unit costs presented in this table are not stand-alone items, but would generally be used in conjunction with one or more of the other items to produce integrated SuDS solutions or treatment trains. For example, the cost of swales might be considered as a stand-alone solution or in conjunction with the costs of an off-site control facility. The water butt cost includes connection costs, as a water butt might be assumed to be located adjacent to a property and connection costs will therefore be relatively fixed and predictable. For other devices, connection costs will be a function of connection length and site constraints, and it is not useful to present these as standard values. These costs are considered as secondary costs, which are considered more fully in the case study presented in section 3.4.

It is not appropriate to compare these unit construction costs with one another at this stage, as they have different capacities.

Technology	Items included in costing	Unit construction cost	
		High	Low
Water butt (0·3 m^3)	Water butt (0·3 m^3) Installation Connection of feeder pipe	£242·93 per property	£100 per property
Infiltration trench BRE 365 design example: 0·6 m (width) × 2·5 m (depth) (1·5 m effective depth)	Excavation Placing of filter material Horizontal distributor pipe Geotextile filter membrane Backfilling Reinstatement Note: all pipework 225 mm (excludes costs of connection)	£99·16 per m length	£73·88 per m length
Swales 2 m wide × 200 mm deep to be excavated in existing grass verges	Excavation (by hand) Disposal of excavated soil Reinstatement Grassing (turfing) (excludes cost of connecting paved or roofed areas)	£20·28/m (compacted soil)	£17·71/m (loose material)
Soakaway BRE 365 design example: 2·4 m (long) × 1·5 m (width) × 2·5 m (depth) (1·5 m effective depth)	Excavation (by hand) Geotextile filter membrane Backfilling Reinstatement (excludes costs of connections)	£551·80 per soakaway (compacted soil)	£453·67 per soakaway (loose material)
Porous car park Using Grasscrete precast concrete units filled with top soil and grass-seeded	Lighting Drainage Forecourts Aprons Access areas (excludes approach roads)	—	£63·33/m^2
Ponds/basins	All excavation Pipework	£55/m^3	£35/m^3
Separate sewerage	150 mm pipe ~1 m depth below paved surface Reinstatement to paved	£173·84/m	—
Storage tanks Using reinforced concrete	All excavation Fill Structural work Valves Pipework	£518·29/m^3	£448·50/m^3

Table 2. Generic unit construction costs for retrofit SuDS

Technology	Relevant design guidelines	Design dimensions
Soakaways	BRE 365 (1991)	$1.5 \times 1.8 \times 1.8$ m (effective depth × length × width)
Infiltration trenches	CIRIA 156 (1996)	$0.6 \times 1 \times 7.5$ m (width × depth × length of base)
Basins	CIRIA 156 (1996)	$1 \times 1 \times 1$ m (width × depth × length)
Ponds	10 yr storm (FoS = 2)	5·3 m^3 (volume)
Porous pavements	CIRIA 156 (1996)	16 m^2 (area) 4×4 m (length × width)

Table 3. SuDS design dimensions required to drain 50 m^2 of contributory area (e.g. a single residential roof)

For example, when considered in volumetric terms (i.e. per cubic metre), the excavation costs associated with ponds and basins may be comparable. The required volume for a pond will, however, be larger than a basin for the same drainage catchment area because the pond will include a permanent pool and may also include an additional allowance for its water quality function. The following two sections provide cost comparisons based on representative contributory areas and a specific case study.

3.3. Retrofit SuDS costings for representative contributory areas

One of the requirements of the decision-support framework mentioned above was to be able to identify the most cost-effective option for a specific disconnection scenario, such as a single residential roof or a small car park. Costs were therefore derived for all potential retrofit SuDS options for each of four representative contributory impervious areas (50, 200, 500 and 2000 m^2): 50 m^2 was chosen to represent a single residential roof, 200 m^2 would be more typical for an institutional roof and 500 m^2 represents a small car park or stretch of road. The two larger areas also represent groups of multiple residential or institutional roofs that might be served by off-site controls.

Specific SuDS technologies were designed to drain runoff from each of these representative contributory areas. The design work for these SuDS proposals was undertaken in accordance with relevant UK design guidelines that were available in 2001. These designs were heavily reliant on CIRIA Report 156,[22] which has now been superseded by CIRIA Report C609.[9] The design dimensions (and hence relative costs) are, however, unlikely to have altered significantly. Tables 3 and 4, for example, present the design dimensions that were developed to serve impervious areas of 50 and 500 m^2 respectively. These design dimensions were generated using a critical 10-year rainfall event and a soil percolation rate of 4.63×10^{-6} m/s. Although infiltration rates as low as 2.78×10^{-10} m/s (0·001 mm/h) are judged to be feasible for the use of infiltration SuDS, the value of 4.63×10^{-6} m/s adopted here related to the case study considered later. Clearly the costs of infiltration structures will tend to increase as the infiltration capacity of the soil reduces. For ponds, it was assumed that the pond volume should equate to the volume of the 1 in 10-year surface runoff volume, multiplied by a factor of safety (FoS) of 2.

Table 5 presents direct construction costs that were generated for these SuDS devices; the table neglects secondary costs associated with connection of the contributory impermeable surface. An indication of conveyance costs is included. Fig. 1 compares construction costs of alternative SuDS technologies to drain a 50 m^2 contributory impervious area.

These results indicate that infiltration basins represent the cheapest form of SuDS device, followed by soakaways, ponds, infiltration trenches and porous pavements. Variations between costs are large. In the 50 m^2 contributory area scenario, for example, soakaways are 3·3 times more expensive than infiltration basins and porous pavements are 12·6 times more expensive. The large variation in these different technology costs underlines the need for accurate SuDS costings, and reinforces the fact that economic issues can have a significant bearing on the viability/feasibility of potential SuDS schemes.

It is not surprising that the analysis suggested infiltration basins to be the cheapest form of SuDS technology as they require less excavation than other surface-based SuDS devices (e.g. ponds) and fewer additional materials for backfilling than sub-surface

Technology	Relevant design guidelines	Design dimensions
Swales*	CIRIA C522 (2000)[23]	0.4×0.2 m (1:4) base × depth (side-slopes)
Filter drains*	Highway Construction Details (Highways Agency, 1998)[24]	1.5×0.6 m × length (depth × width) (+150 mm dia. pipe)
Separate sewerage*	Manning's formula	150 mm (diameter)
Soakaways	BRE 365 (1991)	$2 \times 5.3 \times 5.3$ m (effective depth × length × width)
Infiltration trenches	CIRIA 156 (1996)	$1 \times 1 \times 51$ m (width × depth × length of base)
Basins	CIRIA 156 (1996)	$1 \times 3.2 \times 3.2$ m (depth × length × width)
Ponds	10 year storm (FoS = 2)	53·3 m^3
Porous pavements	CIRIA 156 (1996)	157 m^2 (area) 12.5×12.5 m (length × width)

*Conveyance options
All infiltration structures assume an infiltration capacity of 4.63×10^{-6} m/s

Table 4. SuDS design dimensions required to drain 500 m^2 of contributory area (e.g. a group of ten residential roofs or a small car park/ stretch of road)

Technology	Surface area served: m^2	Construction costs: £	
		Highest	Lowest
Soakaways	50	324·53	268·94
	200	767·48	623·18
	500	3055·77	2413·15
	2000	11 819·15	9156·17
Infiltration trenches	50	638·78	503·26
	200	1622·13	1210·19
	500	4959·63	3853·54
	2000	16 568·86	12 361·26
Basins	50	91·20	80·51
	200	266·57	223·81
	500	588·11	478·65
	2000	2071·69	1606·08
Ponds	50		391·10
	200		1365·30
	500		3413·30
	2000		4716·10
Porous pavements (costs for new car parks)	50		1013·32
	200		3989·95
	500		9943·20
	2000		39 836·14
Porous pavements (replacement surface)	Price per m^2		27·13
Swales*	Price per m	20·28	17·71
Filter drains*	Price per m		61·44
Separate sewerage*	Price per m		173·84

*Conveyance options
All infiltration structures assume an infiltration capacity of $4{\cdot}63 \times 10^{-6}$ m/s

Table 5. Construction costs of alternative SuDS technologies for representative contributory areas

SuDS (soakaways, infiltration trenches and porous pavements). Soakaways were highlighted as the cheapest sub-surface option because excavations are concentrated in a specific location rather than being spread across a much larger area, as with infiltration trenches and porous pavements. The high comparative costs of pond schemes largely relate to the FoS of 2 included in their design in order to allow runoff from previous storms to be accommodated. It should be noted that planting and landscaping costs have not been included and these could be a significant cost in relation to ponds. Porous pavements represented the most expensive of all the SuDS devices investigated in this study, but perform a dual role as drainage device and, for example, car park.

This exercise provides an indicative theoretical cost comparison for different technologies. It is acknowledged that, in reality, many site-specific characteristics (e.g. land availability and cost) would have a significant bearing on construction costs and design options.

It is worth noting from Table 5 that the costs associated with porous pavements appear to vary linearly with respect to the area served. This is not, however, the case for all technology types. For example, in the case of ponds, the additional costs associated with serving additional areas diminish as the area served increases in size; this relates to the economics of scale associated with excavation, planting and waterproof lining costs.

The comparative costs presented in Table 5 are embodied within the decision-making framework described above. For example, the residential roofs portion of the flowchart utilises the 50 m^2 representative contributory area data to rank the potential technology options on the basis of cost.

3.4. Case study costings for retrofit SuDS

This section outlines how costings were derived for the range of retrofit SuDS options judged to be technically feasible in the context of a specific case study catchment. The main difference between these and the previous costings is that the case study includes secondary costs arising from disconnection and transfer of the stormwater from the existing sewer system to the SuDS device.

The Meanwood catchment is situated 4 km to the north west of Leeds city centre. It covers an area of 55·8 ha and is largely served by a combined sewer system. During extreme storm events (approximately once per year) the trunk sewer surcharges, resulting in local flooding problems. Retrofit SuDS were considered as a potential option for addressing flooding, although it was envisaged that some conventional rehabilitation would almost certainly also be required.[16,20]

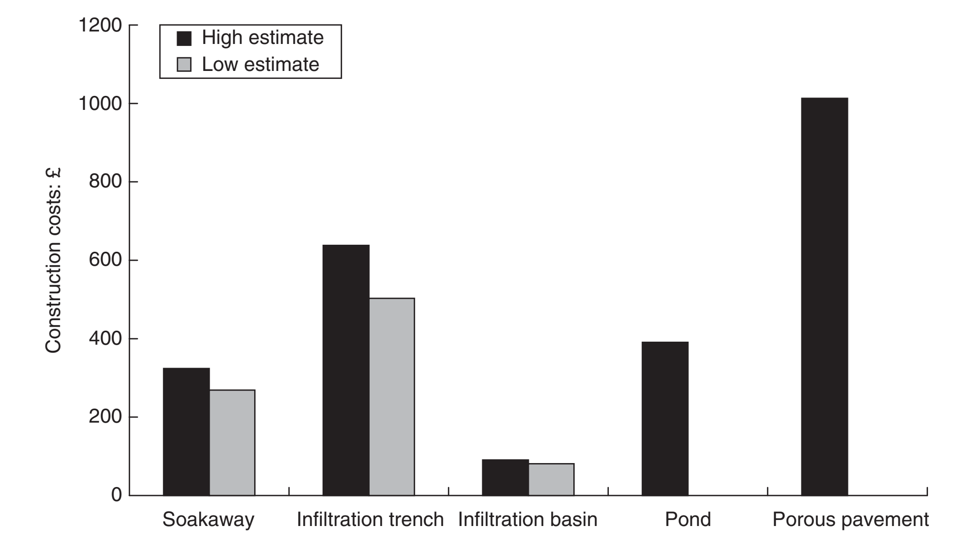

Fig. 1. Construction costs of alternative SuDS technologies for a 50 m^2 contributory area

The catchment largely consists of twentieth-century housing, retail premises and a small number of institutional buildings. None of these institutional buildings is connected to Meanwood's combined sewerage system, so the proposed solutions focused on the disconnection of residential properties and paved areas. The residential

		Paved area disconnected: ha	Roofed area disconnected: ha	Total area disconnected: ha	Cost: £	Cost/m² disconnected area: £
Soakaways to every roof within sandstone region		0	3·022	3·022	178 183	5·90
Construction of 1065 m of infiltration trenches to serve 86 properties within sandstone region		0	0·473	0·473	111 478	23·57
Swales to all grassed verges (roofs only)	Off-site control proposal					
	• Infiltration trenches	0	1·900	1·900	264 297	13·91
	• Porous pavement	0	1·900	1·900	509 348	26·81
	• Infiltration basin	0	1·900	1·900	197 847	10·41
Swales to all grassed verges (paved areas only)	Off-site control proposal					
	• Infiltration trenches	2·886	0	2·886	352 953	12·23
	• Porous pavement	2·886	0	2·886	727 045	25·19
	• Infiltration basin	2·886	0	2·886	263 191	9·12
Swales to all grassed verges (both paved and roofed)	Off-site control proposal					
	• Infiltration trenches	2·886	1·900	4·786	517 140	10·81
	• Porous pavement	2·886	1·900	4·786	1 149 172	24·01
	• Infiltration basin	2·886	1·900	4·786	353 785	7·39

Table 6. Summary of the Meanwood case study costs

areas contain mostly semi-detached housing, with a small number of detached and terraced properties. The use of infiltration devices was considered to be viable within the central sections of the Meanwood catchment since much of this region is founded upon sandstone deposits. The soil conditions of the remainder of the catchment (clay and mudstone) are, however, less suitable for infiltration. The catchment also contains significant amounts of grassed and wooded areas, offering potential for off-site controls. The Meanwood catchment is not part of a groundwater protection zone and therefore the infiltration of surface waters is permissible within this locality. The options considered were

(*a*) disconnection of residential properties to garden soakaways (sandstone region);
(*b*) disconnection of residential roofs to local infiltration trenches (sandstone region);
(*c*) disconnection of residential roofs and/or paved areas to off-site controls (infiltration trenches, porous pavements or infiltration basins) using a network of swales for conveyance.

Although infiltration basins were demonstrated to be the cheapest retrofit source control, they were not considered as appropriate for source control applications in the Meanwood catchment due to space restrictions in residential plots.

Costings for each of these options are presented in Table 6. In this case the costs per square metre of disconnected impermeable area include secondary unit costs (i.e. costs of disconnecting roof drainage from the sewer and into the receiving SuDS device). One example of a secondary cost was an additional £150 per property to disconnect roof water from the sewer system and transfer it to a garden soakaway. It is evident from Table 6 that the use of soakaways represents the cheapest option (£5·90/m²). This approach is, however, only applicable to the 3·022 ha roofed areas contained in Meanwood's sandstone region. The off-site proposal costs were based on the disconnection of a total of 2·886 ha paved area and 1·9 ha residential roof area.

This exercise highlights that the soakaway option (source-based control) is cheaper than all of the off-site proposals. The cost of disconnecting 1 m² using infiltration trenches (essentially also a source control) is, however, more than four times that associated with soakaways and—perhaps surprisingly—considerably more expensive than many of the off-site controls. This reflects the fact that this approach requires its own conveyance network to convey runoff from a roof to a property's boundary with an adjacent field in which the infiltration trench would be located. Source-based controls may therefore not always provide a cheaper option than off-site controls even though they might be logically preferable from a SuDS 'surface water management train' perspective.

The complete solution for Meanwood[16] also incorporated water butts for those residential properties that were neither in the sandstone region nor readily connected to the swale network, alongside a minimal amount of re-sewerage work. The costing procedures associated with storage-based devices (e.g. ponds and tanks) are already well established and presented explicitly in the literature.[17,18] It was estimated that this hybrid solution (part retrofit SuDS, part re-sewerage) proposed for Meanwood would cost around 12% less than a storage-based conventional solution.[1]

4. DISCUSSION

The costs presented were calculated using fairly basic procedures and are intended to give only a rough indication of likely construction costs. The main use of these costs to date has been to enable priority to be given to the least (construction) cost option in the retrofit SuDS decision-making framework. There has been little opportunity to evaluate how realistic these costs are in practice. The presented data should not be taken out of context and clearly are not intended to be substituted for proper site-based costings on specific projects.

The costings presented here relate to the primary costs associated with construction and do not reflect land prices or more long-term (whole-life) cost issues such as maintenance and replacement. The Water Environment Research Foundation or UK Water Industry Research (WERF/UKWIR) report[10] includes spreadsheet-based tools aimed at providing comprehensive whole-life cost estimates for retention ponds, detention basins, swales, filter drains and permeable pavements relevant to the UK. The report does not, however, provide an explicit comparison of the relative costs of these alternative devices. The present paper has proposed the concept of representative contributory areas as a basis for comparing costs. There is an obvious opportunity to update and refine the hierarchies embedded within the decision-support tool by using the WERF/UKWIR spreadsheet to compute more comprehensive costings for representative contributory areas.

5. CONCLUSIONS

Costs of constructing retrofit SuDS devices have been presented. The range of devices considered reflects the range of devices likely to be implemented in a retrofit context. Three distinct types of costs have been analysed. Unit costs provide the costs of construction per device. This approach does, however, not enable devices to be compared in terms of area served. For this reason, schemes were designed and costed according to representative contributory areas such as a residential roof or a small car park. These contributory area-based cost comparisons are embodied in the decision-making framework for retrofit SuDS. The Meanwood case study has briefly highlighted how secondary costs (i.e. the costs involved in disconnecting a roof from a combined sewer and transferring it to a SuDS device) need to be combined with device unit costs accurately to cost the construction of a whole scheme. In the case of Meanwood, it appeared likely that the use of retrofit SuDS instead of a conventional solution could result in cost savings.

The concept of SuDS retrofit offers an exciting and versatile, yet currently underexploited, opportunity for stormwater management in urban areas. The status of knowledge, experience and legislation in this field is changing rapidly. The research described in this paper is one of many current initiatives, involving many different stakeholders, to enable the effective and appropriate use of SuDS retrofit.

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