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Sustainable Urban Drainage Systems (SUDS) in Scotland: Assessment of Monitoring and Maintenance within Local Authorities and Scottish Water

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1 Executive summary

A clear need for increased SUDS monitoring has been identified. This report explores:

i) how information on SUDS is retained by local authorities in Scotland, and

ii) how this information is used to secure appropriate management, monitoring and maintenance of SUDS components.

2 Key findings

- Respondents knew what types of SUDS their organisation was responsible for but record keeping of the exact number of each component was limited.
- Detention basins were most commonly seen across Scotland, followed by filter drains, retention ponds, soakaways and swales. Record keeping in a GIS database is becoming more common practice and is the most efficient way for inspection teams to access SUDS records. Improvements are needed for storing information and all local authorities would benefit from moving to a digital record system.
- Current SUDS monitoring and evaluation is more commonly achieved on an informal, *ad-hoc* basis and not at regular intervals as recommend by The SUDS Manual. Respondents felt current levels of monitoring and evaluation were either 'reasonable' or 'not very effective'.
- Maintenance is more commonly conducted on a reactive basis, as and when required, due to limited resources and budgets. Litter picking, grass-cutting and vegetation were more commonly managed. Finance was found to be the biggest barrier to maintenance and successful implementation of SUDS, with either no dedicated funds or money coming from department revenue budgets. There is a need for maintenance to become more formalised and cyclic.
- Earlier and more frequent communication is needed between departments within the Council, and with Scottish Water particularly over vesting and sharing maintenance of SUDS. This will be more important going forward under Section 7, as part of the Sewerage (Scotland) Act 1968.

These results may benefit from a further phase of work examining monitoring and maintenance as Section 7 becomes more common practice. It would also be beneficial to collect data on the performance of SUDS schemes over time, to improve their future implementation, monitoring and maintenance. Case studies of good and bad practice should be collated and shared for future improvements.

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1. Introduction

1.1 Sustainable Urban Drainage Systems (SUDS)

Management of surface water runoff has led to the implementation of water infrastructure systems which are designed to handle daily rainfall, control extreme events e.g. a 1 in 100 year rainfall event and build resilience to climate change impacts (Melville-Shreeve et al., 2018). This has involved wide, but not routine, installation of sustainable urban drainage systems (SUDS) to alleviate urban flooding (Woods-Ballard et al., 2015). SUDS consist of small-scale water management practices and facilities that are designed to drain surface water in a more sustainable manner than what has been the convectional practice of routing run-off through a pipe to a watercourse. SUDS can minimise flooding and pollution by capturing and controlling storm water runoff at source (Martin et al., 2001). For example, SUDS would help manage surface water as close to the source as possible by slowing down the rate of runoff and treating it naturally e.g. in a pond system by natural processes of sedimentation, filtration and biodegradation, thereby allowing the controlled release of good quality excess surface water back into the natural water cycle via watercourses or groundwater. There are four general methods of control:

- Filter strips and swales
- Filter drains and permeable surfaces
- Infiltration devices
- Detention basins, ponds and wetlands

There is also emphasis that SUDS should not be thought as an individual component (e.g. filter strip, swale etc) but as an interconnected, integral system designed to manage, treat and make better use of surface water. Other components highlighted in The SUDS Manual (Woods et al., 2016) include: rainwater harvesting, green roofs, trees, bioretention systems, attenuation storage tanks and proprietary systems. Increasingly, SUDS are also being recognised for providing wider benefits such as for biodiversity and amenity (Butler and Davies, 2010). SUDS are therefore being designed to address these three essential issues: i) quantity of surface water runoff, ii) quality of surface water runoff, and iii) amenity. There are barriers to SUDS uptake, for example, construction costs, land take, long-term performance and the uncertainty surrounding their maintenance and adoption (Bastien et al., 2010). A key challenge to the future of the United Kingdom is adapting to the impacts of climate change where more intense rainfall, and greater periods of hot, dry weather are predicted (IPCC, 2014). This challenge could be helped by the successful design, operation and maintenance of SUDS.

1.2 Statutory and policy background in relation to SUDS

The European Union Water Framework Directive (European Commission, 2000) was transposed into UK national legislation in 2003 which takes account of all objectives for which the aquatic environment is protected and ensures that measures taken to achieve the objectives are coordinated suitably. The Directive encourages a more sustainable approach to drainage, and a basic requirement is for the implementation of measures that prevent and control diffuse sources of pollution. This means that urban runoff discharges have to be managed such that their impact on the environment is mitigated, therefore SUDS provides a means of addressing the requirements of the Directive. The Flood Risk Management (Scotland) Act 2009 also introduced a more sustainable approach to flood risk management and provides a framework for greater coordination and cooperation between all organisations involved in flood risk management. Sections 17 and 18 require local authorities to map bodies of water and SUDS and prepare a schedule of clearance and repair works. The implementation of SUDS is expected to help secure the objectives arising in the Act. The Surface Water Management Planning Guidance document also has a useful list of the role and responsibilities in relation to surface water flooding in appendix 2.

The obligation for SUDS to be delivered within all new housing developments is contained within legislation and national policy. The Scottish Environmental Protection Agency (SEPA) is the statutory agency responsible for protecting Scotland's water environment under the Water Environment and Water Services (Scotland) Act 2003 (WEWS). Under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 it is a general requirement - with two exceptions relating to single dwellings and discharge directly entering coastal waters - for new developments with surface water drainage systems discharging to the water environment that such discharges will pass through SUDS. Therefore, SEPA requires appropriate use of SUDS features in new developments, particularly for controlling the quality and rate of surface water discharge to water courses. The Controlled Activities Regulations (CAR) also provides regulation under general binding rules (GBRs) 10 and 11 for SUDS (SEPA, 2018)

Scottish Water is the statutory corporation that provides water and sewerage services across Scotland, and under the WEWS Act, Scottish Water are responsible for future maintenance and capital replacement of public SUDS. Any new SUDS infrastructure is now required to meet certain standards before additional investment is granted, and surface drainage should be designed in accordance with the most up to date version of 'Scottish Water's Sewers For Scotland' document. Section 7 of the Sewerage (Scotland) Act 1968 allows road authorities and Scottish Water to enter into management and maintenance agreements for surface water sewers and drains.

At the national planning policy level, good practice advice for planners and developers can be found in 'Planning Advice Note (PAN) 61: Planning and Sustainable Urban Drainage Systems (2001)', which complements The SUDS Manual C753 (2015). PAN 61 acknowledges the integral approach SUDS take to address water quantity, quality and amenity and it also encourages developers to approach the planning authority at an early stage to explore which SUDS measures are attainable. At the local planning policy level, Local Development Plans also have SUDS requirements that vary between local authorities. There are numerous items of legislation, regulations, and design guidance documents available for SUDS online, with a list of key items provided in Appendix II.

1.3 Monitoring and maintenance of SUDS

Monitoring and maintenance of SUDS (Figure 1) is important as poor design and maintenance can result in the system failing to perform to standard, potentially causing impact on localised flooding, and damage to the SUDS infrastructure, adjoining property and land. Guidance on SUDS operation and maintenance requirements can be found in current SUDS documentation, particularly: Sewers for Scotland (3rd Edition), The SUDS Manual C753 (2015), and SUDS for Roads (2015). The SUDS Manual suggests there is a need for developers to produce maintenance schedules, and to ensure that a person or body is responsible for SUDS upkeep.

Where SUDS features collect water from both roads and curtilages (land immediately surrounding a house or dwelling), the maintenance responsibility lies jointly with the local authority and Scottish Water. The developer should therefore agree on maintenance responsibility during the pre-application stage with both organisations, and a formal agreement put in place once the planning application process has concluded. Any drainage infrastructure which a Council becomes responsible for maintaining should be included in the Roads Construction Consent (RCC) application under the Roads (Scotland) Act 1984.

There may also be occasions when the SUDS system is only vested by Scottish Water which would be confirmed during the planning stage. Full details of Scottish Water's vesting process can be found in the Sewers for Scotland document. It includes issuing a Vesting Certificate, with the developer remaining responsible for all costs associated with hard blockages or defects until the end of a 2 year guarantee period from the date of Certificate issue.

If SUDS features collect road-only water e.g. in a swale, then maintenance responsibility would lie within the local authority, and confirmed during the pre-planning stage. Before any formal acceptance of agreed maintenance duties, the developer would have to follow requires of the RCC process. Similarly, any curtilage SUDS would become the responsibility of Scottish Water or the property owner, with the

ownership and maintenance clearly established with the developer if connecting to the public drainage system during the planning application stage.

During the planning application stage, each SUDS feature must be submitted with a maintenance schedule that identifies inspection frequencies, regular maintenance work and who will be responsible for the work, with preference to a perpetuity body. A Design Risk Assessment (DRA) is also submitted during this stage, which includes maintenance related health and safety risks. For example, basin and pond SUDS features should be accessible to allow monitoring and maintenance.

The SUDS Manual also recommends that maintenance schedules should be regularly assessed e.g. annually, to ensure the approach is meeting the SUDS objectives. Ideally an operation and maintenance manual should also be provided by the developer for SUDS within a development which will have information such as locations, visual indictors that would trigger maintenance, silt depth that triggers removal, etc.

There are also numerous factors that influence the type and frequency of SUDS maintenance required, for example, if the SUDS have an aesthetic function for amenity value, higher vegetation and grass cutting might be needed. Maintenance activities (Figure 1) can be broadly defined as:

1) Regular maintenance i.e. basic tasks carried out to a frequent and predictable schedule, including inspections/monitoring, silt or oil removal, vegetation management, surface sweeping, grass cutting, litter and debris removal.
2) Occasional maintenance i.e. periodically required tasks such as filter replacement and sediment removal, vegetation replacement, and responding to and cleaning up after extreme rain events.
3) Remedial maintenance i.e. intermittent tasks to rectify faults associated with the system or major sediment removal activities but timings are more difficult to predict.

Some SUDS also have initial one-off 'establishment maintenance' requirements, particularly for planting. SUDS maintenance is carried out by a variety of people, for example roads authorities, landscape contractors, facilities management companies and school caretakers. The SUDS Manual also recommends that during the first year of operation, monthly inspections should be carried out and after large storm events to ensure proper system functioning. The maintenance section in the SUDS Manual tends towards a frequency requirement, ensuring a predictable care standard and providing a baseline for pricing work. This is typically a monthly inspection as it is the standard site attendance requirement in a landscape specification. Certain tasks fall out with period e.g. wetland vegetation management, silt management, sweeping permeable surfaces, and should be accommodated in a contract.

Operation and maintenance activity	SuDS component												
	Pond	Wetland	Detention basin	Infiltration basin	Soakaway	Infiltration trench	Filter drain	Modular storage	Pervious pavement	Swale/bioretention/ trees	Filter strip	Green roofs	Proprietary treatment systems
Regular maintenance													
Inspection	■	■	■	■	■	■	■	■	■	■	■	■	■
Litter and debris removal	■	■	■	■	□	■	■	□	■	■	■		□
Grass cutting	■	■	■	■	□	■	■	□	□	■	■		
Weed and invasive plant control	□	□	□	□		□	□		□		□	■	
Shrub management (including pruning)	□	□	□	□					□	□	□		
Shoreline vegetation management	■	■	□										
Aquatic vegetation management	■	■	□										
Occasional maintenance													
Sediment management[1]	■	■	■	■	■	■	■	■	■	■	■		■
Vegetation replacement	□	□	□	□						□	□	■	
Vacuum sweeping and brushing									■				
Remedial maintenance													
Structure rehabilitation /repair	□	□	□	□	□	□	□	□	□	□	□	□	
Infiltration surface reconditioning				□	□	□	□		□	□	□		

Key
■ will be required
□ may be required
Notes
1 Sediment should be collected and managed in pre-treatment systems, upstream of the main device.

Figure 1. Recommended operation and maintenance activities for key SUDS components (Source: The SUDS Manual, p. 723, Table 32.1).

1.4 Report purpose

The 'State of SUDS delivery in the UK' by Melville-Shreeve et al., (2017) highlights the need for increased SUDS monitoring, where questionnaire respondents stated there was a lack of practical evidence due to under resourced projects and a lack of monitoring, which prohibited uptake of SUDS. Monitoring and maintenance is particularly important for SUDS in Scotland as they have become obligatory for managing surface water drainage in new developments (Scottish Water, 2015) and are therefore becoming much more widespread across the country (Wild et al., 2002). The 'Climate Change Risk Assessment 2017 Evidence Report – Summary for Scotland (CCRA)', and the independent assessment of Scotland's Climate Change Adaptation Programme (SCCAP), point to a range of key uncertainties and risk. One such research priority identified by the Independent Assessment for buildings and infrastructure under surface water and sewer flooding was SUDS. As SUDS have been a statutory requirement for several years, it was highlighted that it would be timely to assess policy effectiveness, considering location, design, maintenance and resilience. This report addresses a highlighted research priority by addressing: i) how information on SUDS are retained by local authorities in Scotland, and ii) how this information is used to secure appropriate management, monitoring and maintenance of SUDS components.

After initial discussions with SEPA, this report also seeks to know the types of SUDS local authorities are responsible for, the extent to which local authorities know where their SUDS are located and whether they maintain them. This report offers an interpretive analysis of written and verbal responses provided by participants during questionnaire surveys, phone interviews and email correspondence conducted in April and May 2018. Evidence is presented as descriptive findings and quotes are used to reflect participant opinions.

3 Methods

Information presented in this report was collected from numerous sources, with primary correspondence from professionals within local authorities, SEPA and Scottish Water. A questionnaire (Appendix I) was emailed to all 32 local authorities in Scotland during April and May 2018 where roads, flooding and planning departments were approached to gain understanding of the effectiveness of current monitoring and maintenance of SUDS. Through online literature searches and initial discussions with SEPA, it was understood that such departments would have dealings with SUDS and likely professional expertise of the systems. The same questionnaire was also sent to Scottish Water. Members listed as part of the SUDS Working Party (a group of stakeholders who meet to discuss key issues relating to SUDS) on the SEPA website were also approached for comment. Snowball sampling (Patton, 1990) was adopted as an informal method to reach targeted SUDS professionals, which has a main value for gaining respondents from a limited pool. Relying on recommendations to find relevant people, it aims to make use of community knowledge and exploits the social network of a target population. Initial emails with questionnaires attached had an additional request for contact details of people who have working knowledge of SUDS.

The questionnaire contained ten main questions where participants were asked to share their insights on SUDS in their local authority in terms of recoding keeping of SUDS components, monitoring and evaluation conducted, in-house expertise, maintenance conducted and opportunity was also given to suggest improvements. Participants were asked (question 10) if there was anything they would like to add, ensuring aspects they felt important were not excluded. Telephone interviews were also conducted to gather further information beyond the scope of the questionnaire and lasted between 15 and 30 minutes, depending on how much the interviewee had to say. Some participants also provided additional insight by further email correspondence. The study employed theme-centred analysis, taking a semantic approach, identifying themes from explicit or surface meanings of the data (Braun and Clarke, 2006). All questionnaire replies were read through, and interview responses typed up to obtain an overview and insight into emerging themes. A critical approach was taken at every stage of the process, including e.g. taking notes and typing up immediately following interviews. Negative case findings were retained, to hopefully enhance the study's credibility. Including both positive and negative accounts, allows the reader to better judge the quality of analysis and interpretation.

4 Results and discussion

1.5 Survey response

The following results represent opinions of employees across 12 out of 32 local authorities, and within both SEPA and Scottish Water who have past or present experience working with SUDS. The responses also cover a wide geographical range, covering local authorities in both urban and rural regions. A total of eleven local authorities and Scottish Water filled in and returned the questionnaire by email. All participants filled in every question, with those that were not certain of the answer, indicating either 'I don't know' or 'unsure'. Nine individuals also provided further information through email correspondence or were interviewed over the phone. Adopting a snowball sampling technique achieved mixed results; participants did not always have details to pass on, did not have the time to participate or did not respond to the request. However, given the two-month timeframe of data collection, the questionnaire survey reached a wide range of individuals working in different sectors of SUDS: flooding, planning, engineering, roads, maintenance and utilities.

1.6 Types of SUDS components and record keeping

Local authorities and Scottish Water were asked which type of SUDS components they were responsible for (Figure 2), and if known, were also asked to indicate the number of each SUDS feature present under

their remit (Q1). Eleven out of twelve respondents were able to indicate what type of SUDS feature were present, with one local authority indicating 'unsure' for all SUDS features which was later explained in the survey as a result of having no systematic method of recording SUDS. Detention basins were the most commonly occurring component found across nine organisations, followed jointly by eight organisations being responsible for filter drains, retentions ponds, soakaways and swales. One local authority also indicated that they have one rain garden under the 'other' category, which is a less conventional SUDS component. Only four organisations were able to indicate the number of SUDS features present, for example one local authority was responsible for 37 soakaways, whilst another had 9 bioretention areas across one site.

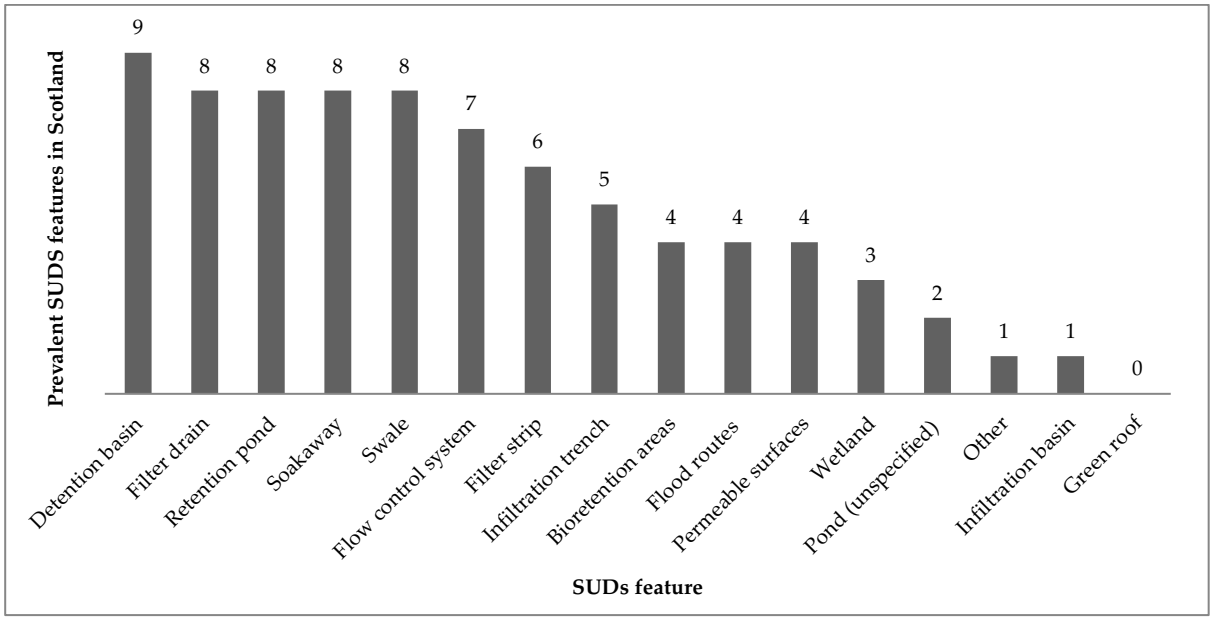

Figure 2. most prevalent SUDS components occurring across local authorities and Scottish Water.

A total of seven respondents indicated that their organisation knew where all SUDS sites that they were responsible for were located (Q2a), with four local authorities indicating that they were aware of some but not where every SUDS component is located. Respondents were then asked (Q2b) about how this information was retained and whether grid references were also available. Results showed that a combination of methods were used to record SUDS, with a Geographical Information System (GIS) database being most common (n = 5) which also meant grid references were easily accessible. Four local authorities do not use a GIS system for recording SUDS locations, but this information was extractable from development files/construction consent drawings:

> "There are paper records in the form of Roads Construction Consent (RCC) documentation. RCC records for projects completed within the last 10 years or so (and therefore taking in the majority of SUDS Schemes completed) are easily accessible to the Roads Support/Roads Authority team."

One local authority indicated that site location data is currently being collated into an excel database, including grid references. At a later date, the intention is to include locations on the GIS system with attributes behind them. Quotes from two further respondents who were unaware of where all SUDS are located are shown below:

> "We are aware of some sites, but do not hold detailed information at present as we do not have an active Asset Management Operating System in place and have limited inventory. Where roads have been given Roads Construction Consent then the SUDS information is recorded on the drawings. Where information is available, it is map based."

> "…it can be seen the Council has no systematic record of SUDS within its area. Majority of schemes feature in private residential and commercial developments, a number also in school redevelopments."

Such results indicate that there is room for improvement in terms of record keeping of SUDS components, particularly with recording the number of individual SUDS features at a given site. Two respondents also highlighted that there is a duty to map all SUDS within the local authority area under the Map of Water Bodies from the Flood Risk Management (Scotland) Act, 2009. However, it was also noted that the government has not set dates as to when this should be completed and "some Authorities are well advanced in collecting the data, some are like ourselves and just getting to grips with it now" which is also reflected in our results. Digital records of SUDS features, for example in a GIS database, could help reduce time when it came to identifying SUDS for monitoring and maintenance purposes, and could potentially allow for maintenance teams to more easily 'drop-by' if they found it was close to another site they were working on but potentially would not be aware of its existence. It would also mean a record of SUDS was more easily accessible and readily available if, for example, staff changed roles or moved away from the local authority, which was identified as a problem by some respondents. SUDS monitoring and maintenance would benefit from a national register map where SUDS assets are easily identifiable and owner known, which could also assist Scottish Water and SEPA in their involvement and potentially allow local communities to become more easily engaged with SUDS in their area that provide public benefits such a recreation and increased biodiversity.

1.7 Monitoring and evaluation conducted

Without monitoring and evaluation, it is unknown whether the SUDS systems are under- or over-performing, therefore survey participants were asked about whether they conduct monitoring and evaluation, and to describe the type and frequency of monitoring activity (Q3). Two respondents indicated 'no comment' and 'unknown', a further participant said no monitoring was occurring because of insufficient resources, and another indicated that monitoring was only occurring on SUDS adopted by the council roads authority. Two respondents specified that SUDS are included in annual inspection regimes for performance and health and safety purposes. However, one of these respondents highlighted that this was just a site visit to take photographs. Another survey participant said that monitoring and evaluation was in accordance with The SUDS Manual or on the recommendation of the installer and likely included checking screens, removing debris and litter, silt management and grass cutting as and when required. Whilst the remaining four respondents indicated that monitoring was much more informal and on an ad-hoc basis, largely due to resource constraints. For example, the operation of SUDS is only monitored during heavy rainfall as resources permit, only reactive maintenance is operated on drainage systems, and SUDS performance are normally monitored informally by visual inspection only for 1 to 2 years after construction. One respondent suggested that there are various reasons for SUDS not being systematically monitored, including: "i) low profile of SUDS at the planning application stage, ii) requirement for SUDS a tick box exercise, future issues for others to sort out, iii) lack of firm guidance and advice on adoption of SUDS, iv) marked unwillingness of Scottish Water to take up its statutory duties to maintain SUDS." Survey results highlight a range of approaches to SUDS monitoring and evaluation which support results in Figure 3, with an overall view of it being reasonable to not very effective. Section 1.3 provided an overview of SUDS operation and monitoring, with suggested requirements from key documentation highlighted. No organisation is conducting regular monitoring which is important as the systems are more likely to underperform, potentially causing impact on localised flooding and damage to the SUDS infrastructure which could be avoided.

Respondents were asked how effective they felt current SUDS monitoring and evaluation is (Q4), where six respondents felt it was 'reasonable', four felt it was 'not very effective' and one respondent indicated 'I don't know' (Figure 3). No respondents felt current SUDS monitoring and evaluation was either 'effective' or 'very effective'. One respondent also noted that it would be difficult to give an answer on behalf of every section within the Council who have different responsibilities for SUDS systems, therefore 'reasonable' was selected to account for any variance.

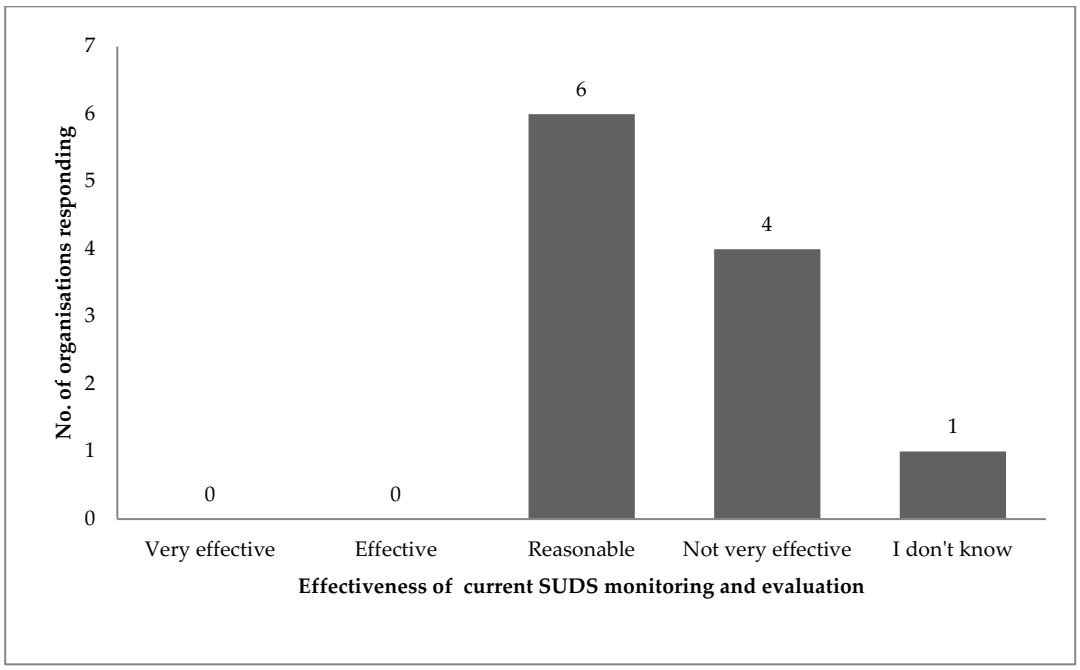

Figure 3. survey participant views on effectiveness of current SUDS monitoring and evaluation.

1.8 Maintenance conducted

Survey participants were asked what maintenance is conducted within their organisation, or if none, what is the reasoning for this (Q5). Litter picking, grass cutting, and vegetation management were most commonly mentioned by seven respondents, and would likely be conducted by the Greenspace department within the Council. Longer term maintenance requirements like silt management are unlikely to feature in maintenance regimes. One organisation also indicated that a charitable trust that focusses on promoting environmental awareness, enhancing visual amenity and public enjoyment was responsible for "upkeep and thin out the pond vegetation in our retention ponds". Two organisations also noted that only systems adopted by the Council would be inspected and maintained, whilst landscape components on private sites would be maintained on a factored basis. However, this approach is likely to change as Section 7 agreements are utilised more frequently. A respondent also noted that there is a "lack of appreciation by factors and ground maintenance contractors of the function and purpose of SUDS. Lack of 'supervision' by statutory body (e.g. planning authority) to ensure proper maintenance carried out."

A recurring theme was that the majority of maintenance is conducted on a reactive basis, as and when required, largely linked to insufficient resources and budgets. Usually this is established by visual inspection to ensure performance is as expected. For example:

> "Visual inspections of some SUDS systems is carried out as part of our safety inspection process, but there is no planned maintenance carried out at present due to available budget and available resources. Litter removal will be carried out on a reactive basis, as is weed and vegetation control."

Or for example:

> "if a system posed a risk of flooding to property then the Council would take action to reduce the risk at that time but would then look at the responsible party to undertake future inspection and maintenance."

4.2.1 In-house expertise available

For the majority of survey participants (seven out of eleven), their organisation does have in-house expertise available that are able to check and advise on SUDS (Q6) at various stages e.g. proposals,

planning, design and development. Such knowledge would largely be transferable to the maintenance stage. One respondent also indicated that they have completed an online SUDS course delivered by University of Abertay, and attended a SUDS designing and detailing course for residential and business, whilst another mentioned that there are in-house resources available e.g. software that allow the design team to help with the design and review of systems. One local authority mentioned that there is sometimes a lack of expertise in-house regarding pond vegetation, for example what is the most appropriate species and on their upkeep, but assistance and advice is available through outside organisations which they use e.g. charitable trusts. Another respondent indicated that there is some in-house expertise, but their knowledge base could be expanded for other SUDS components, for example, they were mainly responsible for detention basins and filter trenches. A further respondent specified "not really" but for example, if surface water drainage was being compromised by a malfunctioning SUDS, the flood team could investigate. Two respondents highlighted that local authorities will vary in the expertise available to them and resources i.e. staff in checking and advising on SUDS, and would be more challenging for smaller authorities. One respondent also noted that it is the developers and not the local authorities' job to become designer of SUDS components. During a phone interview, one participant highlighted that despite in-house expertise being available, the growing number of SUDS which takes years to develop is becoming a large time and resource sink, with more time needed on top for their monitoring. Another phone interview participant highlighted for those smaller, less experienced local authorities, there are schemes like SCOTS group where councils feed into and other authorities can call up and ask to view the information collected.

4.2.2 Finance, a barrier to maintenance

SUDS schemes require a finance stream to cover maintenance, which ensures short-term operation and minimise risks to long-term performance. For example, ponds require vegetation management to ensure species are growing properly and that the system is providing the expected service (Woods-Ballard et al., 2015). Costs towards SUDS typically comprise labour and equipment costs, material or replacement product costs, replacement or additional planting costs, and disposal costs of sediments and vegetation, and more details along with costing tools are available in The SUDS Manual. Survey participants were asked (Q7) how is current SUDS monitoring and maintenance funded. Overall, results indicated that organisations have limited funding available for maintenance of SUDS and it is viewed as a barrier to successful implementation. Four respondents indicated that there is no specific funding within the organisation dedicated to SUDS monitoring and maintenance, and any monitoring conduced is minimal and carried out on an informal, ad-hoc basis due to the lack of resources. For example:

> "No specific budget, any monitoring would be carried out on an ad-hoc basis and reactively to complaints and problems."

> "There is no planned maintenance carried out at present due to available budget and available resources. We only monitor the operation of SUDS systems during heavy rainfall as resources permit. We currently only operate reactive maintenance on drainage systems."

A further respondent also stressed that funding will vary dependent on the individual Council. For example, in their local authority they would expect the developer to have sorted out factoring arrangements and a payment strategy for the development, unless the Council adopted the SUDS. This could include homeowners paying a set annual amount to a factoring company, or commuted sums could be requested from the developer should they wish a Council to undertake a certain aspect of the SUDS upkeep, and if there is capacity and resources within the Council to do so. Three further participants highlighted that funding is through revenue budgets, for example, existing roads budgets are used for grass cutting, environmental budgets used for litter clearing, maintenance is through commuted sums for new developments, inspections and legacy SUDS are through revenue. Different aspects of maintenance is coming from different local authority departments (e.g. parks, roads, etc.) which needs addressed. For example, the local authority could be better at poling revenue and sending one team as minimum. With the arrangements in Section 7, going forward the maintenance of SUDS that convey and treat curtilage, and road drainage will be shared with local authorities and Scottish Water. The local authority working

with the charitable trust also indicated that they do not charge for the work on the ponds as they are able to take water plants for use elsewhere on other projects, creating a win-win situation where both organisations are benefiting from working together. During a telephone interview, a participant indicated that there is no additional money for the growing number of SUDS over the years. In an ideal world, the local authority would follow the maintenance documents that comes with the features, but they are not obliged, and given how tight resources are, the respondent said they are doing the best they can with the resources available. An example was also provided of how ponds require soft landscaping work, normally taken on by the Council landscaping team but as their work is not statutory, there is no core funding so they need to focus on high profile public parks, and these SUDS are left to the Roads Authority to fund, which ultimately diverts road maintenance budgets away from repairs for pot holes.

4.2.3 The role of Scottish Water

The role of Scottish Water in SUDS maintenance was a recurring theme in questionnaires and during interviews, where it was brought up by individuals from more than one organisation. Scottish Water was viewed as too selective over which SUDS they are willing to vest, resulting in a very small number being taken on across the whole of Scotland. Scottish Water provided a record showing that 24 SUDS are currently recorded as being vested, but others would have been added since this record is ~3 years out of date. During a phone interview, an issue was also raised with procuring legacy SUDS between Scottish Water and the local authority. A lot of investigations and work was done during this project, for example on the problem of SUDS ownership (some SUDS are fully owned by the local authority, partly owned or can be privately owned) which creates problems for maintenance and funding arrangements. The Council put forward a large number of SUDS but very few qualified to be suitable for Scottish Water to vest, and the end result was that actually none of the SUDS were deemed suitable for vesting. This was a very long process and a lot of time and money went into it, which resulted in a frustrating ending and trust affected. In response to these comments, further contact was made with Scottish Water to anonymously share respondent's opinions to gain further understanding of these highlighted issues and to provide a more balanced argument:

> "SUDS are not being built to Scottish Water's standard, so they are not willing to adopt them. Once they are adopted, they would be legally required to maintain them...."

Scottish Water's response:

> "this is correct however our responsibility is to drain surface water from the building only. Under section 7 of the sewerage Scotland act, Local Authorities are allowed to connect the road drainage (which they are responsible for) onto our sewers but only by agreement. We never implemented this section of the act and allow LAs to connect without agreement for many years. When SUDS became a legal requirement, we felt the share of maintenance of the drainage assets (now much higher than a pipe and pumping/treatment costs and covered by the proportion of our charges that covers road drainage) should be rebalanced. We worked on an agreement that shares the maintenance of these assets (LAs carry out above ground maintenance and SW below ground) and in doing so we are willing to vest assets that may not strictly meet our standards. For example, we are willing to vest assets that deal with a 1 in 200 rainfall event which is well over our responsibilities to effectively drain normal rainfall events (usually a 1 in 30). It is important to note that, in theory, LAs do not have an automatic right to connect. "

Another respondent mentioned: "There is also an issue with the approach Scottish Water takes when it comes to vesting the asset. They are very worried about the risk involved of some SUDS features"

Scottish Water's response:

> "this is correct and stems from the fact that we had little understanding of SUDS and wish to spend our customers' money wisely therefore we weren't happy to take on too many risks. We are however working on it by expanding our sewers for Scotland standards to include more SUDS types. Ultimately we would like to vest all appropriate SUDS but we are on a journey."

Results suggest that greater communication is required between Scottish Water and Local Authorities to ensure increased understanding of the vesting system. Going forward, it would be beneficial for Scottish Water, local authorities and developers to work closer together earlier in the design and planning stage to ensure SUDS are being built to standard and that work is being checked throughout the build process to ensure continued standards are being met. For example, open ponds and wetlands, are often perceived as posing a risk of drowning. A key part of the SUDS design process is the developer's Design Risk Assessment (DRA) which can result in perimeter fencing and warning signs where all parties involved could have better say in. There should better opportunity as part of Section 7 of the Sewerage (Scotland) Act 1968 which will allow Roads Authorities and Scottish Water to agree and share the maintenance of SUDS systems where both curtilage and roads water enter the system. However, this is only for the shared elements of the SUDS system, but one respondent highlighted that some authorities have agreed to work under the Section 7 principles on below and above ground system split, with agreements are beginning to filter through.

1.9 Benefits from monitoring and maintenance

The SUDS Manual provides numerous examples of benefits from SUDS which are generally grouped into categories of water quality and quantity, biodiversity and amenity. Specific examples include flood risk reduction, health and well-being, educational opportunities working with schools and community groups, increased resilience to climate change, and improved visual character to an area. Participants were therefore asked (Q8) to describe any public and private benefits that have emerged from SUDS monitoring and maintenance work. Three respondents indicated they were unsure or unable to comment. However, a wide range of benefits were highlighted in the survey, including: improved understanding of SUDS performance, improved safety and amenity of SUDS within housing developments, enhances accommodation of storm flows and reduces flood risk, delivering higher quality water to the environment, allowing increased biodiversity, providing enhanced community amenity and visual benefits from e.g. tidying up unsightly basins. Another respondent also mentioned that their local authority encourages the use of surface, rather than below ground SUDS as these systems are easier to visually assess the condition and performance. However, one participant indicated that much of the desired benefits of SUDS are not being delivered due to ineffective procurement, construction, vesting and maintenance arrangements in place across Scotland. One respondent also provided an example where private maintenance factoring has failed at legacy SUDS where the Council had to step in to reduce flood risk and protect properties. Another response said that actually due to the lack of intervention, more protected species may have been allowed to establish.

The SUDS Manual also highlight that SUDS provide an opportunity to be used for community engagement and illustrates ways to participate, such as hosting a SUDS planting day, setting up a maintenance group, or initiating an environmental group linked to the fauna and flora of the SUDS. Only one local authority indicated that they partake in SUDS community engagement with a local charitable trust and highlighted both benefits to the council and trust, for example, the trust assist with retention pond planting and upkeep, saving costs to the council whilst providing a source of plants for other projects. They also stated that with this involvement, the amenity of the area in which the ponds are sited has been improved as they also assist with gardening and footpath maintenance. Results show that there is a wide range of benefits, and each system will be different depending on above or below ground elements and to get optimal benefits and performance out of SUDS, more than just reactive monitoring and maintenance will be required.

1.10 Improving SUDS monitoring and maintenance

The survey also provided participants the opportunity to suggest ways in which SUDS monitoring and maintenance can be improved (Q9), and four respondents provided additional comments when given the opportunity in Q10. The most common suggestion from both interview and survey was that increased resources were required, particularly financial where budgets can accommodate the additional

monitoring needed. Monitoring and maintenance would also benefit from becoming more formalised with increased cyclic maintenance, as opposed to the ad-hoc and reactive maintenance that is currently common. More formalisation would also lead to better understanding of who is responsible for monitoring and maintenance. An additional comment provided by one respondent is provide below:

> "One of the biggest challenges that we have faced with surface SUDS is that we have found that it can be difficult to fund the vital early maintenance needed to allow planting to become established. Construction costs are usually from a capital fund but routine maintenance (from Roads Authority grounds maintenance) is from a revenue fund. The Roads Authority will not adopt schemes where planting is not sufficiently established to allow straightforward maintenance. Funding, and even finding firms to do the work, in the gap between construction and adoption continues to be a challenge."

Better communication and more joined up working is also needed between various departments within the Council e.g. planning, design, roads maintenance, and also between Scottish Water about their vesting procedure. For example, one interview participant highlighted that developers are not paying enough attention to pond design from a maintenance perspective and being more robust and more on the ground feedback was needed. For example, they are having to suggest e.g. inclusion of anchorage points in deep ponds or a spiralling gradual entrance point, how close they are to housing, and making parking nearby for facility maintenance vehicles. One respondent mentioned that there is a project within Scottish Water where the vesting team are looking at legacy SUDS and this is likely to involve cross agency working. They also highlighted that "there is currently a planning review being undertaken and there may be opportunities to look at secondary guidance in relation to SUDS going forward." During a phone interview, an issue raised was that Scottish Water and local authorities do not have enough time to come together prior to the planning process to decide which SUDS should be adopted in developments, which could also make vesting easier. They mentioned that the Section 7 agreement was put in place to help with this problem, highlighting the importance of coming together and identifying who is going to be adopting each SUDS as planning applications come forward. Earlier and more frequent communication will be even more important going forward as Section 7, as part of the Sewerage (Scotland) Act 1968, is adopted. Here a Roads Authority and Scottish Water would agree to shared maintenance on SUDS systems where both curtilage and roads water enter the system. One respondent also indicated that greater levels of expertise was needed for performance-based maintenance rather than aesthetic based, for example non-routine maintenance tasks like de-silting. Ensuring better registers of SUDS, particularly having digital and GIS based records, will mean SUDS are more visible for inspection teams. This will also be beneficial as SUDS numbers are increasing every year and having up to date records as the systems age is important. Another respondent also highlighted issues with legacy SUDS where many Councils are currently building registers of these systems, and as these become better populated and more commonplace, when developments are completed the information on the SUDS will be included providing a better overall picture of these systems within an authority area.

5 Conclusions

We reflected on results from a variety of participants who have expertise working with SUDS and were able to answer a set of research questions relating to record keeping, monitoring and maintenance of SUDS components. The results support the following conclusions;

- Respondents knew what types of SUDS their organisation was responsible for but record keeping of the exact number of each component was limited. Detention basins were most commonly seen across Scotland, followed by filter drains, retentions ponds, soakaways and swales. Record keeping in a GIS database is becoming more common practise and is the most efficient way for inspection teams to access SUDS records. Improvements are needed for storing of information and all local authorities would benefit from moving to a digital record system.

- Current SUDS monitoring and evaluation is more commonly achieved on an informal, ad-hoc basis and not at regular intervals as recommend by The SUDS Manual. Respondents felt current levels of monitoring and evaluation were either 'reasonable' or 'not very effective'.
- Maintenance is more commonly conducted on a reactive basis, as and when required, due to limited resources and budgets. Litter picking, grass-cutting and vegetation were more commonly managed. Finance was found to be the biggest barrier to maintenance and successful implementation of SUDS, with either no dedicated funds or money coming from department revenue budgets. There is a need for maintenance to become more formalised and cyclic. There could also be an opportunity for the private sector to be involved in more specialist SUDS maintenance which could also alleviate some resource pressures of local authorities.
- In-house expertise was overall regarded as not an issue for monitoring and maintenance of SUDS, but exact experience will vary between small and large local authorities.
- Earlier and more frequent communication is needed between departments within the Council, and with Scottish Water particularly over vesting and sharing maintenance of SUDS. This will be more important going forward under Section 7, as part of the Sewerage (Scotland) Act 1968.
- Many public and private benefits are provided by SUDS, particularly if they are properly maintained. More local authorities would benefit from increased community engagement where maintenance, particular vegetation management could be shared with local community groups.

These results may benefit from a further phase of work examining monitoring and maintenance as Section 7 becomes more common practise. It would also be beneficial to collect data on SUDS schemes performance over time, to improve their future implementation, monitoring and maintenance. Case studies of good and bad practice should be collated and shared for future improvements.

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7 Appendix I – SUDS Questionnaire

Sustainable Urban Drainage Systems (SUDS) Questions

The aim of this survey is to look at how information on SUDS are retained by local authorities in Scotland, and how such information is used to secure and fund appropriate management, monitoring, and maintenance of SUDS features.

Date:

What local authority are you from and what is your role in relation to SUDS?

1. What types of SUDS is your local authority responsible for?

SUDS feature	**Occurring in your local authority area.** **(Please mark Yes/No/Unsure)**	**If known, please indicate the number of each SUDS feature present in the local authority**
Bioretention areas		
Detention basin		
Filter drain		
Filter strip		
Flow control system		
Flood routes (exceedance routes)		
Green roof		
Infiltration basin		
Infiltration trench		
Permeable surfaces		
Retention pond		
Pond (unspecified)		
Soakaway		
Swale		
Wetland		
Other, please state:		

2. a) Does the local authority know where the SUDS sites are located?

   b) How is this information retained e.g. database, excel, GIS map? Are you able to provide a list of grid references to the SUDS?

3. **Do you carry out any SUDS monitoring and evaluation?** Please give detailed examples of the type of activity and frequency of monitoring.

   If none, what are the reasons for this?

4. How effective is current SUDS monitoring and evaluation?

   Very Effective Effective Reasonable Not very effective I don't know

5. **Do you carry out maintenance of SUDS features?** Please give detailed examples e.g. litter management, grass maintenance, silt management, wetland and pond vegetation cutting.

   If none, what are the reasons for this?

6. Does local authorities have the expertise in-house to check and advice on SUDS? Please give detailed examples.

7. How is SUDS monitoring and maintenance currently funded?

8. Could you describe any a) public benefits and b) private benefits you think have emerged from any monitoring and maintenance work carried out on SUDS?

9. How can SUDS monitoring and maintenance be improved? Please give detailed examples.

10. Is there anything else you would like to add?

8 Appendix II – Key legislation, regulations, and design guidance documents for SUDS

- Scottish Planning Policy (2014)
- PAN 61: Planning and Sustainable Urban Drainage Systems (2001)
- PAN 69: Planning and Building Standards Advice on Flooding (2004)
- PAN 79: Water and Drainage
- The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (The CAR Regulations) and associated Practical Guide prepared by SEPA.
- The SUDS Manual C753 (2015) published by CIRIA
- Current edition of Sewers For Scotland (currently 3rd Edition)
- SUDS For Roads (2015)
- Sustainable Drainage Systems (2013) published by RSPB & WWT
- Development and Flood Risk C624 (2004)
- Drainage Assessment – A Guide For Scotland (2005)
- Sustainable Urban Drainage Systems (SUDS or SUD Systems) – Regulatory Method (WAT-RM-08) (2017) published by SEPA.
- Technical Flood Risk Guidance For Stakeholders (SS-NFR-P-002) (2015) published by SEPA
- SEPA Standing Advice For Planning Authorities And Developers On Development Management Consultants - SEPA Land Use Planning System Guidance Note 8 (2012)
- Site Handbook for the Construction of SUDS (C698) (2007)

9 Appendix IV – Examples of recommended SUDS operation and maintenance requirements

Example guidance on the type of operational and maintenance requirements that may be appropriate for soakaways and filter drains. Full details of other SUDs components are outlined in The SUDS Manual C753 (2015).

Operation and maintenance requirements for soakaways

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Inspect for sediment and debris in pre-treatment components and floor of inspection tube or chamber and inside of concrete manhole rings	Annually
	Cleaning of gutters and any filters on downpipes	Annually (or as required based on inspections)
	Trimming any roots that may be causing blockages	Annually (or as required)
Occasional maintenance	Remove sediment and debris from pre-treatment components and floor of inspection tube or chamber and inside of concrete manhole rings	As required, based on inspections
Remedial actions	Reconstruct soakaway and/or replace or clean void fill, if performance deteriorates or failure occurs	As required
	Replacement of clogged geotextile (will require reconstruction of soakaway)	As required
Monitoring	Inspect silt traps and note rate of sediment accumulation	Monthly in the first year and then annually
	Check soakaway to ensure emptying is occurring	Annually

Operation and maintenance requirements for filter drains

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Remove litter (including leaf litter) and debris from filter drain surface, access chambers and pre-treatment devices	Monthly (or as required)
	Inspect filter drain surface, inlet/outlet pipework and control systems for blockages, clogging, standing water and structural damage	Monthly
	Inspect pre-treatment systems, inlets and perforated pipework for silt accumulation, and establish appropriate silt removal frequencies	Six monthly
	Remove sediment from pre-treatment devices	Six monthly, or as required
Occasional maintenance	Remove or control tree roots where they are encroaching the sides of the filter drain, using recommended methods (eg NJUG, 2007 or BS 3998:2010)	As required
	At locations with high pollution loads, remove surface geotextile and replace, and wash or replace overlying filter medium	Five yearly, or as required
	Clear perforated pipework of blockages	As required