UNDERSTANDING THE OPERATIONAL COST OF SUSTAINABLE DRAINAGE SYSTEMS

Michael Arthur (Metis Consultants), Dr Alison Furber (Metis Consultants) and Navin Weeraratne (Awa Environmental)

ABSTRACT (500 WORDS MAXIMUM)

There is wide industry agreement that Water Sensitive Design (WSD) / Sustainable Drainage Systems (SuDS) are essential parts of the urban drainage system to manage water quality and quantity. However, despite these approaches being common practice for more than 10yrs, there is limited knowledge around the long-term operational costs of these features.

In England, SuDS have been part of urban development proposals since the 2000's and mandatory from 2014, but there is ongoing uncertainty around who is ultimately responsible for adoption and maintenance of SuDS systems. This is due to the governing legislation (the Flood and Water Management Act of 2010) not completely being implemented. The Act requires SuDS systems serving two or more properties to be maintained long term, but the part of the legislation delegating this responsibility to Local Authorities was never enacted in England. Some Local Authorities have adopted 'community' SuDS systems, but other developments rely on private companies for ongoing maintenance. A significant barrier to adoption is the poor understanding of the long-term maintenance costs.

In New Zealand, Stormwater Management Devices have been used to support land development and achieve Resource Consent requirements since the early 1990's. Auckland Regional Council's TP10 (1992) and more recently Auckland Council's GD01 (2017) provide guidance on the selection, design, operation and maintenance of such systems. These documents have also been used by other local authorities outside of the Auckland Region. Similar to the UK, ownership and maintenance responsibilities for such systems have not been clearly mandated, with individual Local Authorities generally determining relevant rules and responsibilities on a district by district basis. A key outcome has been the maintenance of many such systems remaining the responsibility of private property owners. While these responsibilities are enforceable through the regulatory framework, the effectiveness of their enforcement has been limited by the associated resourcing requirements.

This paper will present the work completed to date in the development of a maintenance costing tool for SuDS / WSD features. The tool was originally developed to compare the maintenance costs of SuDS / WSD features to 'traditional' drainage systems, to assess where SuDS / WSD could be lower cost in the long term. The tool has now expanded to development of a database of common maintenance activities and associated costs for a range of urban assets, including SuDS / WSD, that can be adapted to local conditions. The activities are based on industry best practice, in-house design / operational experience and Local Authority officer experience. The ongoing costs are developed from a

combination of Local Authority contractor maintenance cost data and in-house experience.

The paper will also explore how experiences in England could be used in NZ, along with transferability of activity schedules and related cost rates for use in a NZ context. It aims to provide financial evidence that WSD / SuDS devices are lower cost long term compared to other approaches, along with better informing asset owners of likely long-term costs of adopting assets from developers at a site scale.

KEYWORDS

Asset Management Planning, Water Treatment, Stormwater

PRESENTER PROFILE

Michael Arthur is a Chartered Professional Engineer, Member of Engineering New Zealand and a Chartered Member of CIWEM – including sitting on the CIWEM Specialist Panel for Flood and Coastal Erosion Management. He is a technical specialist in urban flood management and development of supporting business cases for flood mitigation schemes.

INTRODUCTION

There is wide industry agreement that Water Sensitive Design (WSD) / Sustainable Drainage Systems (SuDS) are essential parts of the urban drainage system to manage water quality and quantity. However, despite these approaches being common practice for more than 10yrs, there is limited knowledge around the long-term operational costs of these features – particularly at an individual site scale.

In England, SuDS have been a mandatory part of urban development proposals since 2014. In New Zealand, Stormwater Management Devices have been used to support land development and achieve Resource Consent requirements since the early 1990's. However, there has been ongoing uncertainty in both countries around who is ultimately responsible for adoption and maintenance of these systems (referred to as 'SuDS' for the remainder of this paper).

Some Local Authorities have adopted 'community' SuDS systems, but other developments rely on private companies for ongoing maintenance. A significant barrier to adoption is the poor understanding of the long-term maintenance costs. Previous research (Ira & Simcock, 2019, Moores et al., 2019 and Ira, 2011) has focussed on catchment scale cost approaches, but limited work has been done on site specific scale maintenance cost estimation. This paper presents the work completed to date in the development of a whole life maintenance costing tool for SuDS features to assist in breaking down this barrier, facilitate improved long-term management and understand the whole life costs.

The tool has been developed for the following purposes:

- To develop a tool that could be used to calculate whole life maintenance cost estimates (and / or commuted sum payments) in a fair, consistent and transparent way
- To gain a better understanding of the activities, frequencies and long-term costs of maintaining a range of SuDS and drainage components
- To promote the use and adoption of SuDS by providing a site-specific maintenance cost estimation approach

Most of the work to date has been completed within the context of the United Kingdom (England). The principles applied are directly applicable to the New Zealand working environment as the approaches to SuDS design, construction, adoption and maintenance are very similar – including being undertaken by generally the same entities (local government or private maintenance companies).

LEGISLATIVE BACKGROUND

UNITED KINGDOM (ENGLAND)

Schedule 3 of the Flood and Water Management Act (2010) defines how SuDS systems can be adopted and maintained in England and Wales. It was intended that SuDS Approving Bodies (SABs) would be set up within the Local Authorities in parallel to their duties as Lead Local Flood Authorities. Provided that relevant standards were met, SABs would have been required to adopt and maintain approved SuDS serving two or more properties. However, Schedule 3 has not been enacted in England and considerable uncertainty remains over adoption and maintenance of SuDS built as part of ongoing development. This was exacerbated by the fact that SuDS were made a mandatory part of major developments in 2014 (UK Parliamentary Statements, 2014), meaning that nearly all SuDS systems are privately owned and maintained to an unknown standard as there is no other practical option.

As of 1 April 2020, Water and Sewerage Companies (privately owned entities responsible for managing water distribution and sewer networks within a defined geographic area) will be able to adopt certain types of SuDS. This is defined by the national Sewerage Sector Guidance (Water UK, 2020), but this is not compulsory, and the potential to adopt has seen a mixed uptake in the industry.

Some Local Authorities in England have developed their own SuDS adoption guidance and will adopt some types of SuDS as part of road / highway infrastructure associated with developments. However, this is not widespread and there is no common approach to adoption criteria or calculation of commuted sums to support future maintenance costs.

NEW ZEALAND

The 1991 Resource Management Act (RMA) provides the primary statute for governing water quality and quantity management. These requirements are enforced through Regional and District Plans and / or By-laws, established under the 2002 Local Government Act (LGA). The LGA also enables Local Authorities to act as public asset owners, and establish relevant vesting standards and demarcations for public and private assets.

Stormwater discharges from land use activities generally require a discharge consent under the RMA. This includes public stormwater networks owned by Local Authorities. Requirements for SuDS are generally defined through this process, and enforced through associated Network Discharge Consents (NDCs), with ownership rules, levels of service and minimum design standards specified by each Local Authority to suit NDC requirements.

A considerable portion of SuDS in New Zealand remain privately owned. These generate risks to the NDC holder, as compliance is dependent on the adequate operation and maintenance of a range of private assets. They also generate additional costs to private property owners over and above established rates and developer contributions. Better access to whole of life maintenance costs associated with SuDS may help Local Authorities establish more reliable and cost-efficient stormwater management solutions (including SuDS) and help maximise environmental benefits and value for rate payer funding.

TERMINOLOGY

The following technical terms are used throughout this paper. It is important that the reader differentiates between them as they are often assumed to have the same meaning. All costs / sums defined below area usually expressed as a Present Value (the worth of a future stream of payments in today's value adjusted for interest and inflation).

COMMUTED SUM

"Commuted Sum: A payment of a capital sum by an individual authority or company to the highway authority or company to the highway authority, local authority, or other body, as a contribution towards the future maintenance of the asset to be adopted, or transferred" (CSS / now ADEPT, 2009)

Commuted sums are paid to ensure funding is secured to maintain adopted assets in the future. It is usually expected that commuted sums are payable for 'non-standard' and 'extra over' features, that are liable to increase the future maintenance cost over that of a 'standard' asset. SuDS are currently considered as non-standard assets in this context in the UK.

WHOLE LIFE MAINTENANCE COST

Whole Life Maintenance Cost represents the entire cost of maintaining an asset over its lifetime. It does not include construction or disposal costs. It is not the same as a commuted sum. The commuted sum is only a contribution towards the future maintenance costs over a mutually agreed timeframe (not necessarily the entire future maintenance cost over the full asset lifetime).

WHOLE LIFE COST

"Whole Life Cost: Takes account of the initial capital cost, as well as operational, maintenance, repair, upgrade and eventual disposal costs." (CIPFA, 2011)

This represents the entire life cycle cost of the asset including planning, consenting, design, construction, maintenance and disposal. This is used in economic appraisal to compare the cost of two or more interventions over a common timeframe.

HOW DOES THE TOOL WORK?

OVERVIEW

The tool was initially developed to estimate the future cost of maintaining a range of highway / road assets routinely adopted by Local Authorities and provide the basis for negotiating a commuted sum for adoption based on local practices. In England, the *Commuted Sums for Maintaining Infrastructure Assets* guidance (CSS / now ADEPT, 2009) recommends a 60-year period and discount rate of 2.2%. It has developed over time to provide comparative whole life maintenance costs of different approaches to infrastructure delivery – such as ‘traditional’ piped stormwater systems and SuDS systems.

At the heart of the tool is a database of maintenance activities associated with a large range of assets. The user tells the tool what assets are proposed for adoption and the database will extract the maintenance activities that are likely to be required, along with the frequency and estimated cost of those activities.

The main challenge for SuDS was the true cost of maintaining these assets is not well established – especially at a site specific scale. We completed a UK focussed literature review to find available data to make a first estimation of the required maintenance activities, cost and frequencies to fill the database (HR Wallingford, 2004, Environment Agency, 2007, Stovin & Swan, 2007). Following initial testing, the published literature proved to be inaccurate, particularly with regard to costs as they were often heavily influenced by the local conditions where systems had been constructed.

The second stage of development included refinement of maintenance activities with experienced highway asset managers and contractors in the private and public sectors to sense check, update and improve on the generally very old and site context specific data from the available published sources. The intention is that the database ‘learns’ over time as maintenance activities become better understood, along with the associated costs. The database is set up in a way to facilitate this and be able to use organisation specific in-house activities / rates where they are available to improve confidence in outputs.

FORMAT, INPUT, OPERATION AND OUTPUTS

Figure 1 shows the overall workflow through the tool and the following section provides a case study to demonstrate how it can be used. The tool itself is built within Microsoft Excel using a range of advanced formulae and bespoke Visual Basic macro coding. The workflow to use the tool is summarised as follows:

- **Step 1:** The user reviews the ‘global’ analysis parameters (period for calculation, maintenance regime standard and discount rates) and updates as needed, then clicks ‘create new scheme’. The tool allows the user to retain and compare several schemes to understand the maintenance cost differences associated with different potential design solutions and maintenance regimes.
- **Step 2:** The user enters the details of each asset type within the scheme and the specific geometric details as prompted by the database of activities. The tool draws on a standard database of maintenance activities for each asset type. The user can manually override tasks / maintenance frequencies as required based on local requirements.
- **Step 3:** If any asset types are not held within the database, these can be manually added by the user for use within the tool. Similarly, if any activities for standard assets differ in the local context, these can also be modified within the database.
- **Step 4:** The tool takes all assets, associated maintenance costs and frequencies to calculate the Present Value of predicted maintenance costs over the period set in Step 1.

The user can repeat the above steps to compare the whole life maintenance costs for different ‘schemes’ or asset maintenance approaches for a given site within the same spreadsheet. This allows the user to understand how future costs may vary depending based on these inputs. The maintenance activities can include frequent tasks such as litter picking or grass mowing and less frequent 'capital' maintenance such as replacement / disposal of filtration media.

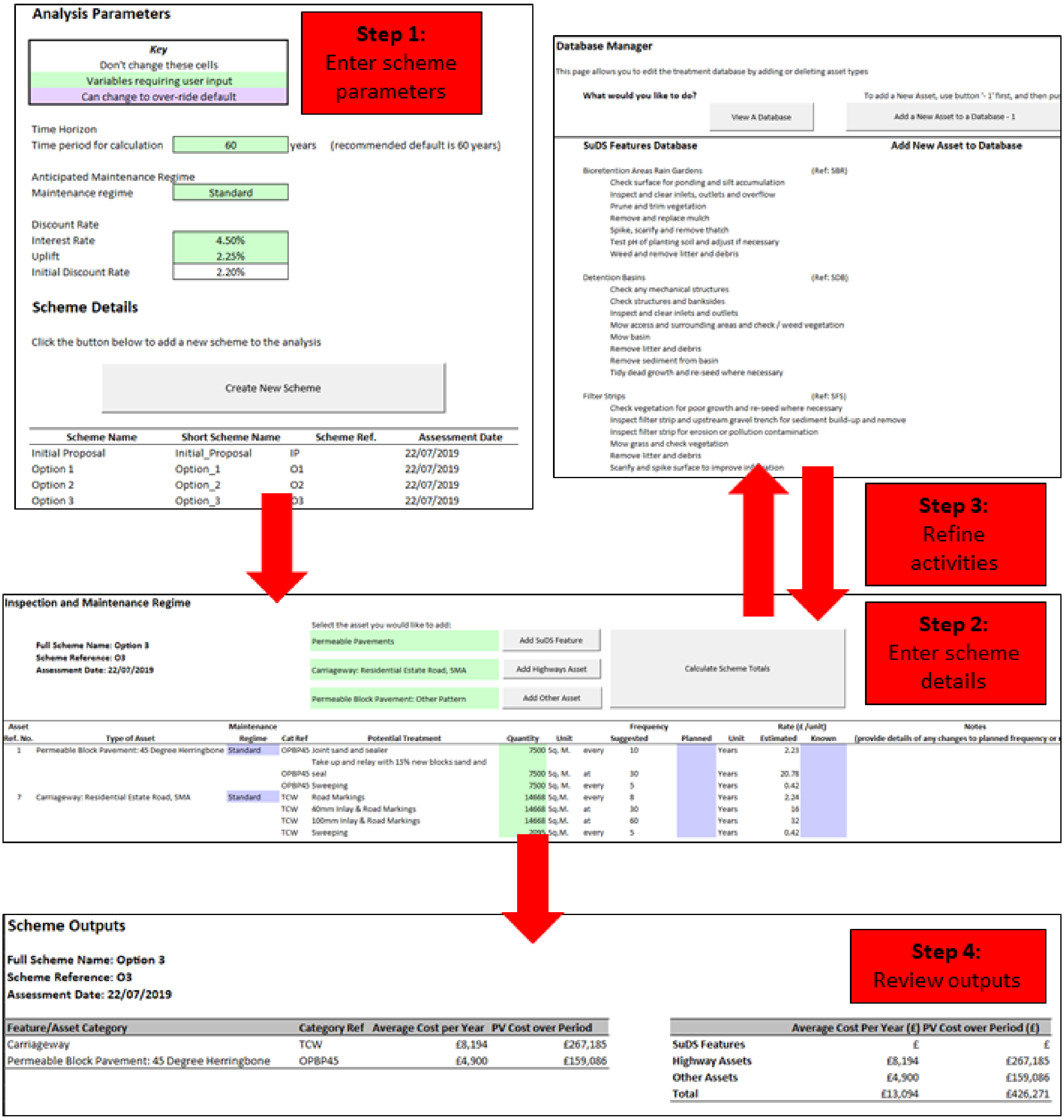

Figure 1: Workflow Summary

CASE STUDY: BIGGLESWADE (CENTRAL BEDFORDSHIRE)

The purpose of this case study is to show how the tool can estimate the whole life maintenance costs for a 'traditional' drainage scheme, then compare this to SuDS approaches that achieve the same design standard. The case study site is a 21ha residential development of 227 houses including road access, landscaping, public open space and supporting infrastructure.

LOCATION

The case study site is located in Biggleswade, Central Bedfordshire – a town of approximately 16,000 people to the north of London. The site is greenfield and the proposed development layout is shown in Figure 2.

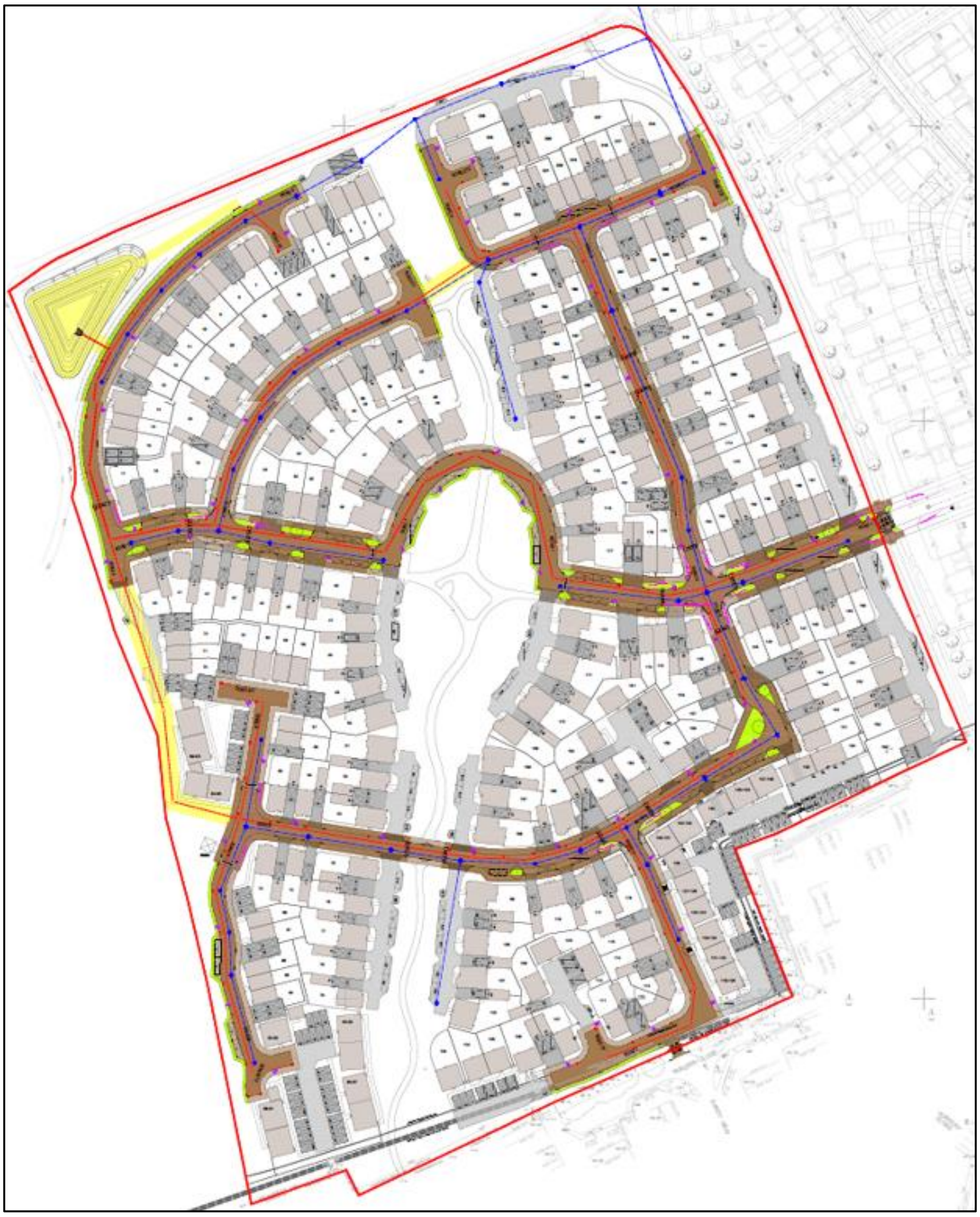

Figure 2: Case Study Site Layout (Source: Central Bedfordshire Council - Planning Portal)

DRAINAGE DESIGN OPTIONS

The baseline drainage design ('Traditional Drainage') is the approach proposed by the site developer. Four other drainage options were developed to offer the same design standard in terms of runoff peak flow and volume, but utilising a range of SuDS solutions. It should be noted that the focus of SuDS in the UK is water quantity management and less effort is expended on achieving water quality benefits overall. The five options analysed are summarised in Table 1.

Table 1: Summary of Design Options

Option		Components
B	Baseline - Traditional drainage	• Road Surfacing: Asphalt (9,000m^2 - major roads) and block paving (13,000m^2 - minor roads / cul-de-sacs) • Drainage Approach: Pre-cast concrete pipes (1.5km) & manholes (48 No.) with standard road gullies (114 No.) and a single large detention basin.
1	Swales and storage basins	• Road Surfacing: As for Option B • Drainage Approach: Roadside filter strips feeding swales and accumulating in two infiltration / storage basins (one large and one small). Reduce Option B by 75% for pipes / manholes and remove all gullies.
2	Rain gardens, tree pits and storage basins	• Road Surfacing: As for Option B • Drainage Approach: Roadside rain gardens and tree pits accumulating in two infiltration / storage basins (two large). Reduce Option B by 75% for pipes / manholes and remove all gullies.
3	Permeable block paving	• Road Surfacing: Asphalt (14,500m^2) and permeable block paving in 45-degree herringbone pattern (7,500m^2) • Drainage Approach: As for Option B, but scaled down by 50% due to online storage / infiltration provided by permeable paving / subbase.
4	Porous asphalt	• Road Surfacing: Asphalt (14,500m^2) and porous asphalt (7,500m^2) • Drainage Approach: As for Option B, but scaled down by 50% due to online storage / infiltration provided by porous surface / subbase.

MAINTENANCE COST ESTIMATION

The maintenance activities, frequencies and associated costs were defined for all assets using Central Bedfordshire Councils activity schedules and rates provided by their term maintenance contractor. All maintenance estimates were reviewed by Central Bedfordshire officers and experienced in-house highway asset management specialists at Metis Consultants.

All asset sizes, maintenance activities, frequencies and costs were entered into the tool and whole life maintenance costs calculated using the standard global parameters (period of 60yrs with a standard maintenance regime and discount rate of 2.2%). To ensure a fair comparison between all options, all road surface, green space and drainage assets were included in the maintenance costs.

OUTCOMES

Table 2 shows the whole life maintenance costs for each option as a Present Value. The options are ranked from lowest to highest whole life maintenance costs for comparison.

Table 2: Whole Life Maintenance Costs (Present Value)

Ranked Option	Whole Life Maintenance Cost (Present Value - £k)
Option 1 (Swales and Storage Basins)	£556
Baseline (Traditional Drainage)	£568
Option 3 (Permeable Block Paving)	£744
Option 2 (Raingardens, Tree Pits and Storage Basins)	£1,007
Option 4 (Porous Asphalt)	£1,495

The tool predicted that the roadside swales and infiltration basins option would be the lowest cost to maintain over the analysis period, but only by a small margin. This shows that for this particular study area, a SuDS solution is comparable to a traditional drainage approach for long term maintenance. However, not all SuDS solutions are lower overall maintenance cost and this should inform design choices early in the development master-planning process. The tool as currently developed could be used early in the design process to inform these decisions. This outcome highlights the need for considering maintenance activities within the early design stages to ensure long term effort can be minimised. The opportunity for reducing effort in well designed SuDS schemes is greater than a traditional drainage approach as more of the components are above ground.

The high relative costs of permeable paving (Option 3) and porous asphalt (Option 4) demonstrate the much higher standard of regular cleaning required to maintain their hydraulic performance. The higher cost of Option 2 (raingardens, tree pits and storage basins) demonstrates the impact of introducing a larger area of vegetation that requires more intensive maintenance compared to Option 1 (swales are generally grassed and require less intensive maintenance than raingardens / trees).

TRANSFERABILITY TO NEW ZEALAND

The work completed to date is based on UK sources and datasets. Table 3 shows how key components could be adapted to a New Zealand (NZ) context. SuDS maintenance costs in NZ are explored in *Activating WSUD – Understanding costs and maintenance of WSUD in NZ* (Ira and Simcock, 2019). This study shows significant variability in maintenance costs primarily influenced by local conditions, cost data recording and overall maintenance approaches. Similar issues are experienced in the UK and this demonstrates the two markets are in a comparable position.

Table 3: Transferability to New Zealand

Tool Component	Comment
Analysis period	This can be set by the user to any period required.
Maintenance regime	Given the amenity and water quality focus of SuDS in NZ (the focus in the UK is water quantity only), regimes can be developed to suit these objectives.
Discount rate	This can be set by the user to any rate required.
Asset and maintenance activity databases	Preliminary review suggests general asset types and activities are similar. Detailed review will need to be undertaken to adapt to local contexts, maintenance approaches and costs. The wide range of proprietary stormwater treatment devices in NZ would need to be accommodated.
Maintenance cost rates	These can be customised to local or site specific requirements, but maintaining a UK comparison will be useful in benchmarking and identifying anomalies.
Outputs	The type and resolution of outputs can be customised to match local asset management requirements.

FUTURE DEVELOPMENT

The tool has been implemented at two Councils in England (Central Bedfordshire Council and Medway Council) to date. The primary use is to determine commuted sums for developer contributions to support SuDS asset adoptions by the Councils. However, the structure of the tool allows it to be adapted to the following applications:

- An online tool that can be used by developers to inform viability assessments and to estimate potential maintenance liability of adopted assets early in the design process to inform critical design decisions
- Inclusion of a wider range of costs such as design / construction, other operational expenses (electricity / replaceable parts for proprietary devices) and disposal to facilitate calculation of whole life costs of schemes
- Inclusion of benefits (such as flood risk reduction, water quality improvement, amenity, biodiversity, habitat creation and mental health benefits) generated by the scheme to provide an overall whole life benefit / cost comparison for schemes

- Addition of a design / build quality factor that recognises and quantifies the fact that good design and high build quality of SuDS substantially reduces long term maintenance costs and increases long term benefits.

CONCLUSIONS

The tool described in this paper has already demonstrated through practical application in the UK that a consistent, transparent and defendable approach can be used to estimate whole life maintenance costs of SuDS. These costs can be lower than traditional drainage approaches with appropriate design consideration at the beginning of the development master planning process.

As with any tool of this type, the robustness of the output is heavily dependent on the input data quality. The development approach for this tool addresses this through establishing a baseline of standard maintenance activities, frequencies and costs that can then be improved on by the end user as maintenance experiences mature over time. This allows the tool to be adapted to local or site-specific circumstances and continuously improve its output accuracy. In turn, this will empower the asset owners to improve maintenance budgeting and collect appropriate / proportionate commuted sums at adoption to ensure the asset is adequately maintained in the future.

Comparison of UK and NZ based studies on SuDS asset maintenance shows that the two countries have comparable challenges, issues and uncertainties in this area. A common conclusion in both countries is that 'designing for maintenance' is critical in the success of delivering durable and effective SuDS schemes. The tool described in this paper can be used to initially inform, then develop and record local SuDS maintenance knowledge (activities / frequencies), costs and ultimately improve outcomes in the long term by reducing the cost uncertainty of asset adoption – one of the biggest barriers to implementing long term SuDS schemes for the benefit of all.

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