Advice Note 5
Road and Street Drainage using Nature Based Solutions

Design Manual for Urban Roads and Streets

Rialtas na hÉireann
Government of Ireland

The Design Manual for Urban Roads and Streets (DMURS) Advice Note 5 – Road and Street Drainage using Nature-based Solutions provides guidance for designers on how to incorporate Nature-based Solutions into road and street drainage design.

This advice note has been prepared in collaboration with State Agencies, Local Authorities and relevant professional bodies. It demonstrates how the aims and objectives of the main DMURS document and the design of urban roads and streets can be adapted to manage rainwater in a more sustainable and nature based manner.

The use of nature-based solutions, alongside traditional drainage, in our roads and streets is particularly important with the multiple benefits that it provides, such as:

- Improving water quality in our receiving water bodies thus benefiting human, marine and aquatic health,
- Protecting groundwater recharge,
- Improved road safety through landscape interventions,
- Creating a high-quality public realm,
- Reduced flood risk, water channel erosion and overflows in our drainage and sewer systems,
- Creating more sustainable and climate adaptive urban neighbourhoods,
- Increased biodiversity,
- Provision of shade and reducing the "heat island" effect,
- Reduction of noise pollution,
- Improved air quality,
- Enhanced visual amenity
- Lessening the negative impacts of urban development on the natural environment,
- Potential for lowering capital and operating costs associated with development.

This advice note encourages designers to incorporate Nature-based solutions into their designs at the earliest stage of a project, using a multi-disciplinary team, to ensure maximum benefits are realised in a cost-effective manner.

It will support and provide additional confidence for designers and those responsible for traffic management and maintenance of urban roads and streets, with the inclusion of nature-based solutions in future projects.

An Roinn Tithíochta, Rialtais Áitiúil agus Oidhreachta
Department of Housing, Local Government and Heritage

An Roinn Iompair
Department of Transport

Local Authority Waters Programme
vibrant communities | catchment assessment | healthy waters

Pelletstown Avenue, Pelletstown

Table of Contents

1.	Background	1
2.	Introduction	4
3.	Integration with DMURS	6
4.	Design Issues in context of DMURS and DMURS Advice Notes	13
5.	Implementing Nature Based Solutions as part of an Urban Project through integrated planning and design	21
6.	Care and Maintenance	22

References/Further Reading

Acknowledgments

Appendix 1 - Water Sensitive Urban Design

BASIC STEPS TO ACHIEVE EFFECTIVE NATURE-BASED RAINWATER MANAGEMENT SOLUTIONS:

Adapted from advice by Ian Titherington, Senior Policy Adviser – Sustainable Drainage. Welsh Government.

- **The primary design and construction criterion for any nature-based drainage feature must be the rapid and effective removal of rainwater from the pavement surface and the diversion of that flow into the nature-based feature.**

- **To achieve this, the designer and contractor must focus on the design and construction of the inlets from the pavement into the nature-based feature. These inlets should be located correctly (often at existing gully locations), should have sufficient width, and be appropriately graded from the adjacent road channel.**

- **Rainfall entering the nature-based feature must flow freely from the paved area onto the surface of the nature-based feature. Therefore, the highest finished level within the nature-based feature must be a specified depth (freeboard) below the level of the paved area.**

- **Existing road gullies adjacent to nature-based features should be relocated so that they are within the nature-based feature. The top level of the gully grid should be designed to allow maximum water storage within the nature-based feature while preventing excess flows overflowing back onto the pavement surface.**

- **The nature-based feature may be lined, if necessary, with appropriate perforated underground drainage to remove any excess water.**

- **Only use trees where there is adequate soil volume available and where conflict with underground services can be avoided. Use semi-mature trees suited to an urban environment and avoid using saplings as they can easily be vandalised.**

- **Use appropriate soil mixtures (e.g., engineered soils for raingardens).**

- **Choose the correct vegetation (this can vary depending on location and context). Look to use native plants as much as possible. Be aware of the ultimate height and spread of selected plants, given the space available. Always aim for low maintenance with resilient plants that can withstand the urban environment, periods of waterlogging and drought.**

1.0 Background

1.1. Road and Street Drainage Using Nature-Based Solutions

The Design Manual for Urban Roads and Streets proposes 'a shift away from recently accepted practice approaches towards more sustainable approaches'. One feature of urban roads and streets is that, in general, they are paved with material that is impermeable, such that rainwater falling on these surfaces cannot be absorbed as would be the case in a natural landscape. This, in turn, has led to the necessity for urban roads and streets to incorporate a system to deal with the resultant flows of rainwater (or surface water) through urban piped underground drainage networks.

It has become increasingly apparent that this approach is not sustainable, particularly given the effects of climate change and resultant increased intensity of rainfall events. This Advice Note seeks to address this issue and demonstrate how the integration of a more sustainable and nature-based approach to rainwater management can lead to the achievement of a "water sensitive" design of urban roads and streets.

National Planning Objective 57 - of the National Planning Framework[1] also specifies the need for sustainable water management solutions, such as SUDS to enhance water quality and resource management.

1 National Planning Framework, Government of Ireland, 2019.

Water Sensitive Urban Design is the process of integrating water cycle management with the built environment through planning and urban design. This approach, which emulates nature (see Figure 1.1) seeks to address issues related to:

Environmental Impact: Urban surface water runoff is contaminated by a wide range of pollutants picked up from urban roads and streets. Discharging this runoff directly to natural water courses causes significant pollution. The rapid discharge of surface water from urban paved areas into combined sewers also leads to heavily polluted discharges from these systems into natural water courses through surface water overflows also called combined sewer overflows. There is growing recognition of the impact of urban runoff on the environment. The current River Basin Management Plan under the E.U. Water Framework Directive and the E.U. Urban Wastewater Treatment Directive have highlighted the need to address this environmental risk.

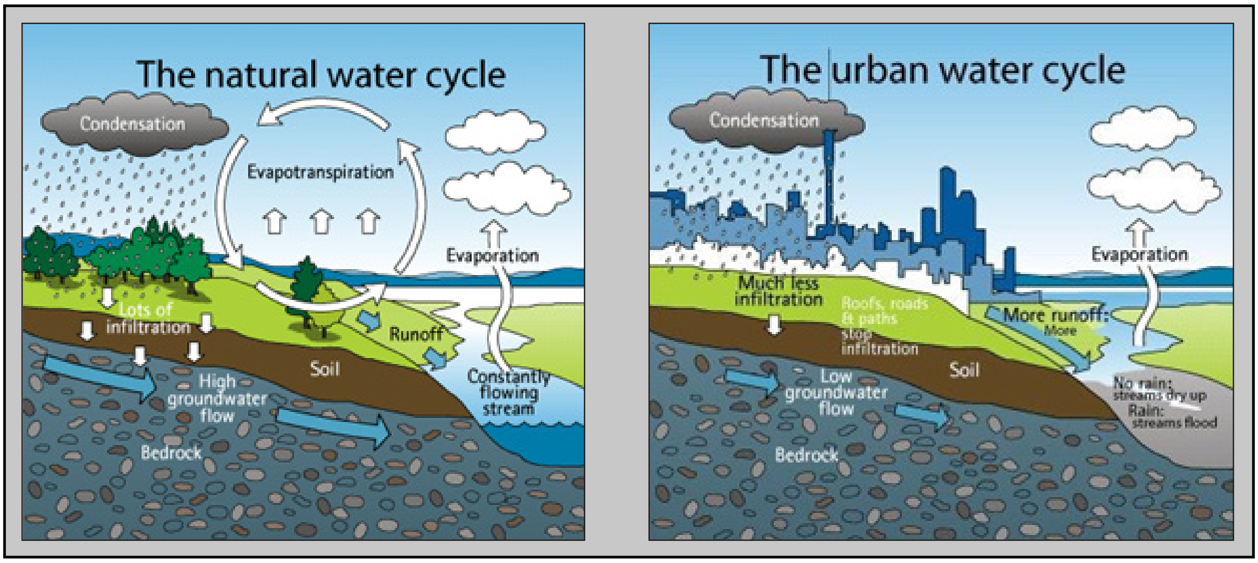


Figure 1.1: The natural water cycle (left) and the urban water cycle (right)

Flood Risk: Rain falling on large impermeable urban areas is rapidly discharged into the drainage network. This is in contrast to rain falling on natural surfaces that are permeable which can absorb and store large volumes of rainwater which then discharges slowly to the environment. This rapid discharge can and does lead to flooding when the rate of rainfall exceeds the capacity of the drainage network. Climate change, with the increased frequency of high intensity and localised rainfall events, has significantly exacerbated this risk. It is, therefore, recognised that nature based SUDS contributes towards climate adaptation and climate resilience. The risk of flooding from rainfall (pluvial flood risk) is recognised as one of the flood risk types in the 2009 Flood Risk Planning Guidelines (DHLGH / OPW) (see section 2.2 below)

1.2 Nature Based Sustainable Urban Drainage Systems

While Sustainable Urban Drainage Systems (SUDS) are referenced in DMURS, the approach to SUDS to date has not been consistent with the principles of sustainability, with a focus on engineered and underground solutions. This Advice Note describes the benefits of integrating nature based sustainable urban drainage into the DMURS approach through the greening and landscaping of urban roads and streets and how to achieve this.

Nature- based sustainable urban drainage measures are incorporated into the designs for urban roads and streets (as well as open spaces as part of a broader network - see Figure 1.2) as an additional feature that overlays the traditional drainage networks of gullies and pipes. These features act as a buffer as they take the initial runoff from the road and provide multiple benefits, as detailed below. The runoff overflows into the traditional drainage systems, thereby ensuring no overflowing onto the road and street network (see also Chapter 2)

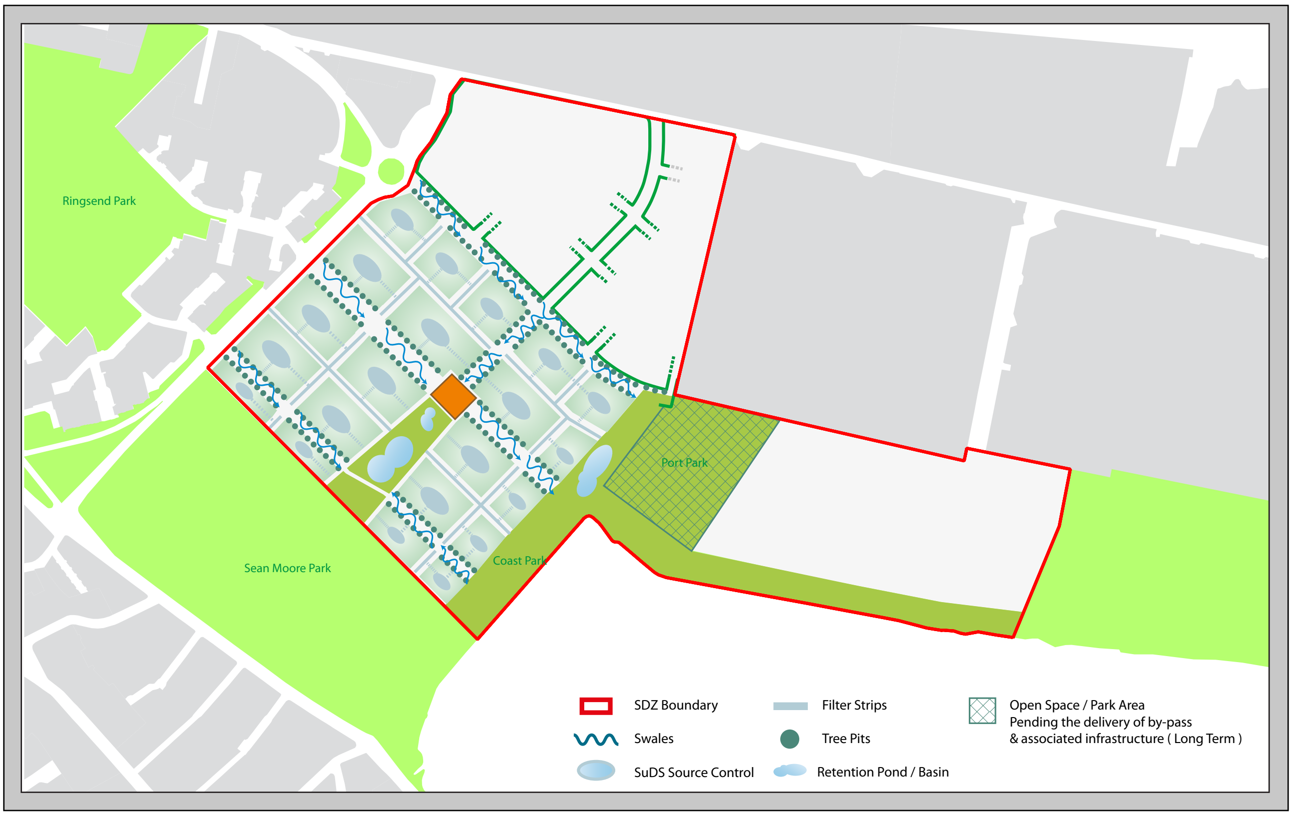


Figure 1.2: Extract from the Poolbeg West SDZ Planning Scheme (Dublin City Council) illustrating the surface water drainage network which includes an integrated public realm and public open space network to to provide high quality and attractive 'green and blue' corridors to enhance local amenity, ecology and biodiversity.

This design approach helps address the environmental and climate change issues arising from a traditional urban drainage design, predominantly based on hard and impermeable surfaces. The benefits of such a water sensitive design philosophy using green and landscaped areas are:

- Reducing the rate of rainwater runoff from roads and streets into existing drainage networks, and filtering that runoff through landscaped areas, thus reducing environmental pollution and flood risk.
- Creating more sustainable and climate adaptive urban neighbourhoods through allocation of space to natural landscaping.
- Creating a high-quality public realm that supports self-regulating streets, shared spaces, walking and cycling.
- Improving road safety though landscape interventions.
- Improved biodiversity.
- Provision of shade and reducing the urban "heat island" effect.
- Reductions of noise and improvements in air quality (landscaped buffer).
- Visual amenity

2.0 Introduction

2.1. The role of Urban Drainage

The use of nature based sustainable urban drainage solutions is in addition to the continuing role of traditional surface water drainage systems. Due to the impermeable nature of traditional roads and streets, a system of urban surface water drainage has evolved that is primarily designed to remove surface water from the roads and streets as quickly as possible through a system of kerbs, gullies and underground pipes. This traditional approach also included an emphasis on removing surface water from the paved areas without allowing it to percolate to sub-surface formation in order to avoid weakening the formation level.

The main objectives of Road/Street drainage systems are:

- The removal of surface water from the paved areas to reduce risks to road vehicles such as aquaplaning, loss of skid resistance and icy surfaces in winter.
- The avoidance of surface ponding of rainwater which is likely to cause a hazard and nuisance for those using the urban roads and streets.
- The provision of effective surface and sub-surface drainage to maximise longevity of the pavement and road edges.

It is essential that adequate drainage is provided to ensure that a road pavement performs satisfactorily. Nature based sustainable urban drainage systems as described in this Advice Note are an additional feature that co-exists with the traditional urban drainage system. It can reduce overloading of the piped network as the rainwater flow has to pass through specifically designed soils before reaching the pipes. This provides storage and slows the flow, thus extending the “time of concentration”. This reduces the impact of sudden peak flows on the network capacity.

The nature-based features are designed to quickly remove rainwater from the paved areas and absorb the runoff, prior to discharge to the underground network. Existing road gullies will be incorporated into these features with appropriate inlet levels to act as overflows when the capacity of the nature-based feature is exceeded. Road Authorities have powers in relation to the Drainage of Public Roads under section 76 of the Roads Act 1993, as amended. Further details in relation to drainage design can be found in TII Standards and the Department of Transport document ‘Guidelines for Road Drainage’.

2.2. Water Sensitive Design and Nature Based Solutions.

Centuries of urbanisation and urban creep, which has been accelerating in recent times has had a significant impact on the natural Water Cycle and on climate change. The consequences of these impacts and the need to restore the natural balance of the natural water cycle are becoming increasingly recognised. While moves towards more compact urban growth will help to avoid further urban creep, there is also a need to reverse previous negative impacts through imaginative urban designs when urban projects are being carried out.

Rainwater falling on the largely impermeable surfaces within an urban area has a number of negative impacts that needs to be addressed. These are:

1. Road Safety

   Whereby inadequate drainage can cause aquaplaning, resulting in reduced road grip and impacting on safety.

2. Environmental Pollution

   The rainwater collects a large variety of pollutants which are then discharged to urban watercourses without any treatment. In areas of combined sewers, this pollution can be through the overflows designed into the combined sewer network.

3. Flood Risk

Due to the large areas of impermeable urban surfaces, the rainwater cannot infiltrate into the ground as it would do in a rural area. This results in large volumes of rainwater being discharged during heavy rainfall events, often resulting in local and downstream flooding. This risk has been exacerbated due to the increased intensity of rainfall events arising from climate change.

These risks can be significantly mitigated by the introduction of planted areas with specially designed soils that allow rainwater percolate through the soil, thus removing many of the pollutants and slowing the flow to reduce flood risk.

Water systems should seek to adopt natural infiltration solutions that places less reliance on the overloaded underground piped system. A sustainable solution to this environmental problem is Water Sensitive Urban Design (see also Appendix 1) which also benefits our water quality, biodiversity and critically the spatial enhancement of our public realm, roads and streets (see Figure 2.1).

The incorporation of planted and landscaped areas as part of a nature-based approach to rainwater management in urban areas is consistent with the requirements of the Water Framework Directive, the Floods Directive and contributes towards climate adaptation and climate resilience. National Planning Objective 57 of the National Planning Framework also requires integrating sustainable water management solutions, such as SUDS to enhance water quality and resource management.

This Advice Note seeks to demonstrate how appropriately designed and located urban planting and landscaping can contribute towards the original philosophy and design principles set out in DMURS, while also incorporating the urban design philosophies of Water Sensitive Urban Design and Nature Based Solutions.

Figure 2.1: Bioretention Areas (Rain Gardens) – Pollerton Road/Green Lane Junction, Carlow. Carlow County Council

3.0 Integration with DMURS

3.1. Planting and Landscaping in Support of DMURS

Section 2.2 of DMURS identifies "the way forward" as "a more integrated model of street design, (incorporating) elements of urban design and landscaping that instinctively alter behaviour, thus reducing the necessity for more conventional measures (such as physical barriers and the road geometry)". The need to create a "sense of enclosure" that "spatially defines streets" is highlighted in DMURS Section 4.1 and the use of urban planting to achieve that is recognised. Section 4.2.7 of DMURS covers the general area of urban planting in the context that "Landscaping is traditionally used to add value to places though visual enhancement (see Figure 3.1)

3.2. SUDS in Support of DMURS

DMURS section 4.2.7 states that "Streets also support an important drainage function within built-up areas. The shift toward sustainable forms of development has seen the emergence of Nature-based SUDS. The incorporation of Nature based elements into the fabric of the street itself can also serve to increase legibility and add value to place".

As such rainwater runoff can be directed towards landscaped areas which, in turn, are specifically designed and constructed to allow that runoff enter the area and percolate through the designed soils prior to entering underground porous pipes which direct the flow back into the existing drainage network. This will help address the negative impacts of urban runoff as set out in section 1.2 of this Advice Note.

It is important to note that this design approach supplements rather than replaces the existing surface water drainage network that is already in place. Appropriate nature-based design solutions will incorporate traditional urban drainage features such as street gullies which can, if appropriately located, act as overflows during more intensive rainfall events. The landscaped areas that also act as urban rainwater management features have specific design characteristics.

Figure 3.1: Extract from DMURS (figure 4.28) illustrating the integration of planting into the design of a street to increase visual amenity, support biodiversity and calm traffic.

3.3. Integration of SUDS into Street Design

Urban planting and landscaping as part of an overall street design provides an ideal method of re-imagining our urban areas to prioritise pedestrians, cyclists and sustainable transport while also providing sustainable and climate adaptive solutions to rainwater management. Opportunities for such measures include:

Street Tree Planting (enclosure)

In Chapter 4, DMURS discusses the importance of planting street trees to create a sense of "enclosure" that reduce traffic speed within urban areas. Trees can be located within rainwater gardens/swales/tree pits that take in runoff from surrounding hard standing areas.

Horizontal Deflections

Section 4.4.7 of DMURS proposes the use of horizontal deflections as a means of reducing vehicle speeds where the carriageway is narrowed locally. These kerb deflections and the space that they occupy, can and should be seen as opportunities for the incorporation of nature-based rainwater management solutions such as rain gardens or equivalent.

Medians, Verges and Strips

Section 4.3.1 acknowledges that medians and verges can be used to accommodate street trees but, if appropriately designed, this Advice Note suggests that they can and should also be used as part of a nature-based rainwater management system.

Strips to the front of buildings also provide opportunities through the incorporation of rainwater storage and associated planting at downpipe locations where roof water can be collected and stored, prior to discharge.

In some urban locations there may be opportunities to introduce a verge as a "filter strip" to allow some rainwater retention and storage, in association with underground filter drainage and overflow gullies.

Medians, or the areas in the centre of divided carriageways, can be planted but the scope for their use to retain and treat rainwater. This may be limited due to the normal carriageway camber that results in rainwater flowing away from the median towards the carriageway edges. However carriageways can be locally graded towards the median.

Car Parking Areas

Section 4.4.9 of DMURS deals with on-street parking and loading. As can be seen from images 3.3 and 3.4 dedicated areas of car parking provide additional opportunities for the introduction of urban planted areas such as rain gardens and surface treatments such as permeable paving.

Transition Zones and Gateways

Section 3.3.4 of DMURS deals with "Gateways" and "Transition Zones". In both cases, the urban designer is seeking to reduce traffic speed and highlight the change to an urban context. This is dealt with in more detail in DMURS Advice Note 1: Transition Zones and Gateways. There are opportunities within these zones for the large-scale use of landscaping and the nature-based management of urban rainwater. The use of best practice rainwater management in these areas also sets a template for their more widespread use throughout the urban area, thus enhancing a sense of place.

Figures 3.2-3.4 illustrate how street space can be reimagined with planting and landscaping to support the DMURS design approach. This enhances the urban spaces and delivers climate adaptive sustainable solutions, whilst also calming traffic and improving comfort/safety for more vulnerable users. Figures 3.5-3.6 also provides examples illustrating how nature based solutions can be incorporated in to the street layouts and transition zones.

Figure 3.2: Link Street (top) reimagined (bottom) with SUDS.

1. As an alternative to the ghost Island, road space has been reallocated to verges containing swales/rainwater gardens. This narrows the vehicles carriageway, slowing traffic and creates a buffer for pedestrian/cyclists

2. As an alternative to walls/fences defensive landscaping consisting of swales/rainwater gardens is provided. This increases surveillance of the street (from adjacent buildings) and creates a more comfortable pedestrian environment.

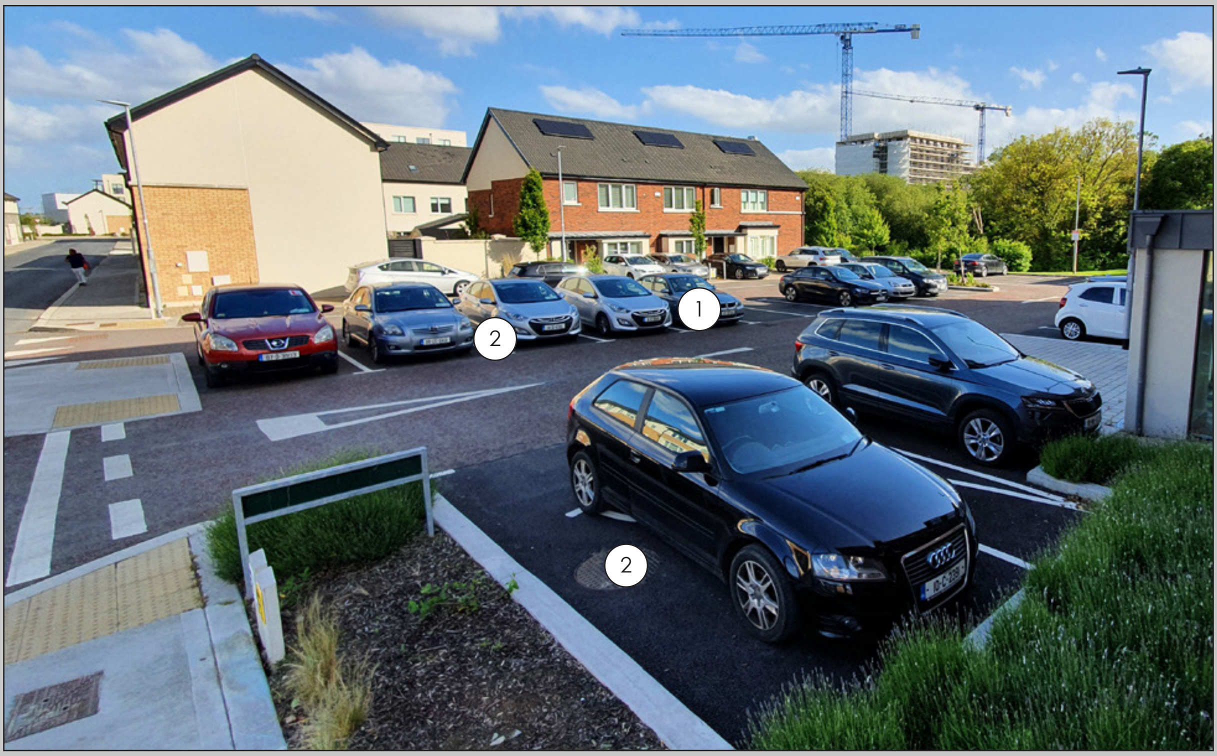
3. Trees are planted in the swales/rainwater garden areas creating a greater sense of enclosure and calming traffic.

Figure 3.3: Local Street (top) reimagined (bottom) with SUDs

1. Parking bays have been separated with rainwater gardens that also create additional space for street tree planting (enclosure) within build outs that narrow the carriageway.

2. Combined with more conventional measures (entrance treatment), build outs also narrow the main carriageway, calming traffic.

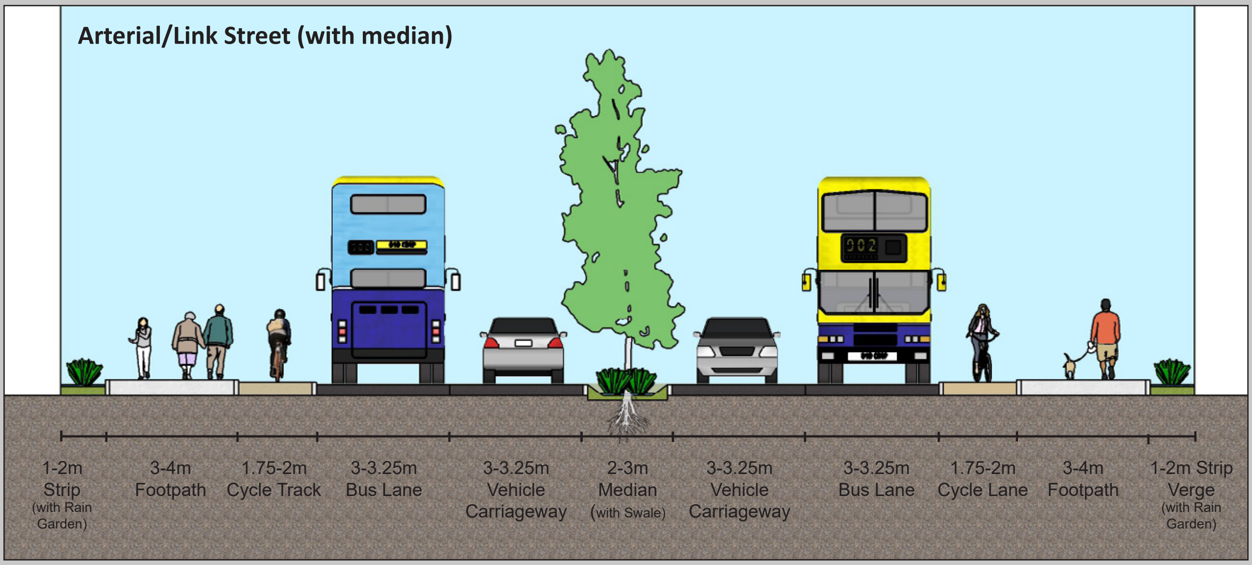
Figure 3.4: Car parking court (top) reimagined (bottom) with SUDs.

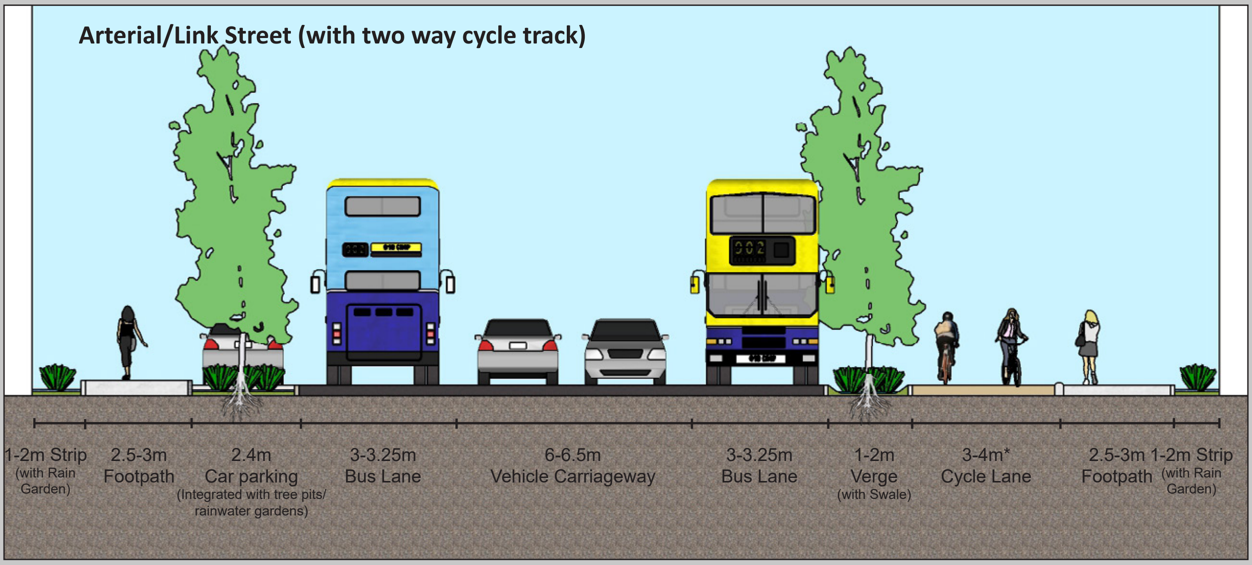


1. Parking bays have been separated with rainwater gardens which also reduce the visual impact of large area of surface parking

2. Parking Bays have bee resurfaced with reinforced grass, delineating parking areas from circulation areas and further breaking up the visual impact of the hard surfaced area.

Figure 3.5: Sample Street cross section illustrating how Nature Based SUDS can be integrated with streets of differing functions/configurations





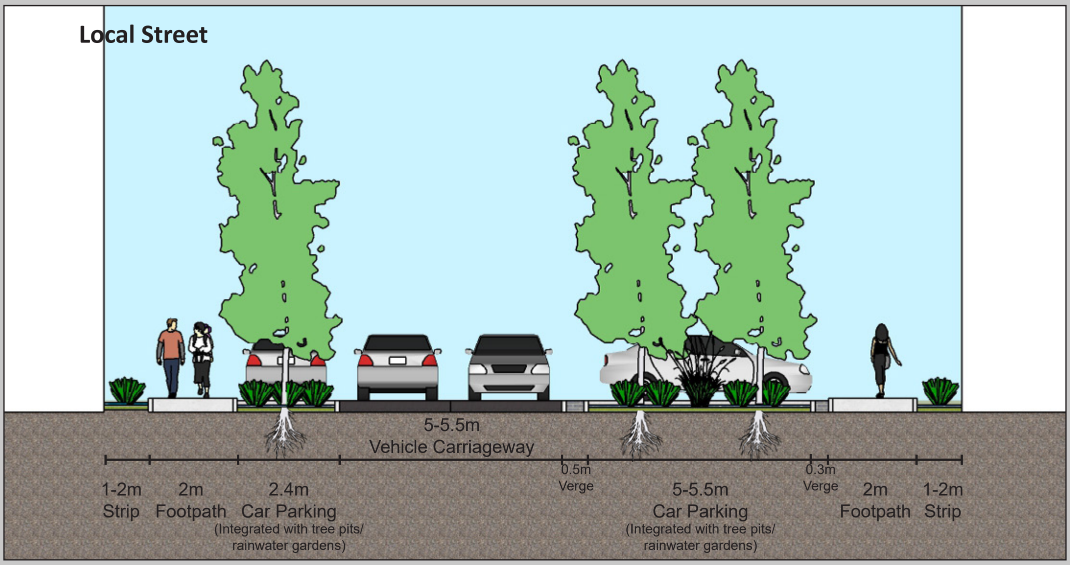


Figure 3.5 continued: Sample Street cross section illustrating how Nature Based SUDS can be integrated with streets of differing functions/configurations

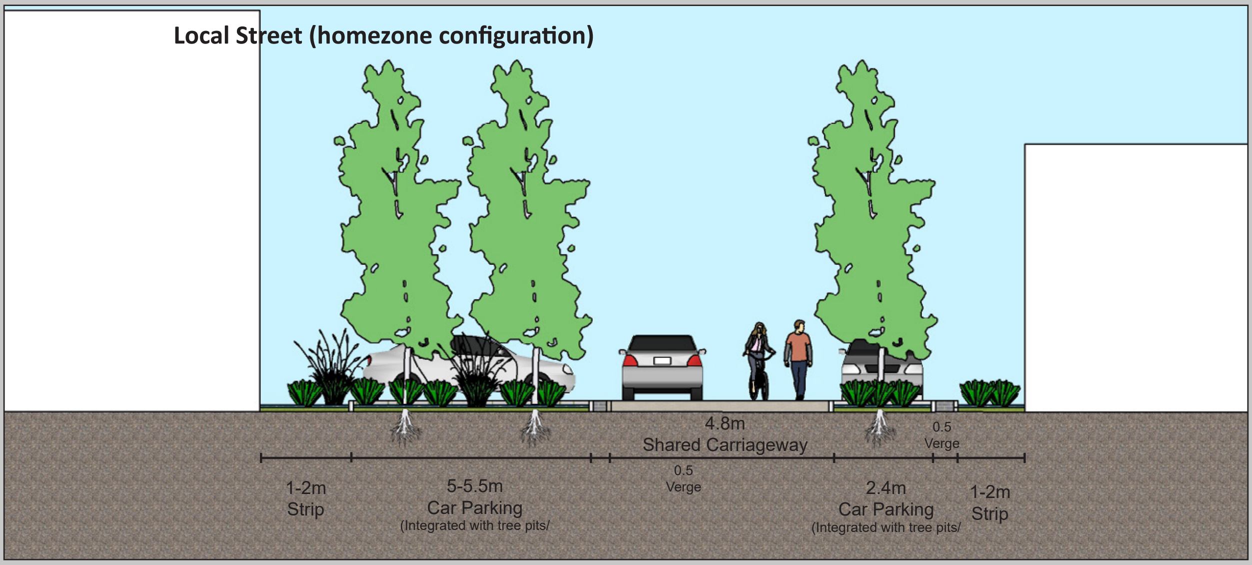
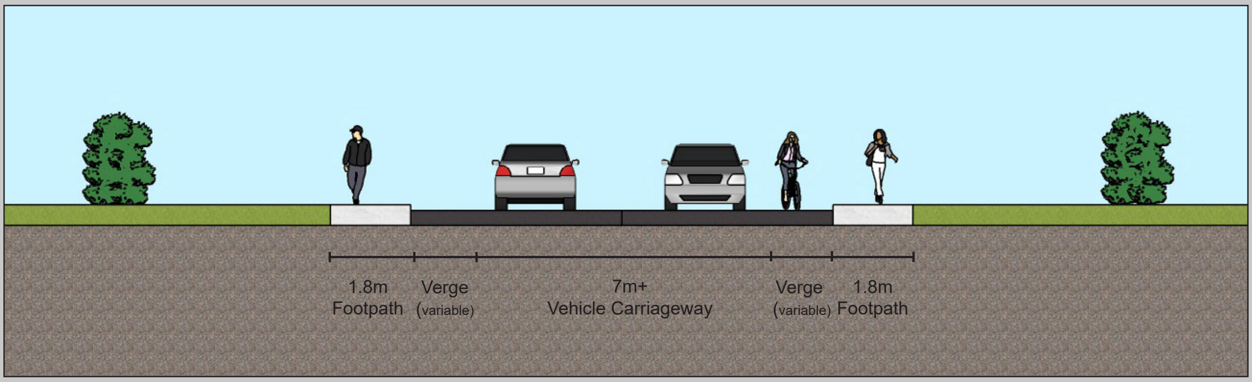
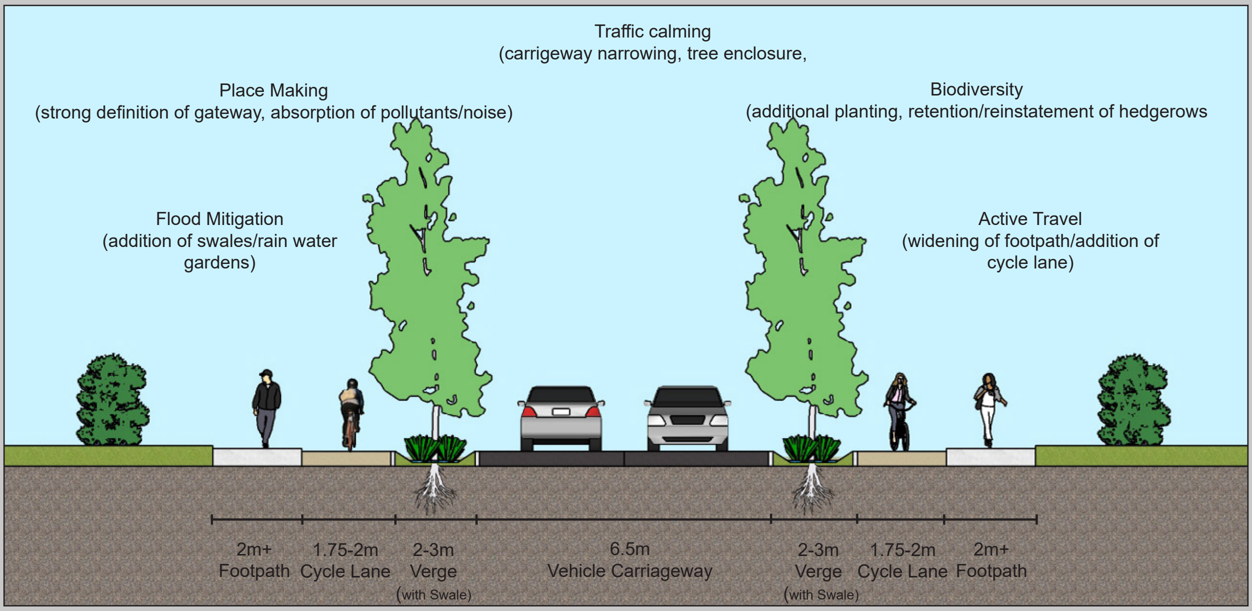


Figure 3.6: Transition zone incorporating landscape/SUDs features which reinforce a gateway to reduce vehicle speeds upon entry to an urban area.



Existing typical section in Transition Zone - predominantly hard surfaces with limited Active Travel



Potential section in Transition Zone - reallocate and better define road space to promote active travel while integrating SUDS/NBS measures

4. Design Issues in context of DMURS and DMURS Advice Notes

In this section, the intention is to demonstrate how a nature-based approach to urban rainwater management can be "incorporated into the fabric of the street itself" as stated in Section 4.2.7 of DMURS. The proposed approach is to design roads and streets so that, insofar as is practicable, rainwater flows from paved surfaces into planted areas, with appropriately designed soils to allow retention and treatment prior to discharge to existing subsurface piped networks. In this advice note, the aim is to identify a menu of options that would be appropriate to various urban situations.

4.1. Rain Gardens

Most landscaped areas that act as nature-based solutions to urban rainwater runoff can be described as Rain Gardens. They can be within the traditional verge area (between the footpath or the carriageway), median or contained within areas of kerb extensions or "build outs" (see Figures 4.1 to 4.2). These planted areas need to be designed in such a manner to allow runoff from the nearby impermeable area to infiltrate into it.

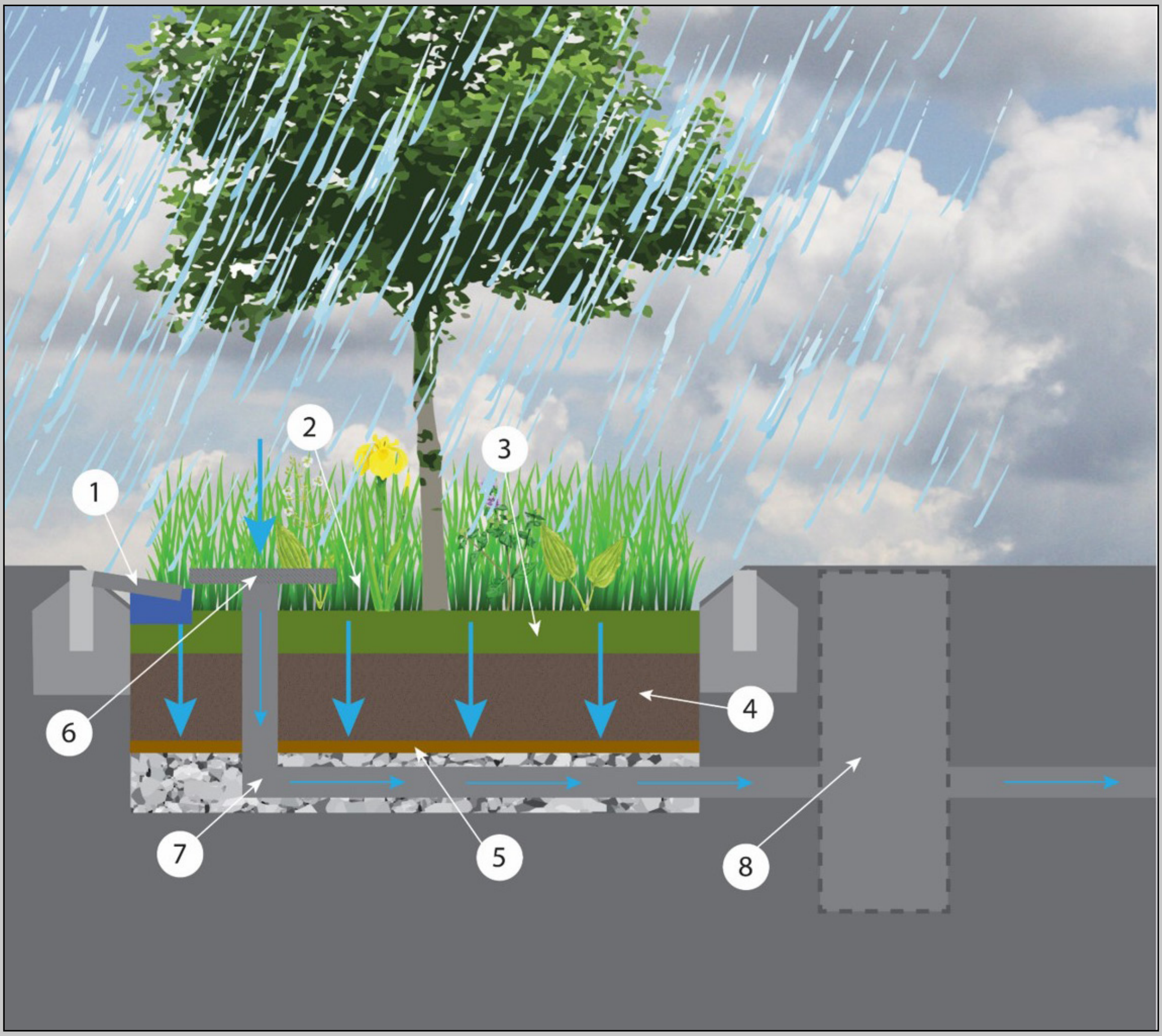
Planted areas should be able to withstand wet weather and drought conditions so that there is no ponding during wet weather and no need for external watering during dry weather. Typically, rain gardens will incorporate underground perforated pipes to accept the percolated rainwater with slightly raised gully grids at surface level to allow the raingarden to be bypassed during periods of extreme rainfall (as per Figures 4.1 and 4.2).

Rain gardens can be incorporated into the general design of urban areas, even where the traditional kerbed verges or kerb extensions are not in place or proposed. They can range in size and shape but must be located at locations that will allow the rainwater flow into them from adjacent paved areas (see Figures 4.3 and 4.4 for further detail). Existing services such as telecom or water / gas mains can be accommodated within raingardens without the necessity of service diversions. Rain gardens can be incorporated into the design of pedestrianised areas and urban public realm.

Figure 4.1: Verge (top) and median (bottom) designed as SUDs features. Note both features include an overflow drain into a more conventional system should the feature become saturated.

Figure 4.2: Median containing a rainwater garden designed to intercept rainwater on the way to a more conventional drain.

Figure 4.3: Rain garden schematic – Cross Section



1 Silt trap: use a small apron or slab to collect silt and allow its removal. Flush kerbs can either have a thin stone traps along the inside edge to catch the heavy silt (on busy roads) or the soil can be scraped annually/biannually.

2 Freeboard: the space above the soil level for water collection before infiltration through the soil. Usually about 25mm from soil surface to overflow, but can be increased if challenging to hold the first 5mm/1in1 year storm before overflowing.

3 A layer of slate chippings, surface grit or gravel which will protect the infiltration capacity of the soil. Do not use mulch, organic matter or wood chippings on the surface as these may float and clog filtration.

4 A 450 - 600mm deep, free draining soil mix of 60% 1-6mm grit, 10% organic matter and 30% mix graded washed sand is recommended. This soil cleans, stores and conveys runoff to a drainage layer and ensures that the soil stays permeable when there is a large ingress of silt off a heavily trafficked area. For heavily trafficked areas the plants chosen should be hardy for a very dry soil, slow growing and pollutant tolerant conditions. The grit % can be reduced for roof and footpath drainage and plant diversity increased.

5 An intermediate layer of grit/pea gravel (50mm) or a double layer of hessian sacking. This protects the drainage layer.

6 An overflow gully to take excess water should the rain garden design capacity be exceeded (e.g., extreme weather events or blockages). This should be set just below the freeboard maximum height (which can vary but at a minimum of 25mm) above the soil level and nominally below the road or footpath level, ensuring no flooding. The down pipe can be a 300mm pipe inverted, with a hinged DI cover on the top for easy access.

7 A perforated discharge pipe connected to the existing storm water network or watercourse. Sometimes this can be wrapped to stop tree roots or too much silt entering.

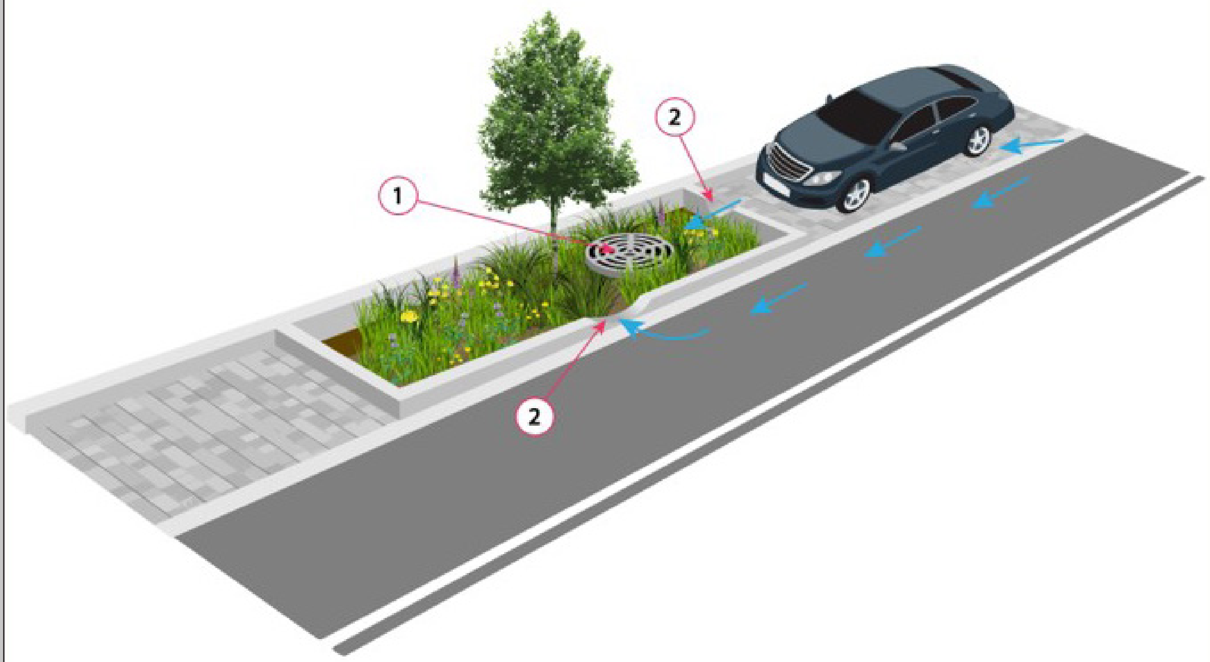
8 Access chamber for flow control, such as an orifice plate, to ensure that storage is utilised. A non-return valve is sometimes used if connecting back to existing combined sewer (if no other option) and new gully trap is necessary.
Potential water line after storm.

Notes:

Planting should occur in early winter (a few weeks before early frost), as the roots will have established by the spring needing less watering.

- Create a 'V' shape in the soil slightly to the centre, or have it absolutely flat (if narrower than 2m). This makes maximum use of the soil area, which is critical in terms of treatment.
- A maximum 5:1 ratio is advisable for busy roads, as otherwise the silt loading can cause problems.
- Slot inlets are better for parked areas and flush kerbs for non-parked areas with straight and fairly wide lanes.
- The fall from the road to the soil is usually around 100mm, as any more may become a fall issue for pedestrians. It can be a little lower in order to enable the rain garden to store more before overflowing (to catch the first 5mm storm), but this very much depends on the location

Figure 4.4 Rain garden schematic –3 D



1. Surface overflow or existing gully could provide overflow.
2. Inlet in kerbing to allow runoff from hard surface to enter rain garden. Note: the level of raingarden soil is approx. 200mm lower than the draining hard surface. This allows water to drain into the rain garden rather than pond on the road.
3. Slot inlets are better for parked areas and flush kerbs for non-parked areas with straight and fairly wide lanes.

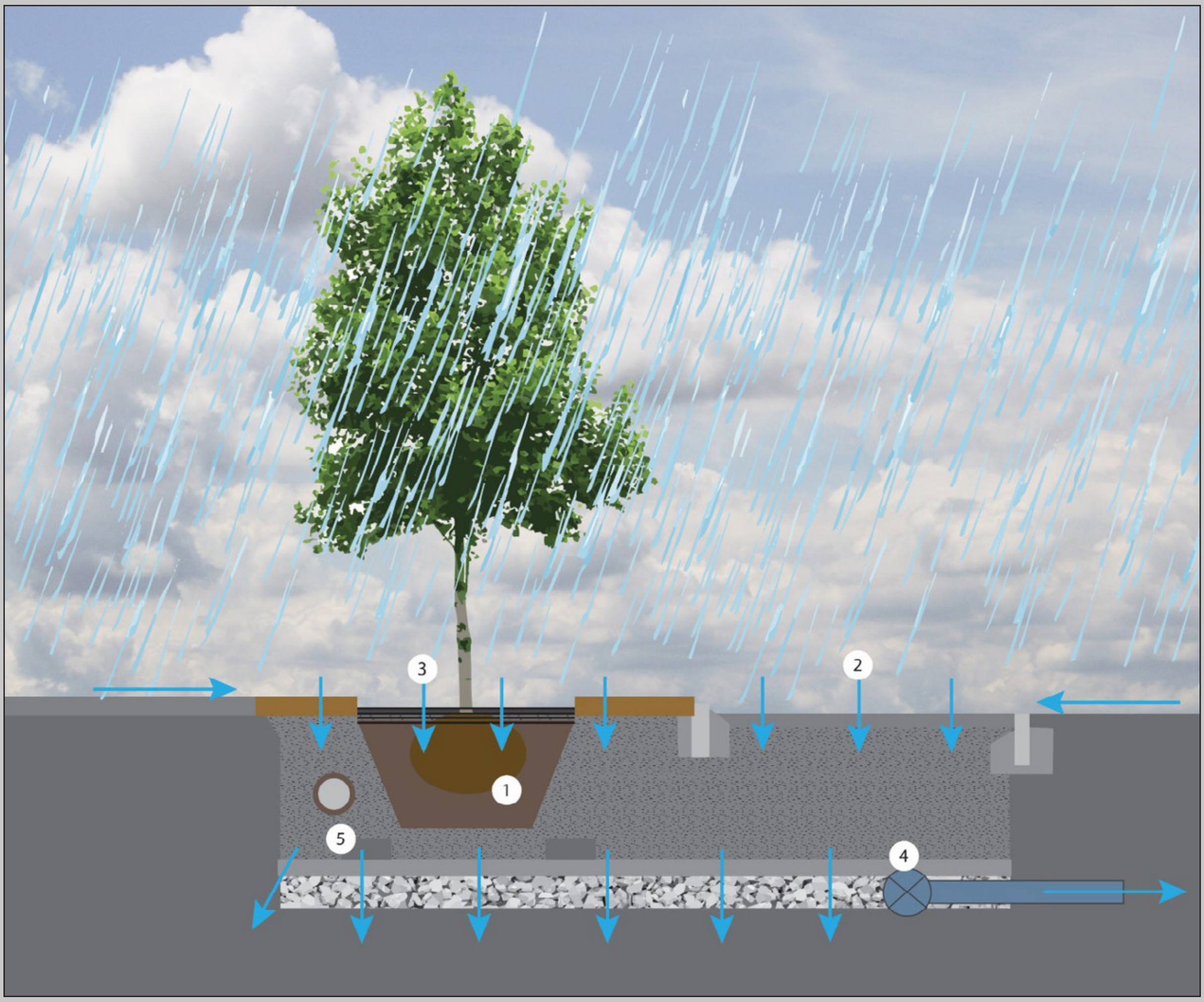
4.2. Tree Pits

DMURS, when referring to urban planting, refers mainly to the planting of street trees. This Advice Note recommends that street trees should, in general, be planted within a raingarden area, where practicable. The tree is, typically, planted within the raingarden but also within a specially designed tree pit. Tree pits are designed to ensure that there is sufficient volume available for the tree roots to grow and develop, while protecting underground services from damage from the tree roots. The tree pit should be designed to retain and treat rainwater runoff as part of the overall rain garden design (see Figure 4.5). Specific engineered soil will be required. Refer to Appendix 1 for the specification of this soil.

While, in many cases, existing underground services can be accommodated within a rain garden without diversion, the volume required by a tree pit is more likely to impact on underground services so the decision where to plant trees should have regard to the location and types of underground services as well as the space available for the tree canopy (as per section 4.2.2 of DMURS). Consultation with utilities companies early in the design process is highly recommended.

Trees can have a major beneficial impact on the retention and disposal of urban rainwater runoff. Evapotranspiration can lower water levels in close proximity to trees, thus assisting in the functionality of an adjacent rain garden.

Figure 4.5: Tree pit schematic - Cross Section



1. Trees require a growing medium of between 10 - 30m³ depending on tree species depending on the tree species. Please consult tree expert. A few trees can be placed in a trench to enhance the growing medium volume available to each tree.

2. Silt removal, via swales, raingardens' or other mechanisms must be designed within the tree pit design to allow runoff from roads into the tree pit. Ensure sufficient freeboard is provided to avoid clogging by silt, litter etc.

3. Positioning and specification of trees to be in accordance with Design Manual for Urban Roads and Streets.

4. A drain down pipe must be provided. This ensures no waterlogging of roots or build up of road salt within the tree pit.

5. Service trenches can be designed through the tree pit for services such as water, gas and drainage systems.(in agreement with the Local Authority). Electrical supply or telecoms with a joint box located within the tree pit feature is not recommended. Liaise with Uisce Éireann to identify how best to reduce surface water ingress into combined sewers.

4.3 Swales

Swales are areas of planting or grass that are larger than standard urban verges (see Figure 4.6) but are in close proximity to urban roads or streets. They may form part of a small open space or where there are larger verge areas available. The level of a swale is lower than the surrounding area in order to provide rainwater runoff storage. They provide the functions of an urban rain garden but with additional storage capacity. Swales can form part of the overall surface water conveyance system through providing surface level connectivity between nature-based rainwater management features to form a "SUDS Train", thus providing additional retention and treatment (see also Figures 4.6, 4.8 and 4.9).

4.4 Surface Car Parks and Car Parking Bays

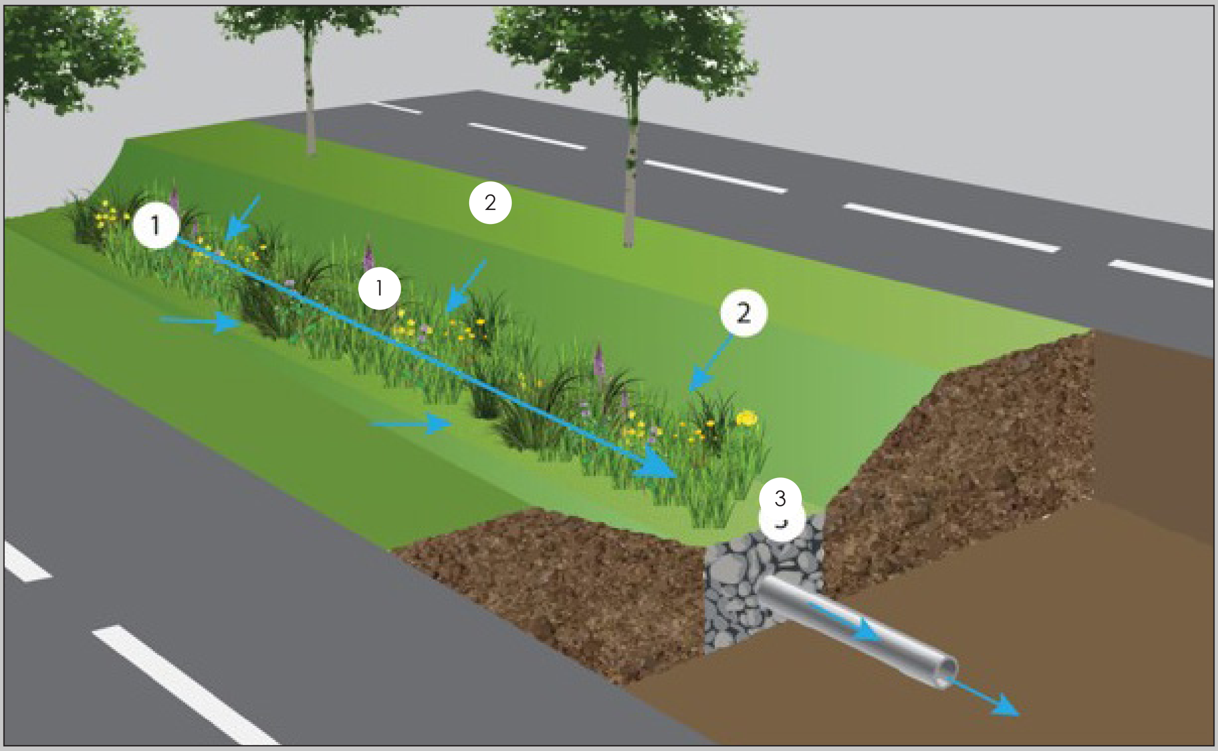
The use of exposed earth with appropriate reinforcement at parking bay locations should be promoted, in conjunction with adjacent rain gardens and sub-surface drainage. Similarly, areas where cars are parked, either on-street or off-street, can be designed using planted areas, reinforced to accommodate the parked vehicles. Reinforced grass (see Figure 4.7) and other options will allow infiltration of runoff either directly into the ground or into sub-surface drainage. These designs provide treatment and attenuation of urban runoff while also softening the general urban design and avoiding excessive use of hard surfaces.

Permeable pavements may also have a role in urban areas such as car parks, but the long-term effectiveness of these solutions in terms of the retention and treatment of rainwater runoff should be considered, relative to the use of a more nature-based approach (see also Chapter 5).

Figure 4.6: Swales should be designed with gentle slopes to facilitate ease of maintenance with positive drainage provided to prevent long-term ponding.

Figure 4.7: Car Parking using reinforced grass

Figure 4.8: Dry swale - 3D Cross Section



1 Horizontal slope

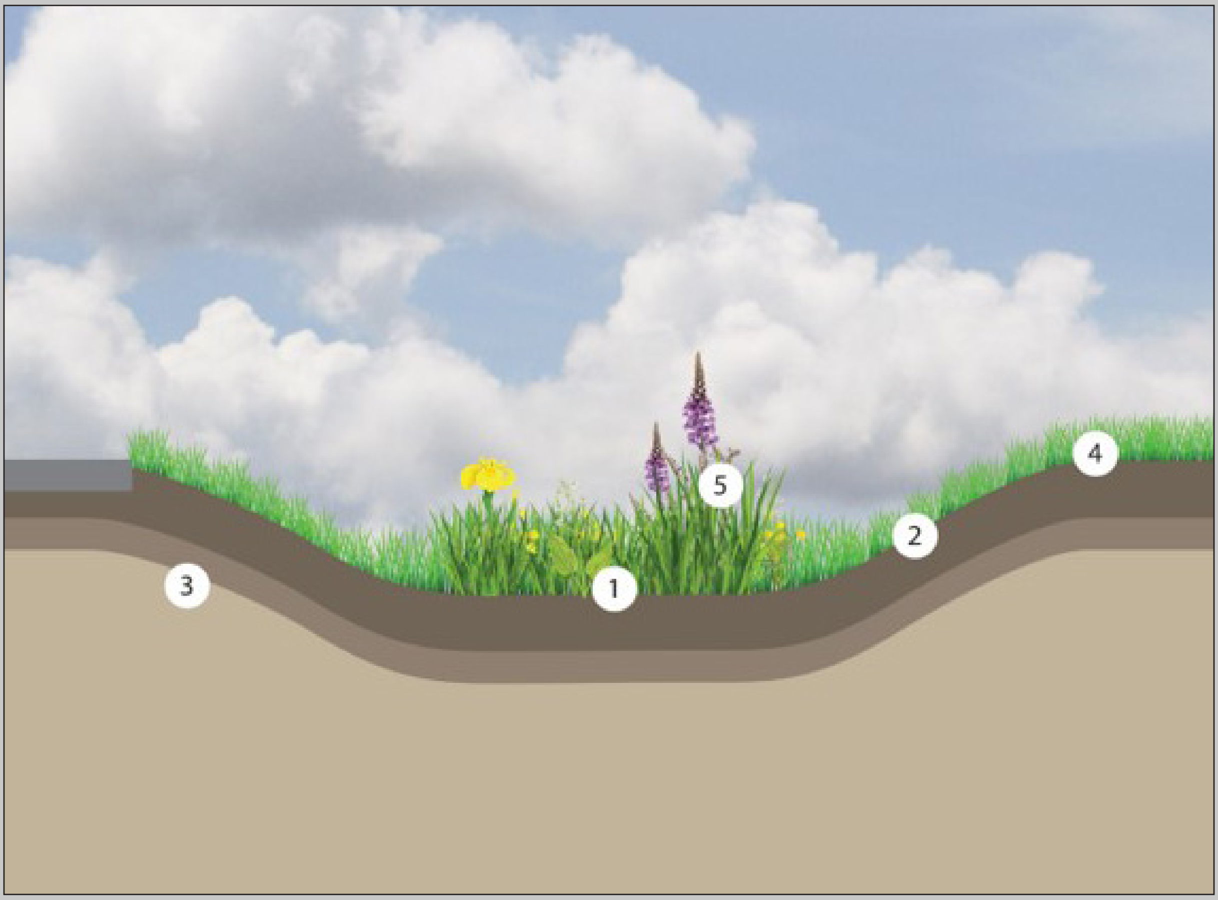
2 Vertical slope. Conventional landscaping will suffice here to allowable gradients.

3 Filter media.

Notes:

- Manage for biodiversity where appropriate and may require prescribed management protocols (e.g., reduced mowing).
- Keep channel clear of blockages.
- Choose plants that grow slowly and not wildly, to keep maintenance down (litter picking will be easier).
- Create check dams where there is some gradient to avoid erosion and ensure adequate interception of pollutants. These dams can often be timber/stone/other materials and can add to the feature in terms of visual amenity.
- Trees can be placed in swales preferably along the sides to avoid blocking of flow and damage to underground pipes. The latter can be offset in the swales with root barriers around the pipe.

Figure 4.8: Dry swale - Cross Section (top) and vegetated swale - Cross Section (bottom)



1. Flat base swale falling horizontally at no more than 1 in 50 to prevent erosion.
2. Vertical Side slopes are normally 1 in 3 or 1 in 4.
3. Layer of 150mm clean topsoil over the subsoil.
4. The shoulder of the swale should be rounded rather than a sharp angle to reduce risk of erosion of soil.
5. Swales can be planted with suitable pollinator plants.

Notes:
Check dams or terraced swales (timber/stone/other materials) can be used to help reduce the risk of erosion when 1 in 50 falls cannot be achieved
Ideal base width between 1m – 3m. When less than 1m wide, the risk of erosion will increase. When swale base with is wider than 3m a channel can develop

4.5 Open spaces and Amenity Areas

In terms of the adoption of a sustainable and nature-based approach to urban rainwater management, it is equally important to look at the broader urban areas that are contiguous with the urban roads and streets. Existing and proposed green spaces, amenity areas and parks can provide significant additional opportunities to store and treat excess rainwater flows and, when designing urban roads and streets with appropriate Nature Based Solutions, the designer should consider opportunities to direct some rainwater flows into adjacent open spaces or green areas, with appropriate designed retention and treatment areas for urban rainwater runoff, prior to discharge into the urban piped network or into a natural water body (see Figure 4.10).

Urban Planners and Designers should consult the DHLGH document "Best Practice Interim Guidance Document on Nature-based Solutions to the Management of Rainwater and Surface Water Runoff in Urban Areas" which includes the concept of a Rainwater Management Plan for each urban area.

4.6 Kerbs, Gullies and underground pipes.

Rainwater falling in urban areas should, insofar as is practicable, be routed through a landscaped area that is designed to allow rapid infiltration of runoff, provide storage and treatment prior to discharging the remaining flows back into the existing surface water or stormwater drainage system. The location of existing gullies on urban roads and streets generally reflects the optimal location for rainwater to run off the impermeable surfaces and designers should use the existing gully infrastructure when selecting locations for landscaped rain gardens or other nature-based rainwater management features.

The existing gullies represent "readymade" overflows to allow excess flows from nature-based features to be discharged back into the piped network. Underground permeable drains can be incorporated into the lower levels of rain gardens, tree pits or other features and, if so, these can also be connected to the existing piped network, using existing gully connections.

Combined sewers (carrying both urban runoff and wastewater), are the responsibility of Uisce Éireann. It is Uisce Éireann Policy to promote the use of a nature-based approach to rainwater management as this results in reduced and delayed flows of urban runoff into their combined sewers. Design teams planning to use nature-based rainwater management solutions in areas served by a combined sewer network should consult with Uisce Éireann.

Figure 4.10: Area of open space adjacent to the street network, if appropriately designed, will form an important part of a broader SUDs network.

4.7 Nature Based Solutions and Mobility

It is important, when introducing or altering landscaped areas that are designed to manage rainwater runoff, that appropriate space and/or delineation is made between Nature-based SUDS features and paved or parking areas (see Figure 4.11). It is also important in the case of longer, more linear features, that crossing points are provided (see Figure 4.12).

Figure 4.11: A wide edge is provided between parking and a swale to ensure clear access to vehicles.

Figure 4.12: Small bridging elements are provides at regular intervals across a swale.

5. Implementing Nature Based Solutions as part of an Urban Project through integrated planning and design

In Chapter 5 of DMURS dealing with Implementation, section 5.1 focuses on the need for a plan-led and multi-disciplinary approach. This approach is also essential to the integration of urban landscaping and nature-based rainwater management into the overall planning and design of urban roads and streets as set out in this Advice Note. DMURS requires that urban planners and built environment design professional incorporate the DMURS design philosophy into all plans, proposals, strategies, and projects. This level of integration should also encompass the philosophy and concepts set out in this Advice Note.

While projects are generally required to limit their proposals to within the "red line" plan area, it is important that, in the area of rainwater management, the planners and designers have regard to opportunities for rainwater retention and treatment as well as possible impacts on runoff receptors such as natural waterbodies that may be located close to the proposed development but outside of the "red line" area.

In that regard, the design team should consult with the Planning Authority on their broader strategic plans for rainwater management in that urban area and should consult the DHLGH "Interim Guidance Document on Nature-based Solutions to the Management of Rainwater and Surface Water Runoff in Urban Areas Water", as referenced earlier.

5.1. Existing Urban Areas

Many capital investments in existing urban areas will impact on the urban roads, streets, and public realm. Typical of these would be sustainable transport or active travel schemes, the introduction of pedestrianization, enhanced public realm, outdoor amenity areas or urban regeneration projects. All of these provide opportunities to retrofit nature-based landscaping that incorporates rainwater management solutions.

The planner and built environement design professional should seek out these opportunities when setting out the overall design concept for the particular project, using the information in the previous chapters of this Advice Note.

If incorporated into the initial concept and design, the use of urban landscaping and nature-based solutions will, as a general rule, not add significant time, cost or complexity to the project, relative to the benefits achieved.

5.2. Future or proposed urban plans or projects.

Larger urban regeneration projects and private urban developments will provide greater opportunities to incorporate a water sensitive urban design approach throughout the planning and design process.
The integration of nature-based rainwater management solutions into the DMURS design approach should be highlighted by the Planning Authority as a requirement during pre-planning discussions

This will include the incorporation of multiple nature-based rainwater management solutions that are described in the earlier chapters of this Advice Note, including the incorporation of features such as rain gardens and storm water storage into the implementation of the DMURS approach. Because projects of this nature are being planned and designed on a greenfield or brownfield site, the planning and design teams have opportunities to be creative and innovative in integrating these DMURS aspects into an overall landscaping and biodiversity plan for the site that may include other features such as blue/green roofs.

Designers should ensure the maximum level of connectivity between nature-based rainwater management features in a "SUDS Train" approach as this will maximize the benefits in terms of rainwater storage and runoff treatment and also provide an extended biodiversity corridor.

Larger scale projects will, typically, include new areas of public open space and public realm. The fact that these projects are being designed from a relatively blank template should also provide opportunities to include solutions such as larger scale raingardens and swales than would be available for an urban retrofitting project.

6. Care and Maintenance

In DMURS, the issues around long-term care and maintenance are not explicitly covered. However, DMURS does focus to a great extent on the user experience and need to put "well-designed streets at the heart of sustainable communities". The need for long term resilience of any solutions is implicit in Advice Note 2 on Materials and Specification and Advice Note 4 on Quality Audits.

This Advice Note includes this brief chapter on care and maintenance because the use of urban landscaping as part of the overall selection of urban design palettes can lead to concerns in this area. While DMURS does include for urban planting, this Advice Note is promoting an increased use of urban planting and landscaping that has, as a primary function, the management of urban rainwater.

This approach inevitably blurs the lines between what were traditionally distinct maintenance and "taking in charge" roles within the Local Authority such as "roads and streets", "drainage", and "parks and amenity". It is, therefore, important that the planning and design team that is implementing DMURS as part of any project, will consider the issue of how best to ensure that any nature-based rainwater management solutions are designed, and constructed in such as way as to minimize any medium to long term care and maintenance issues.

Due to the fact that such nature-based solutions involve specialist soils and planting as described earlier, it is recommended that:

- The design team should include expertise is the area of urban landscaping and nature-based rainwater management function. This is in line with the multi-disciplinary approach promoted in Section 5.3 of DMURS.

- Consideration be given to incorporating a design and build care and maintenance contract to cover these features for a minimum period of five years following their completion. International experience would also support the use of a form of contract that allows early engagement between the client and the prospective design and construction team.

The Local Authority and the design team should look at the overall area impacted by the proposed works as a single integrated urban area. This is in line with the 'holistic', design-led approach of DMURS that looks at "the design of the street environment and street network as a whole". This approach should facilitate the newly completed urban area to be "taken in charge" by the Local Authority.

REFERENCES/FURTHER READING

Designing Rain Gardens – a Practical Guide, Urban Design London, 2018.

Nature-based Solutions to the Management of Rainwater and Surface Water Runoff in Urban Areas - Water Sensitive Urban Design: Interim Guidance Document, Department of Housing, Local Government and Heritage, 2021.

The SUDS Manual (C753), CIRIA, 2015.

Sustainable Drainage Explanatory Design and Evaluation Guide, South Dublin County Council, 2022.

Sustainable Drainage Explanatory Design and Evaluation Guide, Dublin City Council, 2021.

Water Sensitive Urban Design in the UK - Ideas for the built environment practitioners (C723F), CIRCA, 2013.

ACKNOWLEDGMENTS

Conway, Adrian; Engineer, DHLGH Water Section
Egan, Lisa; Scientist, DHLGH Water Section.
Forde Bradley, Mick; Architect Limerick City and County Council.
Fox, Eimear; Landscape Architect, Transport Infrastructure Ireland.
Galvin, Chris; Engineer, South Dublin County Council.
Gannon, Averil; Engineer, DHLGH Water Section.
Halpenny, Kevin; Landscape Architect, Fingal County Council and Irish Landscape Institute.
Igoe, Fran; Scientist, Local Authorities Water Programme.
Keegan, Kevin; Architect, Mayo County Council.
Kelly, Joseph; Engineer, Dublin City Council.
McCarthy, John, Engineer, DoT.
O'Connell, Bernadette, Landscape Architect, JBA Consulting and Irish Landscape Institute.
Oldroyd, Emma; Landscape Architect, Arup Consultants.
O'Malley, Stephen, Engineer, Civic Engineers Consultants.
O'Neill, Leonore, Executive Officer, Clare County Council.
Seymour, Joe; Engineer, National Transport Authority.
Taylor, Jason, Planner/Urban Designer, DHLGH Planning Section.
Titherington, Ian, Engineer, Cardiff City Council.
Tudor, Zack; Landscape Architect, Arup Consultants.
Vallone, Giulia, Architect, Cork County Council.
Vaughan, Brendan, Architect, Arup Consultants.

APPENDIX 1

Water Sensitive Urban Design

Water Sensitive Urban Design (WSUD) is an approach to design that delivers greater harmony between the water cycle, the environment, and communities. This is achieved by integrating water cycle management with the built environment through sustainable urban planning and urban design. Water Sensitive Urban Design is the process, Water Sensitive places are the outcome. (CIRIA document "Water Sensitive Urban Design in the U.K. – Ideas for built environment practitioners")

There are four stages in the design process for any NBS feature; site appraisal, concept deisgn, outline design and detailed design. Outlined below are each of these processes showing where they align with the public spending code stages (see also Figure A1).

Initally the designer must appraise the site. This will include an investigation of the topography, drainage characteristics and geology of the site. Other aspects are the general characteristics and usage of the public realm area, as well as design constraints such as existing street furniture, services or utilities.

During the concept design stage, the design team will ensure that NBS is considered correctly as part of the layout in the development. This aligns with the Strategic Assessment Stage under the Public Spending Codes. As set out in Chapter 5 of this Advice Note, the designer, in carrying out the appraisal and concept design stages, should have regard to the broader topopgraphy and drainage characteristics of the urban area within which the site is located. This should include examination of opportunities to manage rainwater in the broader urban area in consultation with the Local Authority.

The outline design stage is where the design team provide the minuimum design detail for the planning stage of the project. This correspond to the Preliminary Business Case stage in the Public Spending Codes.

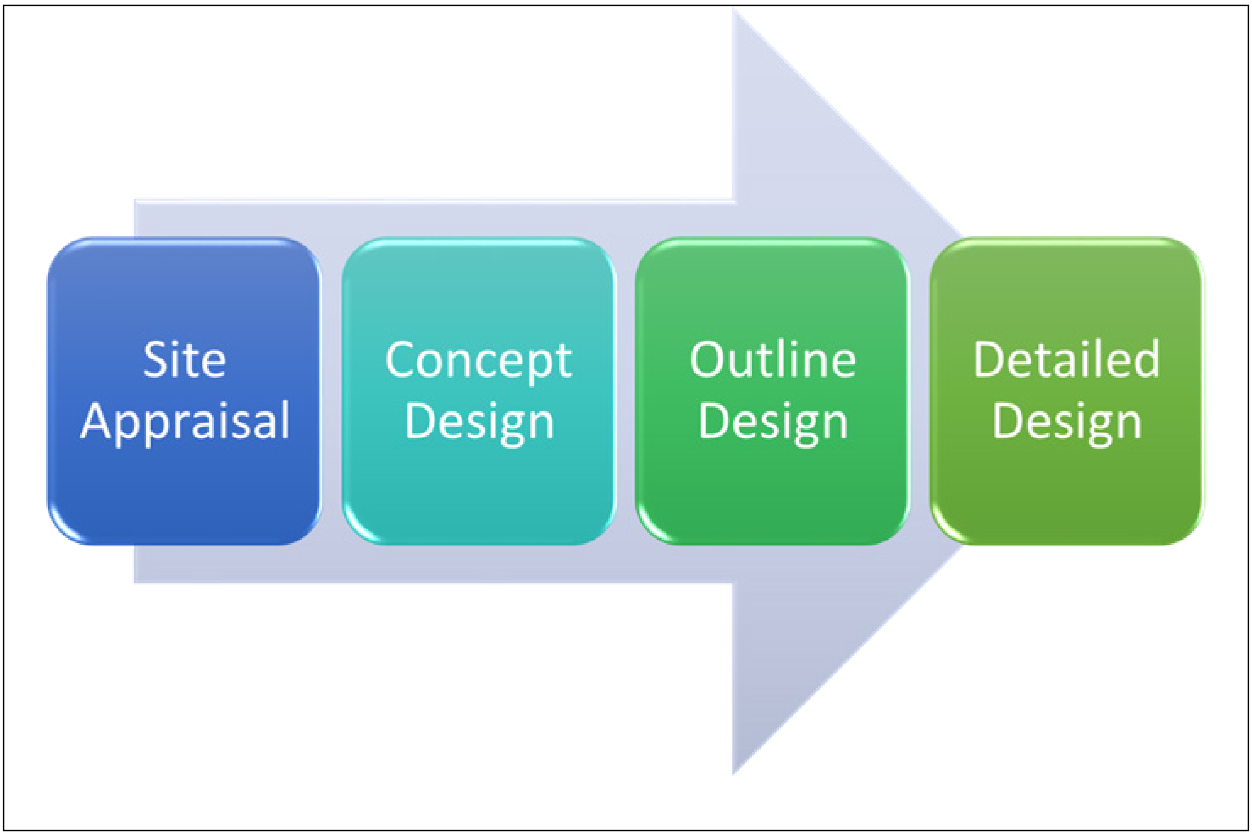


Figure A1: The four stages in the design process for any NBS feature

Detailed design stage includes the detailed design of the particular NBS elements. This stage incorporates into the Final Business case stage in the Public Spending Codes. This is a key stage in terms of project risk management. Adequate site investigation to identify all constraints as well as widespread stakeholder consultation must take place so that the outline design put forward for planning approval is robust and capable of being constructed. Once Planning Approval is granted, the design of the NBS cannot easily be changed.

WSUD and Nature Based Rainwater Management – Design Features

Advice should be sought from a horticulturist or landscape architect when designing rain gardens or other features set out below.

Rain Gardens

Many of the features listed in Section 4 of this Advice Note are designed and constructed in a similar manner and can be seen as coming under the generic description of rain gardens. Some features, such as swales, will have a different surface treatment. However, the general make-up and functional elements of all of these features are quite similar as described below.

Some terms such as "engineered soils" or "structural soils" are interchangeable.
The word "soil" is used occasionally to denote the material within the rain garden. However, this "soil" is not naturally occurring but a mixture of elements designed for a particular purpose, as described hereunder.

The main purpose of an urban rain garden is to receive rainwater runoff from the surrounding impermeable area and to allow this runoff percolate through the specially designed soil , thus providing storage, flow attenuation and treatment of the runoff.

Key functions of rain gardens when considering water management include surface water attenuation and water quality benefits. However, importantly there's also a huge number of wider benefits for humans and nature including an improved public realm, increased biodiversity, reduction in the urban "heat island effect" and increased climate change resilience.

Raingardens and NBS features in general supplement rather than replace the existing urban surface water drainage systems.
In most cases, there will be a permeable pipe contained within the lower layers of the rain garden that will be connected to the new or existing urban surface water drainage network. This will usually be supplemented by the incorporation of a raised grille or gully that will allow excess water to enter the existing surface water drainage system directly during periods of intensive rainfall, in order to avoid ponding and surface flooding.

The performance of a rain garden is dependant on its capacity to filter pollutants and provides storage capacity for rainwater. These 'engineered' rain gardens are often referred to as bioretention systems, however in practice there is no clear distinction between rain gardens and bioretention systems. There are six simple steps to designing a rain garden:

1. Choose the right location

Existing gully locations can be used as a guide to locating the rain garden as these are often the optimal locations for removing urban runoff. The existing gully and associated pipework can also be incorporated into the footprint of the rain garden, thus providing an in-built overflow. The rain garden location should also be flexible and take account of the overall urban design criteria as set out in DMURS.

2. Composition of a rain garden

A rain garden typically comprises the following features: (see Section 4.1).

- **Freeboard**

  The freeboard provides potential water storage volume, above the growing medium. A freeboard depth of 200-300mm is recommended (dished towards the centre) with the top level below the pavement surface in order to encourage water to flow into the rain garden and to accommodate silt accumulation and build-up of leaf litter. The top layer should consist of a 75mm depth of clean gravel / aggregate, the function of which is to protect the growing medium.

- **Growing Medium**

  Rain gardens have a more open and permeable growing medium than would be typical of urban landscaped areas to allow appropriate rates of infiltration. The growing medium typically consists of a 450 - 600mm deep, free draining mix of 60% 1-6mm grit, 10% organic matter and 30% mix graded washed sand, This mix cleans, stores and conveys runoff to a drainage layer. This equates to about 400mm/hr in hydro-conductivity, and ensures that the soil stays permeable when there is a large ingress of silt off a heavily trafficked area. If trees are used, this soil will also be acceptable.

  The permeability of the growing medium can be specified according to the ratio of the above components and increase storage potential. A specific ratio of the four components can vary to accommodate the functional requirements of the rain garden and future proof against long term sedimentation through the structural layers

- **Storage Layer**

  The lower part of the rain garden is the storage layer. There should be a 50mm deep filter / transition layer of 6mm aggregate on top of the storage layer in order to prevent the growing medium being washed down into the storage layer.

  The storage layer should be between 100-500mm deep. The depth of the storage layer will vary depending on the required storage capacity, presence of underground services and connectivity to the existing drainage system.

  The storage layer is also where the collection/drawdown pipe would be located. The designer should consult the operator of the existing drainage network in relation to the connection from the rain garden, including whether it is required to incorporate an orifice control chamber to controls the rate of discharge from the raingarden into the existing drainage network.

3. Calculate the size and depth

A typical highway gully drains a catchment area of around 200m^2. As a rule a rain garden should be 5-10% of the catchment area hence, 10-20m^2 for a rain garden drains the same area as a typical gully.

One design target of the rain garden should be to store the first 20mm of rainfall (based on a rainfall rate of 20mm/hr) – The first 5mm of this rainfall will carry most of the pollution, such as silt and oil from road runoff, and is often known as the 'first flush'.

4. Consider infiltration

It is important that rain gardens can drain down within a reasonably short time period to ensure that they do not become water-logged and have enough storage capacity available for the next storm event. However, this must be balanced against the requirement that the rate of percolation will allow treatment of the runoff as it percolates downwards (through removal of sediment as well as organic treatment).

In order to achieve this optimal infiltration and treament regime, the design of the rain garden material is critical, as outlined above. In most cases, there will be a need to provide an under-drain. This is a perforated pipe installed close to the bottom of the storage layerthat connects to the piped surface water drainage network.

Infiltration and treatment as well as storage should be the primary goal. However, this is not always possible. Appropriate storage and controlled release of urban runoff (attenuation) may be the only achievable outcome in some urban situations.

The target should be to have adequate capacity to deal with rainwater (through infiltration and / or storage) falling within a 24 hour period.

5. Manage flows

Overflows are required to safely manage surface water runoff from the rain garden when its design capacity is exceeded, in order to avoid surface ponding and flood risk. In most cases where rain gardens are being retrofitted into an urban landscape existing drainage features such as gullies can be retained as overflows (As per Sections 4.1-4.3).

The inlet detail between the pavement surface and the rain garden must be carefully considered. In some cases a concrete channel can allow runoff flow directly into the rain garden. In other urban settings, a raised kerb between the carriageway and the rain garden will be considered necessary to reduce the risk of vehicles entering the rain garden. This may incorporate slots or opening to allow rainwater into the rain garden.

Designers should also consider the need to provide an adequate amount of haunching concrete behind the kerb, especially where the freeboard depth is significant – in these cases it may be necessary to use deeper kerbs to achieve the required support.

6. Select the planting

Rain gardens can be planted with a wide range of different plants. Advice should be sought from a horticulturalist or landscape architect. In general, the use of native planting is recommended. Where possible a mix of plants that provide cover and interest throughout the year should be used.

Plants should be able to withstand periods where they are in standing water as well as periods of drought. They should also be slow growing and resistent to air and water pollution. The ultimate height and spread of each plant should be appropriate to the size of the rain garden and the surrounding area.

See Designing Rain Gardens – a Practical Guide (2018) Urban Design London.

Trees and Tree Pits

Tree pits were traditionally used in urban areas to avoid damage from tree roots to pavements and underground services and to provide a suitable growing medium for urban trees. However, if correctly designed, trees and tree pits can form an important part of a nature based urban rainwater management system. The design and construction of urban tree pits that do not incorporate urban rainwater management solutions represents a major missed opportunity.

The following general guidance demonstrates how to ensure that tree pits can perform their traditional role while also contributing to the nature based management of urban runoff These numbered points should be read in conjunction with the typical cross section (Fig. 4.5 – see also text in Section 4.2 of this Advice Note) and the same numbering system is used:

1. Trees should have a growing medium of between 10 - 30m³ depending on tree species.

2. A number of trees can be linked along a trench to optimize the volume available to each tree.

3. Robust silt removal must be incorporated within the tree pit design to allow runoff from roads into the tree pit. Adequate freeboard is necessary to avoid clogging by silt, cigarette butts and litter debris.

4. Positioning and specification of trees to be in accordance with Design Manual for Urban Roads and Streets, subject also to the need to consider their position in terms of urban rainwater flows. A drain down pipe must be provided to ensure there is no prolonged waterlogging of roots and no build up of road salt within the tree pit.

5. Service trenches can be provided through the tree pit (by agreement with the Local Authority and with the relevant utility company). Suitable services include most water, gas and drainage systems. Consider any requirements for replacement if the utility is old. Electrical supply or telecoms with a joint box located within the tree pit feature is not recommended. (removed redundant reference to UE and combined sewers).

A structural soil is a stone-based growing medium used in tree pits that can support pedestrian and vehicular traffic. The use of structural soil allows tree pits to be extended beneath existing paved areas. This enables designers to provide enough soil for a tree to be healthy and reach maturity. When designing tree pits with structural soils, rainwater that has been collected from roofs, roads and paved surfaces can be diverted into the tree pit. Trees grow extremely well in tree pits constructed in this way and the approach also contributes to stormwater management systems.

An aeration layer of clean stone is included between the paved surface and the structural soil, this aeration layer is linked to the inlets to allow air and water to reach the whole of the tree pit. The inlets are deliberately designed to be at the low point of hard surfaced areas so that they receive as much rainwater as possible. Nature based urban rainwater management and urban tree establishment should form part of one integrated design.