Living Roofs

Contents

Acknowledgements:
The Edinburgh Sustainable Rain Water Management Guidance - Living Roof Fact Sheet has been developed by Atkins on behalf of City of Edinburgh Council with support from Nature Scot.

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What are Living Roofs?

A Living roof (green or blue) is a roof where a planting forms an integral part of a roof structure in order to deliver a range of additional practical benefits for people and nature. **Living roofs can provide valuable source control as part of sustainable rainwater management** by absorbing, reducing and slowly releasing rainwater at the point where it falls.

A living roof (green) consists of two distinct layers – **a natural layer and an engineered layer.** The natural layer consists of vegetation and a growing medium (soils) whilst the engineered layer consists of a series of elements that ensure that the vegetation and growing medium perform as they should and have no negative impact on the integrity of the building.

Figure 1. Edinburgh Parliament Building with Extensive Green Roof | Mark Longair

Living Blue roofs include an additional layer of temporary storage for storm water which can make a significant contribution to **localised water management.** The **n**atural interactions of the vegetation and growing medium deliver the environmental performance on all living roofs.

Depending on the type of living roof they can also provide a range of **multiple benefits such as amenity, biodiversity and various ecosystem services as part of climate change adaptation.**

This fact sheet is part of Edindinburgh's Sustainable Rain Water Management Guidance. It provides an introduction to the various types of living roof, design principles and key considerations along with guidance on fitting living roofs into Edinburgh's built environment. It supports the Water Vision, Edinburgh's Living Landscapes and Edinburgh's Nature Network and 2030 Climate Strategy.

More detailed technical guidance on the design, installation and maintenance of green roofs can be found in the UK trade body's, (the Green Roof Organisation (GRO)) Code of Practice 2021.

- GRO Code of Practice 2021
- Building Greener, CIRIA

Fitting Living Roofs into Edinburgh's Built Environment

Where can Living Roofs be considered?

Living roofs should be actively considered in new developments (including extensions to existing buildings) with a presumption that all new flat roofs should be living roofs unless this would conflict with the context or heritage value of the building. Pre-app consultation with City of Edinburgh Council is strongly recommended to establish appropriate design and location.

A key consideration will be how a proposed new living roof will fit within the surrounding cityscape with distinctive historic areas more sensitive to change. As most living roofs (green or blue) are flat roofs there may be potential for impacts on Edinburgh's distinctive skyline of pitched roofs and spires. Both distant and local street level views should be considered along with building height and landform.

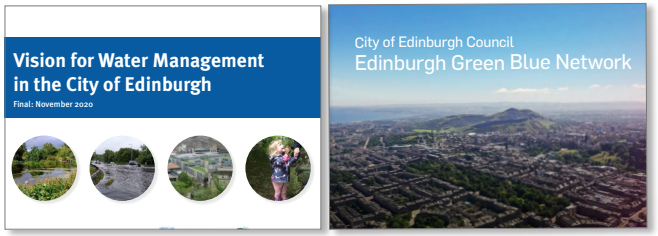
The design statement submitted at pre-app stage or full planning application should include full detail of any heritage considerations including changes to heritage buildings, or the potential effect of a living roof development on valued qualities or character of the wider area.

Figure 2. City of Edinburgh Council Headquarters, Waverley court, East Market Street | Shutterstock

Supporting Edinburgh's Blue Green Network

"Green Roofs...are encouraged in appropriate locations particularly adjacent to green/blue corridors and will be encouraged in locations adjacent (within 15m) of river corridors"

City of Edinburgh Council, Edinburgh Design Guide, 3.4 Biodiversity, Green Roofs (p77)



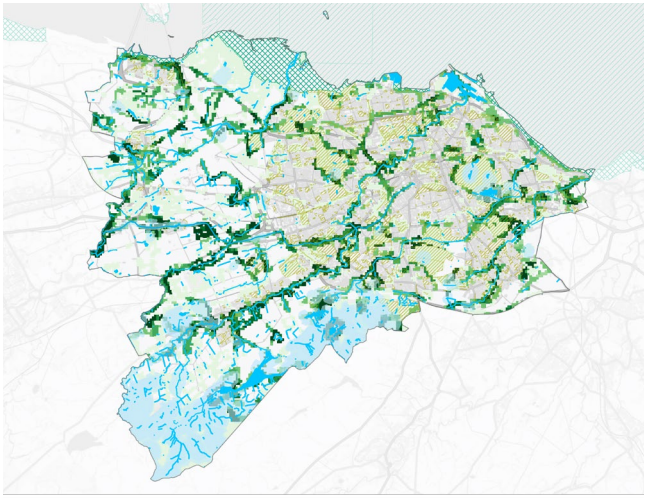


Figure 3. Edinburgh Green Blue Network | Atkins

Planning Applications

Typical information that should be included in a Planning Aplication for a living roof:

- A comprehensive Design Statement including maintenance regimes and responsibilities
- Detailed plans and sections to gauge height implications
- Details of proposed roof planting including the likely end appearance of self seeding brown roofs. Photomontages provided should be realistic, reflect the season of planting and should provide information on seasonal changes.

Additional planning requirements for living roofs developed within 13km of Edinburgh airport can be found on page 20 of this factsheet.

Building Regulations and Technical Standards

Like any alteration to an existing roof, the installation of a living roof to an existing building or as part of a new development will require a building warrant. While there are no specific Scottish Building Regulations about Living Roofs, the design and installation should meet the standards set out in Scottish Building Regulations for all structural, waterproofing, electrical and plumbing works.

The Scottish Government's customer journey explains the building standards system to anyone making home improvements or starting building work. https://www.gov.scot/publications/building-standards-customer-journey/

Technical references:

Scottish Building Regulations:

- Building standards technical handbook 2022: domestic
- Building standards technical handbook 2022: non-domestic
- Fire Performance of Green Roofs and Walls, Department for Communities and Local Government

Green Roof Organisation

- GRO Code of Practice 2021

CIRIA

- Building Greener, CIRIA

Figure 4. Development in Edinburgh | City of Edinburgh Councl

Additional guidance on the design, installation and maintenance of Living roofs can be found in the GRO Code of Practice 2021.

Technical references:

Edinburgh City Plan 2030

- Env 4 Development Design – Impact on Setting (f) (p102)
- Env 5 Alterations, Extensions and Domestic Outbuildings (f), (p102)
- Env 5 3.93 (p102)
- Env 6 Green Blue Infrastructure, (c) (p102)
- Env 7 Sustainable Developments (a)
- Env 8 New Sustainable Buildings (b)
- Env 9 World Heritage Sites
- Env 30 Building Heights (a,b,c) & 3.149, 3.150, 3.151, 3.152 (P116)

Edinburgh Design Guide

ESRWMG:

- Rainwater Management and Changes to Existing Buildings – Extensions (p44)
- Sustainable Rain Water Management in New Developments (p49)

Living Roofs as part of sustainable rainwater management

The Water Vision for Edinburgh requires … *"all new development (and retrofit) to manage the first 5mm of rainfall at a plot level where appropriate and adhere to the SuDS Management train so run-off is managed in stages as it drains through and from a site."*
City of Edinburgh Council, Water Vision - Objectives (P5)

Living roofs can play an important role in achieving this objective.

Types of Living Roof

The types of green roofs are defined, not by their structural requirements but the level of maintenance that they need.

Figure 5. Intensive roof, Greenside Row, Edinburgh | Atkins

Figure 6. Semi-Intensive Roof, London | Townsend Landscape Architects

Figure 7. Sedum Roof Ikea, Greenwich | Dusty Gedge

Intensive

To provide a functional intensive living roof the total surface should be at least 70% soil (growing medium) and vegetation (including water features). For biodiversity benefits include at least 50% native species plus non-native species of wildlife value. Tree planting will require consideration of wind loading and secure anchoring.

Deep soils = heavier structural loading (250-2000mm depth)

Amenity value - high - public accessibility or visibility

Water storage - excellent

Maintenance costs - High, essentially similar to a garden or park

Semi Intensive

A lighter form of intensive living roof system that can include low maintenance planting ground cover, small shrubs, perennials and grasses with amenity value.

Medium depth soils = medium weight structure (150 -1000mm depth)

Amenity value – medium – may be publicly visible, may or may not be publicly accessible

Water storage - Medium

Maintenance costs - Low–with a focus on ensuring drainage and shingle perimeters are kept vegetation free

Extensive

Deeper growing mediums on extensive living roofs deliver the greater environmental benefits and performance. To be compliant with the GRO code (and fire compliant) systems should have a minimum of 80mm of growing medium (including the rooted layer).

Shallowest soils = lightest structure (80-120 mm depth)

Amenity value –Low – not usually designed for public access

Water storage - Low

Maintenance costs – Low – (However Sedum roofs have higher maintenance costs than other extensive green roofs)

Figure 8. Biodiverse green roof on PWC 7 More London | Dusty Gedge

Biodiverse Roof - (Extensive/ Semi Intensive)

Biodiverse roofs are usually extensive or semi intensive roofs designed for habitat creation. They typically combine native wildflower and meadow type vegetation with varied depth of growing medium and materials. They can include features designed to attract and sustain pollinators, invertebrates, and the fauna that forage for them. This type can include 'Brown Roofs', typically aggregate roofs allowed to naturally self seed.

Medium depth soils = medium weight structure' (120-250mmm depth)

Amenity value – Low or medium - if there is access

Water storage - Medium

Maintenance costs – Low

Figure 9. Bio solar roof, London | Dusty Gedge

BioSolar

Solar panels can be combined with extensive living roofs to create biosolar roofs. Standard panels should cover no more than 2/3 of the roof , if a greater area is used the green roof will not function as it should and it may have a negative impact on the energy produced by the panels. As semi-transparent and other solar panel designs become more prevalent this proportion can change.

Medium depth soils = medium weight structure (120-250mm depth)

Amenity value – Low – not usually designed for public access

Water storage - Medium

Maintenance costs - Low–with a focus on ensuring drainage and shingle perimeters vegetation free. Strimming in front of panels may be needed mid-summer

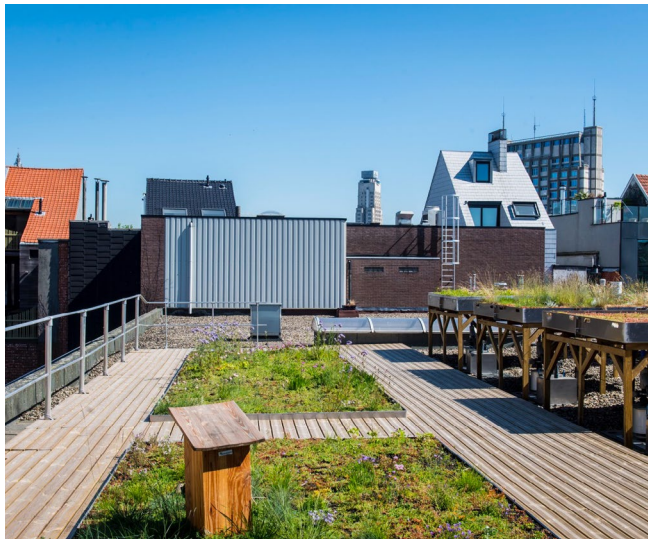


Figure 10. Smart blue roof with green roof element | Vegetal i.D

Blue Roof

A blue roof provides stormwater attenuation capacity at source on all types of living roofs by including water storage within the roof structure below the planting and growing medium layers. A series of roof restrictors sit over each roof outlet to release the attenuated water at a controlled discharge rate. Blue roofs are most effective as part of a wider SuDS management train.

Variable depth soils = Medium to heavier structural loading

Amenity value – Variable depending on type

Water storage - High

Maintenance costs - Low

Providing Multiple Benefits

Living roofs can provide a range of ecosystem services which vary depending on which type of Living roof is used.

Living roofs can provide important benefits that can help to mitigate the effects of climate change. The benefits of green roofs in cities include:

Stormwater management - living roofs are a source control mechanism intercepting and storing rainfall close to the point where the rain falls then releasing it slowly into the drainage system. Some rainwater stored in the growing medium will also evaporate or is transpired by plants. Deeper growing medium can store more rainfall. **Blue roofs** provide additional attenuation below the growing medium layers. For sustainable water management living roofs function most effectively as one stage in a wider SuDS management train providing an initial stage of attenuation and water treatment.

Noise - Living roofs types with deeper soil or growing medium layers can provide effective sound absorption. The noise reduction properties of living roofs can be beneficial for building occupants within busy urban environments.

Carbon Sequestration – depending on the type of vegetation, depth of growing medium, and construction, living roofs can potentially provide some low levels of carbon sequestration (by reducing atmospheric carbon).

Insulation, Energy Savings & Carbon Reductions

Living roofs can provide insulation reducing heat loss in cold weather. In hot weather the roof surface temperature is reduced by reflection of sunlight, shade and evaporative cooling. Deeper growing medium layers provide more cooling and insulation than a shallower layer and reduce the operational carbon of a building by providing annual energy savings.

Biodiversity - Living roofs provide benefits to wildlife by creating habitats and by supporting a range of flora and fauna. The level of biodiversity benefits generally increases with the size of roof area. Living roofs can also provide valuable biodiversity 'stepping stones' in Edinburgh's Nature Network and Green Blue Network that can support habitat connectivity.

Health & well-being - in dense urban areas, where access to nature is limited, accessible living roofs can provide opportunities for people to exercise, relax, grow plants and experience nature.

Air quality - Living roofs can reduce heat island effects, helping to cool air in urban areas therefore reducing the harmful breakdown of pollutants at high temperatures. For users of roof garden spaces vegetation can reduce air pollution by filtering and capturing particulates and absorbing and breaking down gases (including nitrogen dioxide).

Technical references:

- LONDON-LIVING-ROOFS-WALLS-REPORT_MAY-2019.pdf (livingroofs.ovrg)
- Living Roofs and Walls - Technical Report: Supporting London Plan Policy
- Creating Green Roofs for Invertebrates
- Acoustic Absorption in Sand and Soil: The Journal of the Acoustical Society of America: Vol 20, No 4 (scitation.org)
- Impacts of vegetation on Urban air pollution DEFRA
- ESRWMG What are the benefits of Sustainable Drainage? p7, Contributing to Quality of Life p8, Designing with Nature p35, Multiple Benefits and Whole Life Cost, p54

Multiple Benefits of Living Roofs

SuDS features	Benefits: Amenity	Biodiversity	Health	Water Quantity	Water quality	Building temperature	Operational Carbon Reduction	Carbon Sequestration
Intensive	High	High	Medium	High	High	Medium	High	High
Extensive		Medium		Low	Low	Low	Medium	Low
Semi-Intensive	Low	Medium	Medium	Medium	Medium	Medium	High	Medium
Extensive/ Biodiverse		High	Low	Medium	Medium	Low	Low	Medium
BioSolar		Medium		Low	Medium	Low	Low	Medium
Blue Roof		Medium		High	Medium	Medium	Low	High

High

Medium

Low

The Structure of Living Roofs

Key Design Considerations

- Depth of growing medium
- Structural weight capacity of the roof structure
- Waterproofing
- Fire Safety

Growing medium and Structural Capacity

Buildings need to have the strength required to support the saturated weight of a green roof. A typical saturated weight of a GRO compliant lightweight extensive green roof system is approximately 95 kg/m². Systems that are lighter than this may suffer from die-back in dry weather and often require irrigation and remedial work. **Ultra-lightweight (shallow) extensive green roofs should be avoided**.

The average saturated weight of a **good quality biodiverse extensive green roof of at least 100mm growing medium depth, is around 150kg/m2**. Costs (environmental and financial) associated with supporting structures for heavier (deeper) living roofs need to be balanced against the increase in benefits.

The depth of the engineered components will vary between different types of living roofs. **Intensive** living roofs generally have a deeper engineered layer and **extensive** green roofs a shallow engineered layer. **Living Blue roofs** will have the deepest engineered layer in relation to planting and growing medium as they include additional capacity for temporary water storage. The **structural weight of a blue roof** will therefore be the **sum of its natural and engineered layers plus the weight of it's potential water storage capacity.**

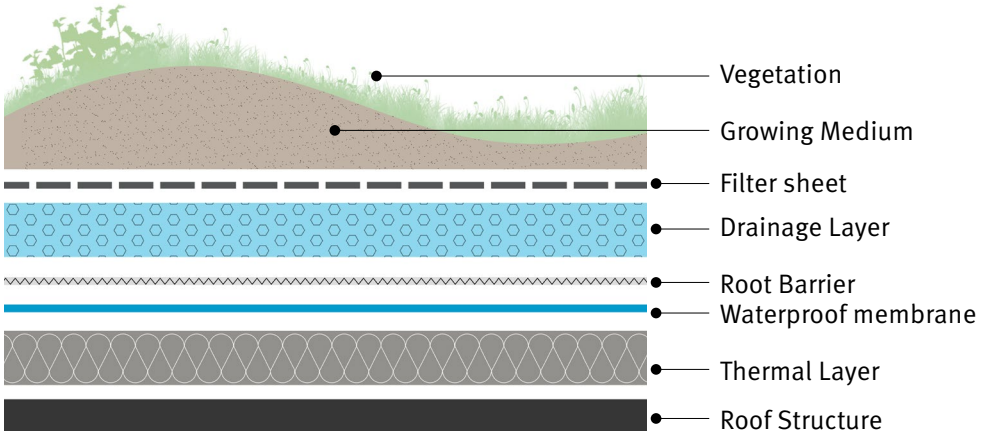


Figure 11. Typical green roof layers (Exploded Diagram)

The Engineered Components of a Living Roof

Main functions of the engineered components:

- To **protect waterproofing** layers from damage
- To **provide drainage** and moisture to the soil and vegetation above
- To **protect the drainage system** from clogging with fine materials migrating from the growing medium

In general, these functions are met by:

- **Protection layers** (which can also function as moisture retention layers)
- **Drainage layers** to designed to provide the necessary drainage flow rates and (in the case of blue roofs) additional water storage
- **Filter sheets** that act as a barrier between the other engineered components beneath and living elements of the green roof (soil and plants), above.

Living Blue Roofs

A living blue roof is a form of living roof designed to attenuate water during high rainfall events as part of a SuDS system, treating and releasing water to the wider drainage system at a controlled rate. Blue roofs can provide an important service helping to meet planning requirements to attenuate the first 5mm of rainfall at plot level and reduce drainage discharge rates.
Not all blue roofs are living roofs and some types are constructed with gravel or hard surfaces. While all blue roofs can provide some stormwater attenuation, living blue roofs can provide a much wider range of benefits including water filtration and treatment.

Blue roofs are not solutions for long term water storage and should retain water for no more than 24-hours after a storm event.

Water Attenuation and Drainage

Water is gathered over the entire surface of a blue roof within a **shallow attenuation layer not more than 100mm in depth** which, **when filled to capacity would provide an additional loading of 1.0kN/m².** However as the roof will start to drain at a regulated rate as soon as water begins to accumulate in the attenuation layer, full capacity would be likely only in very high rainfall for short periods. The controlled discharge rate should allow the roof to empty half of the total volume of attenuated water in a 12-hour period.

A **blue roof should also provide emergency drainage to remove excess water should capacity be exceeded during an extreme weather event.** The waterproofing, drainage points, blue roof build up and planting layers should be considered holistically as one complete system during the design process.

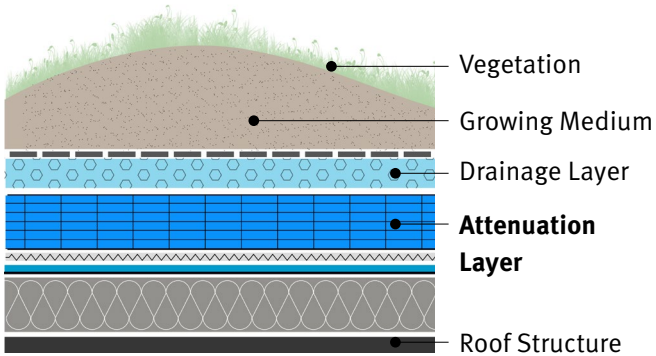


Figure 12. Typical blue roof layers (Exploded Diagram)

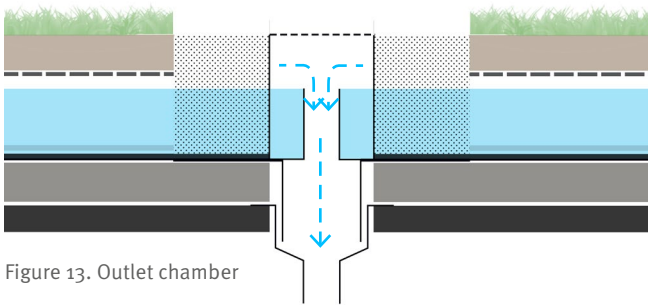


Figure 13. Outlet chamber

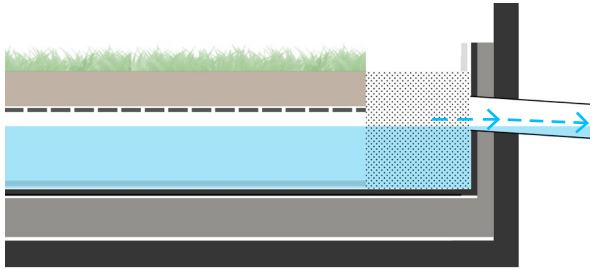


Figure 14. Parapet outlet for exceedance

Living Blue Roofs can be constructed as :

- Extensive sedum or biodiverse living roofs
- Semi intensive or intensive living roofs with access
- Biosolar sedum or biodiverse living roofs

Technical references:

- NFRC Technical Guidance Note for the construction and design of Blue Roofs.
- Gro Code
- ESRWMG - Sustainable Rainwater Management in New Developments, p49

Retrofitting Existing Roofs

Depending on the allowable dead load, existing roofs can potentially be retrofitted with living roofs. For instance, a multi-storey car park upper deck can easily be converted to an intensive green roof with capacity for shrubs and trees. On other types of roofs an allowable dead load of 100 kN/m² can potentially allow a living roof to be retrofitted, anything less and the systems used would not be GRO compliant.

Sloping Roofs

While most living roofs are flat roofs, pitched or sloping roofs are possible. Steeper roofs will require more detailed consideration of growing medium depth, methods of growing medium retention and drainage.

Typical slopes used for living roofs

- intensive living roofs of up to 5 degrees
- extensive living roofs up to 30 degrees

Waterproofing

All green roofs should be installed onto a waterproof layer that has been tested and which is protected by a root protection layer. It is unlikely that the living roof will cause damage to the waterproofing layer. Where leaks do occur under a green roof, this is usually due to poor quality control or mechanical damage which has occurred before the green roof is installed. A living roof protects the waterproofing layer from mechanical damage, sun light and frost, potentially extending its life by decades.

Fire Safety

The GRO code recommends that "a minimum 80mm of growing medium with an organic content not exceeding 50% should be used on all green roofs to achieve regulatory fire compliance in the UK".

To prevent the spread of fire design in fire breaks consisting of shingle or similar non-flammable permeable material. These should be:

- 300mm width at perimeter, and around any feature penetrating the roof e.g. rooflights, pipes, rainwater outlets etc.
- 500mm width at openings such as doors, windows, etc.
- 1m width fire break on large roofs at 40 m interval

Figure 15. Chicago City Hall retrofit living roof | Farr Associates

Technical references and Further Guidance :

In Scotland all designers, contractors and building owners should comply fully with all recommendations set out in detail in the Building Standards Technical Handbook:

- For domestic Structures see https://www.gov.scot/publications/building-standards-technical-handbook-2020-domestic/
- For non-domestic see https://www.gov.scot/publications/building-standards-technical-handbook-2020-non-domestic/
- More detailed help and design guidance can be found in 'Green Roofs and Walls' section 4.5 recommendations for green roofs in terms of fire https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/230510/130819_SW3529R_-_Issue_3_-_Green_Roofs_and_Walls_Project_web_version_v3.pdf (greenrooforganisation.org)

Key Design and Construction Considerations

Design

- ☑ **DO** consult with City of Edinburgh Council planning at an early design stage to establish any restrictions related to key views, skylines, building heights or heritage character that could affect living roof proposals.
- ☑ **DO** consider at an early stage in the design process the functions your living roof needs to provide (such as amenity, water management, biodiversity etc.) in order to determine what type of living roof to construct. The desired function can then determine the structural requirements of the design (rather than as an 'add on' at a late stage).
- ☑ **DO** use a qualified structural engineer to assess the loading capacity of the roof (particularly for any retrofit scheme) as this will dictate the type of roof that can be installed.
- ☑ **DO** consider maintenance requirements including establishment irrigation and safe access arrangements in the design process from the outset. A maintenance plan should be submitted as part of the planning application for any new or retrofitted living roof.
- ☑ **DO** ensure the living roof design is GRO compliant including engineered elements and fire safety
- ☑ **DO** use landscape professionals to design intensive or semi-intensive roof gardens and amenity spaces
- ☑ **DO** consider living roof design in the context of a wider sustainable drainage strategy (a management train) to minimise the quantity of stormwater entering combined sewers or piped systems. For example, roof run off can be used to irrigate rain gardens.
- ☑ **DO** consider wind resistance when designing intensive living roofs and include appropriate anchoring systems for larger shrubs and trees
- ☑ **DO** consider construction access and buildability in your design along with safe access arrangements for maintenance including any special requirements for working at height.

Construction

- ☑ **DO** use experienced contractors to install the living roof. Roof components should be tested throughout and following construction to ensure installation quality.
- ☑ **DO** ensure the waterproof layer is correctly installed and avoid damaging it during construction of the living roof
- ☑ **DO** use biodegradable netting to secure growing medium layers in windy locations until planting is established.
- ☑ **DO** ensure green roof components including growing medium are stored carefully and protected from damage and weather before installation. Vegetation mats or plants should be stored in a sheltered area, kept watered and planted out as soon as possible.
- ☑ **DO** programme works to limit the amount of foot or mechanical traffic over particular areas of the living roof after installation to avoid growing medium compression or vegetation damage
- ☑ **DO** ensure that new planting is kept well-watered (in dry weather) for the first 12-18 months
- ☑ **DO** consider using specialist maintenance contractors during the establishment period
- ☑ **DO** provide individual reports to confirm the waterproofing and green or blue roof systems have been installed as specified. These reports should be retained with initial deck levels survey and the integrity test certificates as part of the project Operation & Maintenance Manual.

Planting on Living Roofs

Intensive Living Roof

Intensive living roofs tend to be made up of planted beds and occasionally trees and lawns. They are often referred to as **roof gardens**. Whilst they can be natural in character, most tend to be designed as formal landscapes and a professional landscape architect should be involved in the design process. Roofs that are used for urban food growing also fall into this category.

Intensive green roofs are usually irrigated, require a deeper growing medium and a higher level of maintenance.

Species selected for roof gardens should be hardy and tolerant of periodic dry conditions, full sun and exposure. For larger plants and trees consider using cultivars of native species in order to provide predictable height and form while still providing a natural resource.

Flowering, fruiting and berrying plants and additional features such as clay sand mounds, log piles and bird boxes (or bird bricks) can increase the biodiversity value. Where possible, the planting of rock rose (Helianthemum nummularium) is recommended as the food plant of the Northern Brown Argus caterpillar. a key species in the Edinburgh Biodiversity Action Plan along with identified priority species such as Sticky Catchfly, Maiden Pink, Meadow Cranesbill.

Minimum 120-250mm Growing medium Depth	Wildflowers and Grasses	Sticky Catchfly, Maiden Pink, Meadow Cranesbill, Native grasses and wildflowers of Scottish provenance including Scotia Seeds *Urban pollinators* seed mix	Choose appropriate native grasses and wildflowers suitable for the microclimate of the roof eg. full sun/ semi shade, exposed/ sheltered, coastal/inland etc. All types of living roof will tend to be dry rather than damp.
	Bulbs	Spring and autumn bulbs such as: Colchicum autumnale – and other native Scottish bulbs Scilla autumnalis and other non-native bulbs.	Plant bulbs to provide an early nectar source All bulbs should be sustainably sourced. Plant passports can provide evidence of origin
	Hardy Perennials	Native heathers Exposure/dry tolerant garden perennials	Note that heathers will require a growing medium at an appropriate ph.
	Shrubs	Native shrubs such as gorse, hawthorn, broom, juniper and rock rose Lavender, rosemary, and other hardy Mediterranean shrubs that attract wild bees Other exposure/dry tolerant garden shrubs	For larger shrubs consider wind resistance factors – anchoring may be necessary. Consider prostrate forms of native shrubs such as Juniper
Minimum 150-400 mm Growing medium Depth	Small Trees	Dwarf or small cultivars of native trees such as Rowan and Scots pine Small blossoming and fruit bearing tree varieties etc	Choose compact, dwarf or prostrate hardy exposure tolerant varieties Ensure the root balls of trees on roofs are firmly anchored
	Large trees	Dry and exposure tolerant deciduous and evergreen native trees Dry and exposure tolerant fruiting and berrying trees (such as pear or cherry)	Only to be considered on roofs with the depth and demonstrable structural capacity to accommodate trees at their mature size and weight (including factors such as snow and wind loading). Ensure the root balls of trees on roofs are firmly anchored

The example species listed are not exclusive. Other species could be considered if they are sufficiently robust, environmentally and climatically tolerant of conditions on site. All native species should be of Scottish Provenance. Specification in general should follow the principles set out in the Edinburgh Design Guide Ch3.

Extensive Living Roofs

Designing for Biodiversity

Biodiverse living roofs are planted/seeded with native wildflowers, grasses and sedums to provide a range of flowering species through early spring summer to early autumn. Sedums generally only flower in June and July. The benefits of biodiverse roofs have been studied in depth and the principles are laid out in the Buglife – the invertebrate charity's Creating green roofs for invertebrates. https://www.towerhabitats.org/wp-content/uploads/2016/12/Creating-Green-Roofs-for-Invertebrates_Best-practice-guidance.pdf

- Planting can be seeded (native meadow/ wildflowers), plug plants (wildflowers/sedums), or take the form of pre planted mats or blankets (sedums or native meadow/wildflowers).
- To support biodiversity extensive living roofs should vary the depth of growing medium 80–150mm (occasionally deeper to 200mm) across the roof. Purpose-made green roof growing medium are now widely available in the UK and can be formulated for particular types of planting such as dry grassland and native wildflowers.
- All native wildflowers should be of Scottish provenance. An 'Urban Pollinator' seed mix formulated for Edinburgh, is sold by Scotia Seeds along with other hardy, dry tolerant, green roof and coastal mixes. Employ a qualified landscape architect to specify a species mix appropriate to the roof micro-climate and locality.
- Provide additional habitats for wildlife by including elements such as clay sand mounds, log piles and include small areas of bare growing medium or shingle/ growing medium mixtures to support invertebrates, especially native wild bees and wasps.
- When designing or specifying a biodiverse green roof it is important to ensure that there is a varied depth of growing medium. This should be between 80mm and 150mm, with at least a third of the roof being 150mm deep.

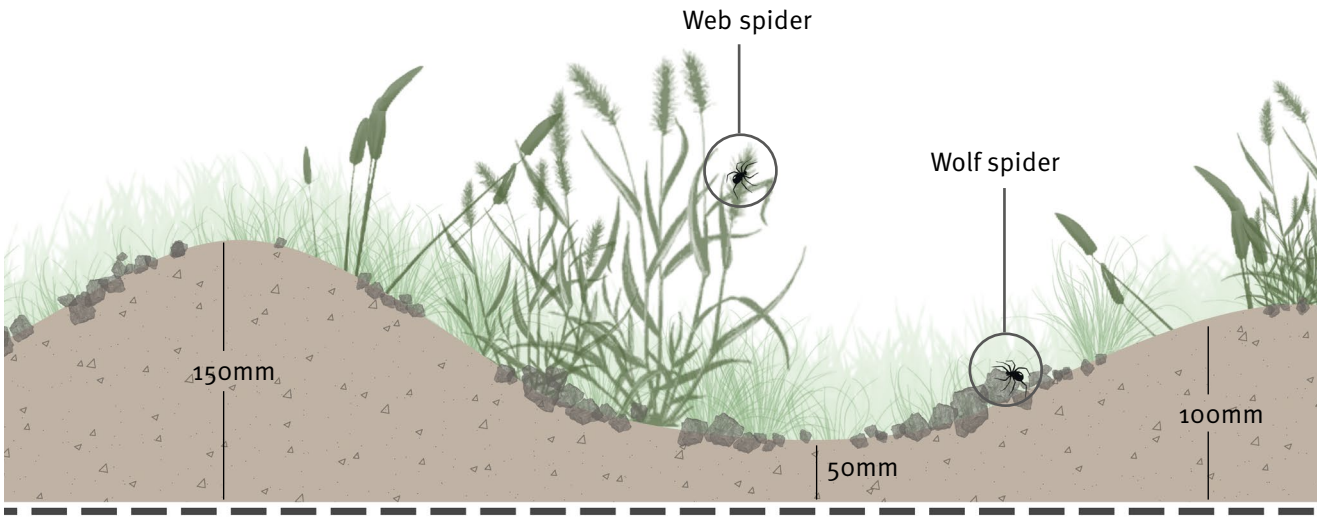


Figure 16. Topographic and floral diversity

Some Edinburgh brownfield sites provide rare and important mosaic habitats. Where these important urban habitats are lost through development there will be a presumption in favour of biodiverse living roofs that recreate mosaic habitat over an agreed proportion of the roof. Habitat requirements for living roofs can be established with City of Edinburgh Council at the pre-app stage.

Technical references and Further Guidance :

Poposed City plan 2030:

- ENV 37
- ENV 6
- ENV 8
- NPF4 Policies

Planting For Extensive Living Roofs

Sedum roofs	• At least 14 different species of sedums should be required, • Total minimum growing medium depth of 80mm (including rooted layer)
Biodiverse	• At least 16 species of a mix of native wildflowers planted and seeded and a wide range of sedum species or native non-invasive grasses. • Minimum 100mm – 150 mm (varied) depth of growing medium • Additional elements (logs/clay sand mounds)
Biosolar - Biodiverse	• At least 16 species of a mix of native wildflowers planted and seeded and a wide range of sedum species or native non-invasive grasses. (Choose low growing varieties or seed mix) • Minimum 100mm – 150 mm (varied) depth of growing medium • Additional elements (logs/clay sand mounds)
Biosolar - Sedum	• At least 14 different species of sedums should be required, • Total minimum growing medium depth of 80mm (including rooted layer)
Blue Roof - Biodiverse	• At least 16 species of a mix of native wildflowers planted and seeded and a wide range of sedum species or native non-invasive grasses. • Minimum 100mm – 150 mm (varied) depth of growing medium • Additional elements (logs/clay sand mounds)

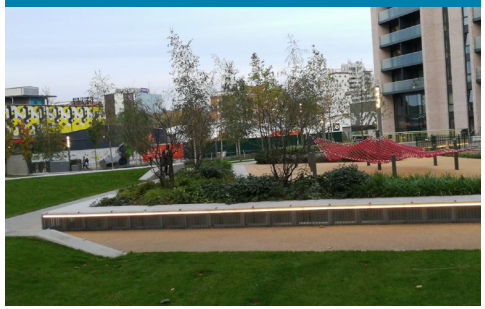
Sedum a

Biodiverse b

Biosolar - Biodiverse c

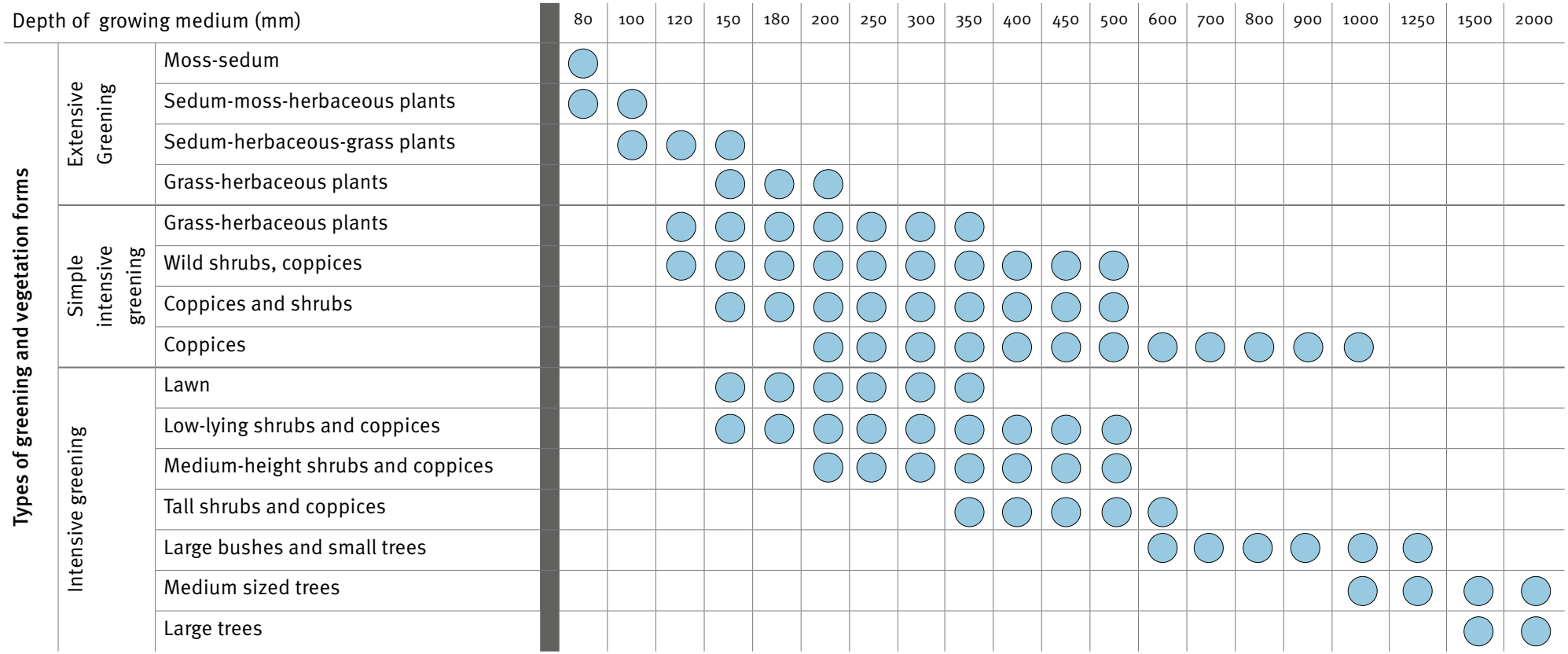
Biosolar - Sedum d

Blue Roof e



Blue roof -Biodiverse f

Depths of Growing Medium (soils) in Relation to Plant Types



Maintenance

Levels of maintenance required will depend on the type, planting and design of the living roof. For an intensive or semi-intensive roof designed as a garden or amenity space this may require monthly or weekly checks. In contrast extensive or biodiverse roofs and planting designed to be low maintenance may only require quarterly or twice-yearly visits.

Sedum roofs may require more maintenance than other types of extensive roofs. A maintenance plan for the lifetime of the building should be submitted as part of the planning application for any new or retrofitted living roof.

Figure 17. Maintaining a Living Roof | ICB Projects

Typical Maintenance Requirements

Roof Type	Typical frequency	Maintenance Actions
All Living roofs	1-2 times a year	Clear gutters and drains, Remove any debris, autumn leaves or litter Remove self-sown plants on shingle perimeters or fire breaks
Extensive Sedum Roofs	Up to 3 times a year Once a year in early spring In dry weather as required	Weeding Apply fertiliser as per supplier's recommendation Irrigate roofs with shallow growing medium
Extensive - Biodiverse	Once every six months In dry weather as required (establishment period only)	Weeding to remove self-sown invasive or woody plants such as Buddleia. Irrigate roofs while planting becomes established (2-3 years)
Intensive	At regular intervals during the growing season Outwith the bird nesting season	Will require a similar maintenance regime to a park or garden (level of maintenance dependant on design and type of planting) Carry out disruptive maintenance such as (such as trimming, or tree works) that could affect nesting birds
Bio – Solar and Solar	Frequency as 'Extensive roof' Once in late summer	Maintain as extensive or bio-extensive roof Cut back any tall vegetation in front of panels
Blue Roofs	Frequency as 'Extensive roof' After storm events	Maintain as extensive or bio-extensive roof Clear gutters and drains, Remove any debris, autumn leaves or litter

Key Maintenance Activities

- Ensure all drainage points, outlets and gutters are kept clear of debris or vegetation
- Maintain fire-breaks by clearing any debris and vegetation
- Remove undesirable or invasive plants (such as Buddleia)

Irrigation

All Living roofs will need irrigation in dry weather while vegetation gets established to prevent die back. Living roofs with deeper growing medium are able to retain moisture better and therefore are more resilient. Depending on the design and type of planting some intensive and semi-intensive living roofs may continue to require some irrigation. Most extensive living Roofs should not require irrigation beyond the establishment period (with the exception of those with very shallow growing medium).

Fertilisers

Avoid using fertilisers unless required by a specific type of planting such as a sedum only roof or some specific types of planting within an amenity space. The use of fertilisers will be detrimental to water quality and biodiversity. No fertilisers should ever be used for biodiverse planting

Avoiding Damage to the Roof Structure

Make sure those carrying out maintenance activities are briefed on the construction and components of the roof and ensure no tools are used that may damage roof layers below the growing medium. Avoid compressing the growing medium by repeated trafficking over a small area.

Health and Safety

Where maintenance will be undertaken within 2m of the edge of a living roof, fall protection must be provided. It is important that fall protection systems are themselves inspected and maintained as required. For living roofs used as amenity spaces appropriate barriers should be provided.

Figure 18. Irrigation | ICB Projects

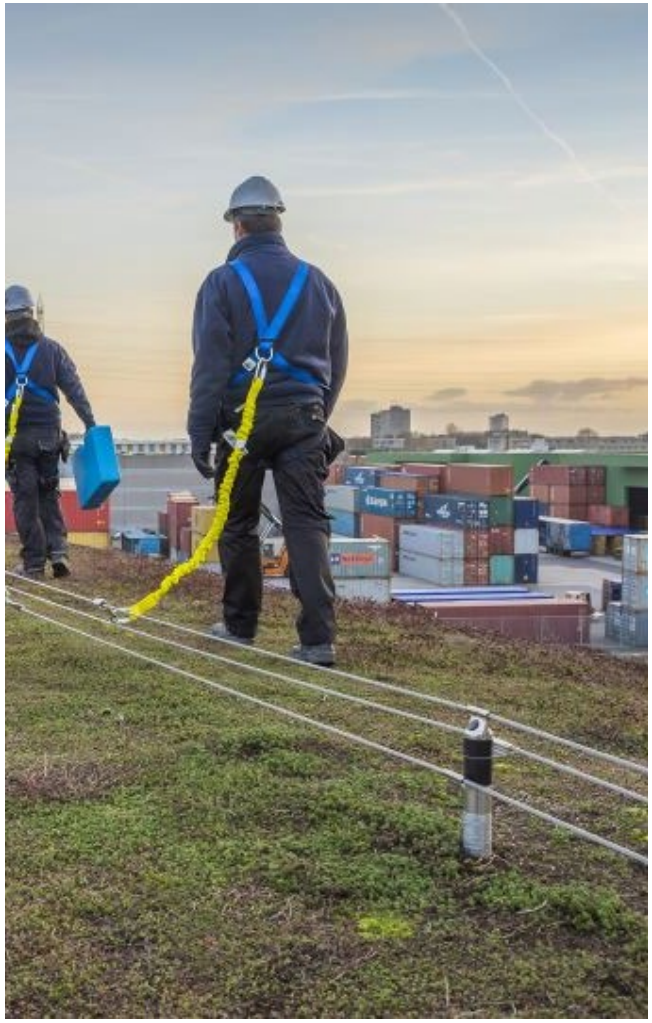


Figure 19. Maintaining a green roof safely | XS Platforms

Designing Living Roofs for Multiple Benefits

Cost Benefit Analysis and Whole Life Costs

CIRIA's Benefits of SuDS Tool (B£ST) provides a methodology and guidance on calculating the value of the benefits that SuDS (including living roofs) can deliver. The approach allows for the qualitative, quantitative and monetised estimate of the magnitude of benefits that would be delivered by living roofs as part of SuDS. This tool along with other useful resources, calculating whole life costs and constructing an enhanced business case are discussed in the ESRWMG pages 54- 58.

Approaches to calculating the carbon sequestration rates and potential energy savings of living roofs are set out in the research paper 'CO2 Payoff of Extensive Green Roofs... ' Looking at extensive green roofs researchers calculated CO2 payback would take between 6 and 16 years (allowing for construction, maintenance and eventual disposal carbon costs).

Figure 20. La Vignole Paris | Dusty Gedge

Figure 21. Community Maintenance | Susdrain

Technical references:

- W074b B£ST Guidance – Guidance to assess the benefits of blue and green infrastructure using
- B£ST, version 3, 2019
- Environment Agency, 2015, "Cost estimation for SUDS – summary of evidence"
- RICS, 2011, "RICS practice standards, UK: Green infrastructure in urban areas", 1st edition
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Living Roofs within the Airport Bird Strike Hazard Zone

A bird strike is the collision between a bird and an aeroplane during flight and can be a significant threat to safety with particularly high risks during take-off or landing. Developments that could attract large birds or flocks of birds that cross or congregate close to airports should be assessed for risk.

Any development within the 13km bird strike hazard zone of Edinburgh Airport that results in a change of habitat has the potential to attract hazardous bird species. All flat roofs, including living roofs can make attractive bird roosting and nesting spaces.

As living roofs, flat and shallow pitched roofs will be attractive to hazardous species, they should be avoided within the immediate area of the airport.

Where living roofs proposed within 13km of the airport, they must be appropriately designed and maintained to reduce risk for the lifetime of the building. Construction within 5km of the airport may also need an agreed risk management plan for the construction phase.

The reduction of birdstrike risks in roof design can be split into three stages:

- Identify potential attractors for hazardous birds and assess risk levels in relation to the proximity of the airport
- Evaluate design and management options to reduce potential to attract hazardous birds
- Develop strategies to manage risk both during construction and long term during the lifetime of the building

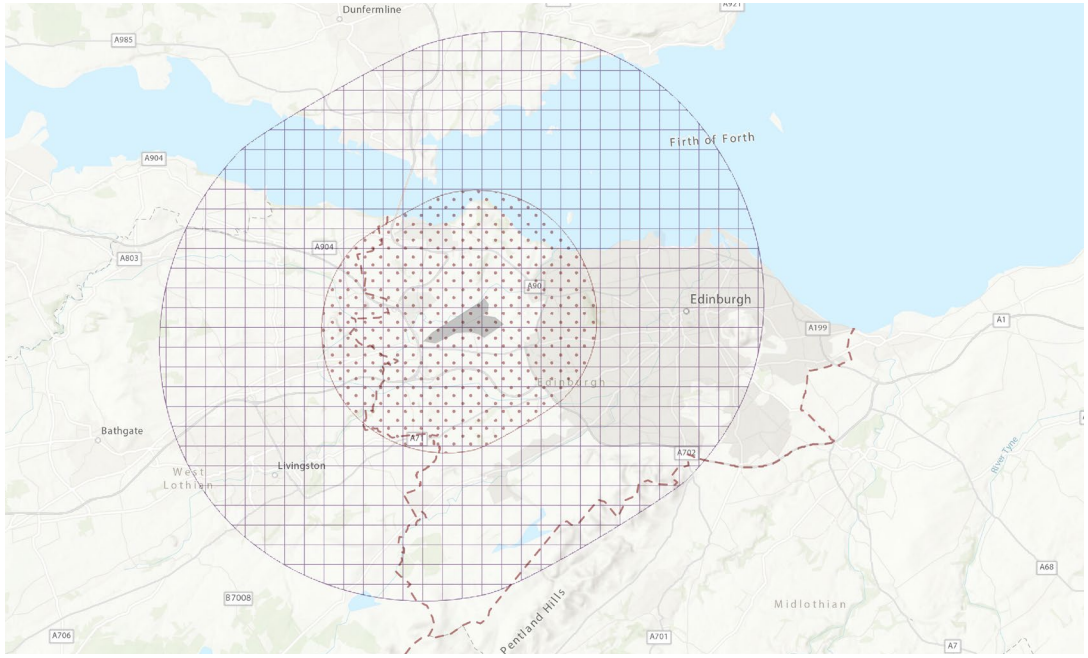

Figure 22. Edinburgh Airport Bird Strike Hazard zone |Esri, Intermap, NASA, NGA, USGS | Esri UK

Key

- Edinburgh Airport
- 5Km Zone
- 13Km Zone

Figure 23. Edinburgh Airport | Ad Meskens

Design, Construction and Maintenance Considerations to Reduce Bird Strike Risks

- Roofs that are **larger and closer to the airport** boundary will **require more rigorous measures to ensure safety** compared to sites that are smaller or further away. Flat or shallow pitched roofs proposed **within 13 km,** should contact the airport at an **early design stage** to agree any requirements for long term **risk management** measures before the development starts. Within 5km there may also be a requirement for **a Construction Phase Bird Hazard Management Plan (BHMP).**

- In the area close to the airport, **or the take-off and landing flight path**, the introduction of **any flat or shallow pitched roofs (including living roofs) should be avoided**.

- Within the wider 13km bird strike risk hazard zone **intensive and semi-intensive roofs pose less risk than extensive roofs** as there are opportunities to break up the space with planting of different heights. For intensive roofs the presence of people may also deter bird nesting.

- In relation to bird strike hazards **photovoltaic roofs with panels set flush to the roof are preferable** to those with panels set on stands which can attract roosting and nesting pigeons..

- All flat roofs within the 13km hazard zone where the airport have required or requested **a bird hazard management plan** will require **safe access for regular inspection** during the breeding season to discourage birds and in some cases hazardous birds, and/or their associated eggs and nests may require removal under license from NatureScot.

- The use of **loose netting** as a deterrent **will not be acceptable** as birds can become trapped, resulting in death, **other injurious and lethal deterrents will also be unacceptable**. Alternative deterrents could include 'automated laser bird repellents', (see Elbers and Gonzales (2021)) along with standard mitigation approaches used at airports documented by the Civil Aviation Authority.

Figure 24. Herring Gull

Examples of Hazardous Bird Species that can be attracted to flat or shallow roofs:

- Herring Gull *Larus argentatus*
- Lesser Black-backed *Gull Larus fuscus*
- Herring Gull *Larus argentatus*
- Common Gull *Larus canus*
- Oystercatcher *Haematopus ostralegus*
- Lapwing *Vanellus vanellus*
- Starling *Sturnus vulgaris*
- Feral Pigeon *Columba Livia domestica*

Planting on living roofs within the bird strike hazard zone

- **Sedum and gravel, or brown** (aggregate) **roofs should be avoided** as they mimic their natural nesting habitats of hazardous species like gulls and oystercatchers.

- **Wildflowers, herbaceous or small perennial plants and grasses** (including ornamental grass varieties) may be suitable **as part of a biodiverse or intensive roof,** ensuring any area of open grass is maintained at minimum height of 220-300 mm.

- **Non-fruiting species of shrubs and trees** (including sterile cultivars) which will be less attractive to smaller hazardous species such as wintering thrushes and can be used to break up the open space of an intensive or semi-intensive roof

- On **intensive roofs accessed by building users,** planters and furniture may also be used to break up the roof space.

Figure 25. Living Roof, London | Local Plan Monitoring Report –Roof Terraces and Green Roofs

Technical reference:

- Civil Aviation Authority, Cap22 Wildlife Hazard Management at Aerodromes, 2017
- Edinburgh Design Guide - section TBC
- Elbers, A. R. W., and Gonzales, J. L. (2021) *Efficacy of an automated laser for reducing wild bird visits to the free range area of a poultry farm.*

Case studies

Figure 26. Ikea Greenwich living roofs | Ikea / Susdrain

IKEA Greenwich

The green roofs, blue roof and roof garden consist of biodiverse and sedum covered areas; wildflower meadows; raised urban farming beds for school, community, and co-worker use; planters; paving; and areas for community activities. IKEA Greenwich has achieved an 'Outstanding' BREEAM UK New Construction certification.

Components: green roof, blue roof and roof garden, rainwater harvesting

Cost: SuDS element £490,000

Extent: SuDS (green and blue roofs) 4000m²

Location: Greenwich Peninsula, London SE10 0QJ

Date Feb 2019

For further details see Susdrain Case Studies

Figure 27. Rathbine Market | Susdrain/ English Cities Fund

Rathbone Market, London

A sustainable and mixed-use community at Rathbone Market, including 652 homes with shops. Facilities include public walkways and ornamental ponds at podium level, biodiverse roof finishes and an allotment for residents at roof level. The blue roofs met the planning requirements for storm water attenuation within the restricted roof areas.

Components: Blue roof stormwater attenuation system

Cost: £85k

Extent: 1000m2

Location: Rathbone Market, Barking Rd, London, E16 1EH

Date: April 2017

For further details see Susdrain Case Studies

Figure 28. Ruislip Tube Depot | Susdrain

Ruislip Tube Depot, London

The trial project was developed to monitor the effectiveness of retrofitting living roof on an industrial building. Two experimental living roofs were fitted, both sections of the roof were planted with sedum and annual perennial wildflowers. Retrofitting on operational railway had to follow the rigorous assurance and safety procedures. Benefits included increased bio-diversity and reduced runoff rates.

Components: biodiverse extensive green roofs

Cost: £30k

Extent: 122m²

Location: W End Rd, Ruislip HA4 6NS, UK

Date: Completed 2012

For further details see Susdrain Case Studies

Examples of Green Roofs in Edinburgh

Figure 29. Intensive roof, Greenside Row, Edinburgh | Atkins

Figure 30. Greenroof - Scottish Parliament | Mark Longair

Figure 33. Extensive Green Roof | Edinburgh Vet School (©. Bauder)

Figure 31. Bog Garden - National Museum of Scotland | Bakarama

Figure 32. Extensive Green roof - student Accommodation | Atkins

Figure 34. Residential house with green roof | Google earth

Image References

Figure 1. Edinburgh Parliament Building with Extensive Green Roof | Mark Longair
Longair, M. (2009) The Scottish Parliament [online], Flickr, available: https://www.flickr.com/photos/mhl20/3925817094/ [accessed 25 Oct 2023].

Figure 2. City of Edinburgh Council Headquarters, Waverley court, East Market Street | Shutterstock
Stoff, K. (2023) Photoskyline [online], Shutterstock, Shutterstock, available: https://www.shutterstock.com/image-photo/edinburgh-skyline-218212414?consentChanged=true [accessed 25 Oct 2023].

Figure 3. Edinburgh Green Blue Network | Atkins
Atkins (2022) Edinburgh Green Blue Network 2022

Figure 4. Development in Edinburgh | City of Edinburgh Council
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Figure 5. Intensive roof, Greenside Row, Edinburgh | Atkins
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Figure 6. Semi-Intensive Roof, London | Townsend Landscape Architects
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Figure 7. Sedum Roof Ikea, Greenwich | Dusty Gedge
Image courtesy of Dusty Gedge

Figure 8. Biodiverse green roof on PWC 7 More London 2 - 1
Image courtesy of Dusty Gedge

Figure 9. Bio solar roof, London | Dusty Gedge
Image courtesy of Dusty Gedge

Figure 10. Smart blue roof with green roof element | Vegetal i.D
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Figure 11. Typical green roof layers (Exploded Diagram)
Diagram courtesy of Atkins

Figure 12. Typical blue roof layers (Exploded Diagram)
Diagram courtesy of Atkins

Figure 13. Outlet chamber
Diagram courtesy of Atkins

Figure 14. Parapet outlet for exceedance
Diagram courtesy of Atkins

Figure 15. Chicago City Hall retrofit living roof | Farr Associates
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Figure 16. Topographic and floral diversity
Diagram courtesy of Atkins

Figure 17. Maintaining a Living Roof | IBC Projects
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Figure 18. Irrigation | IBC Projects
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Figure 20. La Vignole Paris | Dusty Gedge
Image courtesy of Dusty Gedge

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Esri, Intermap, NASA, NGA, USGS | Esri UK

Figure 23. Edinburgh Airport | Ad Meskens
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Figure 31. Bog Garden - National Museum of Scotland | Bakarama
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Figure 32. Extensive Green roof - student Accommodation | Atkins
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Figure 33. Extensive Green Roof | Edinburgh Vet School (©. Bauder)
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Figure 34. Residential house with green roof | Google Earth
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