
APPENDIX 5.0 – BIODIVERSE ROOF BUILD UP DETAIL

APPENDIX 6.0 – NOTES ON MAINTENANCE OF BIODIVERSE ROOF & MONITORING PROGRAMME

MAINTENANCE

A maintenance scheme will likely be provided by the installation contractors; however this section gives a basic overview of maintenance required for biodiverse roofs. Should the installation contractor not offer maintenance then a specialist contractor will be sought to do so.

There will be a maintenance scheme that is adhered to for the living roof at the site despite extensive biodiverse roofs of the like being considered relatively 'low maintenance'. This maintenance scheme will be in addition to the management and monitoring actions detailed in section 4.0. The primary factors considered as part of maintenance of the living roof will be the following:

Undesirable Plants

Vegetation found across the roof and in drains that damages the biodiversity aims, planting regime and building fabric (e.g. Buddleja) will be removed whilst immature.

Fire Breaks

Vegetation breaks/barriers have an important safety function and prevent the spread of fire. All vegetation barriers at up-stands, roof penetrations and fire breaks will be maintained at their original width and cleared of any encroaching plants.

Drain Heads and Outlets

All drainage points will be checked every year and cleared out if necessary to ensure optimum performance. Excess water must be able to leave the roof, to avoid ponding and overloading.

Health and Safety During Maintenance

Where maintenance will be undertaken within 2m of the edge of a green roof, fall protection will be provided. The fall protection systems will themselves be maintained once a year.

MANAGEMENT, MONITORING & FUNDING

This section provides an overview of the relevant management, monitoring and funding features of the ecological enhancements at the site. As an overview, Greengage will monitor the ecological aspects of the enhancement features (e.g. checking species mixes are appropriate for the locality) with general maintenance and 'day to day' management being undertaken by an external company appointed by the owners/developers. Funding will be from an annual residents surcharge for grounds and property maintenance. The maintenance of the living roof will be undertaken by the installation contractors. However, as discussed in the section 2.0, should this maintenance not be offered then the services of a specialist living roof maintenance company will be sought.

This Ecological Management Plan will maintain and enhance the living roof habitats and species that are included in the London and Camden BAP. It will help achieve initiatives and targets set out within these BAP's providing habitat for priority species. In particular the living roof will contribute to targets for the London BAP Wasteland HAP, London and UK BAP Stag Beetle, Bat Species and Black Redstart SAPs, and Camden BAP the Built Environment.

The Ecological Management Plan will follow a clearly defined 5 year timetable in the first instance that will be used as a reference point for site maintenance, monitoring and any future planting and enhancement works that may be necessary for the biodiverse roof.

Living roof are dynamic, and the species composition is anticipated to change over time, due to plant selection resulting from the prevailing climatic conditions, natural colonisation, and succession. As a result, some of the actions within the first 5 years will be dependent upon rate of growth or success of initial planting/sowing and enhancements. In general, where measures have not been stated it is due to a non-intervention policy once the features have been established.

This Plan will also be iterative in the medium to long-term, adapting in a staged process to the changing roof composition and in response to the feedback from monitoring exercises. Suggestions can be made to alter the enhancement measures or supplement the planting regime as necessary. Primarily, the Ecological Management Plan will include actions to maintain the ecological objectives for the Living Roof, which are:

- Optimise biodiversity measured by the range of wildlife benefiting plant species, lichens, mosses and fungi, and invertebrate and bird species using the living roof;
- Encourage invertebrates through diverse range of floral species and suitable invertebrate niche habitats;
- Encourage species highlighted in the UK BAP, Red Data Book and English Nature's Species Recovery Programme such as the black redstart, the house sparrow, the brown-banded carder bee and ground nesting mining bees.

Greengage will undertake the monitoring programme that will measure the success of the living roof for their overall biodiversity value, observing any natural colonisation, the success of the seed mix and plug planting and use of the roof by birds and invertebrates as key biodiversity indicators. The monitoring for birds and invertebrates in particular will occur annually for the first 3 years and is recommended biennially thereafter. Monitoring will focus on the diversity and abundance of these species.

At or just after Practical Completion of the living roof, we will inspect the ecological enhancements implemented as a result of the recommendations in this Living Roof Specification. We propose to undertake three further site surveys over the following 3 years after practical completion to monitor the effectiveness for increasing biodiversity.

After the initial 3 years of establishment and annual surveys, we highly recommend that biennial site surveys over the following 10 years are undertaken to monitor the effectiveness of the ecological enhancement and amend the Ecological Management Plan accordingly.

Indicators of success will include the successful establishment of a wide variety of plant species, natural colonisation of floral species in the bare areas on the roof, evidence of invertebrates inhabiting the ecological features incorporated on the roof, evidence of bird activity on the roof such as birds using the nest boxes or signs that the black redstart is using the living roof.

The table below summarises management actions for the first 5 years. Assuming that practical completion of the living roof is undertaken by autumn 2013, Year 1 Spring will be Spring 2014. Following the initial 5 year period, the actions should be repeated, with any changes to the actions informed through the reactive process that should be used as a basis of this iterative management/monitoring plan.

In addition to checking the living roof, Greengage will check the status of the other ecological enhancement features during each visit, however specific maintenance and management of these features (if required) was included.

Table Showing Key Stages of the 5 Year Management Plan

Year and Season	Action	Comments
Year 1 – Spring	-	-
Year 1 – Summer	<ul style="list-style-type: none"> • Annual monitoring programme (survey to be undertaken between May and August) • Survey for signs of invertebrates and bird species using the roof areas • Check enhancement measures are intact 	<ul style="list-style-type: none"> • An annual monitoring programme by Greengage will measure the success of the roof for their biodiversity value, including surveying for dominant plant species - this will inform the need for any improvements/alterations • Survey for signs that invertebrates are inhabiting enhancement features and other fauna are using the site for foraging, nesting or perching • During the monitoring programme it will be necessary to check the enhancement measures are intact, such as the wire netting not been blown away and the rope coils nailed down
Year 1 - Autumn	<ul style="list-style-type: none"> • Re – plant or supplement planting if necessary • Weed out competitive species if necessary 	<ul style="list-style-type: none"> • Feedback from the monitoring programme will inform the need for any further planting or weeding if required
Year 1 – Winter	<ul style="list-style-type: none"> • Check if any litter needs removing and dispose where necessary 	-
Year 2 – Spring	<ul style="list-style-type: none"> • Annual monitoring programme (survey to be undertaken between May and August) • Survey for signs of invertebrates and bird species using the roof areas • Check enhancement measures are intact 	<ul style="list-style-type: none"> • An annual monitoring programme by Greengage will measure the success of the roof for their biodiversity value, including surveying for dominant plant species - this will inform the need for any improvements/alterations • Survey for signs that invertebrates are inhabiting enhancement features and other fauna are using the site for foraging, nesting or perching • During the monitoring programme it will be necessary to check the enhancement measures are intact, such as the wire netting not been blown away and the rope coils nailed down

Year and Season	Action	Comments
Year 2 – Summer	-	-
Year 2 – Autumn	<ul style="list-style-type: none"> • Re – plant or supplement planting if necessary • Weed out competitive species if necessary 	<ul style="list-style-type: none"> • Feedback from the monitoring programme will inform the need for any further planting or weeding if required
Year 2 – Winter	<ul style="list-style-type: none"> • Check if any litter needs removing and dispose where necessary 	-
Year 3 – Spring	-	-
Year 3 – Summer	<ul style="list-style-type: none"> • Annual monitoring programme (survey to be undertaken between May and August) • Survey for signs of invertebrates and bird species using the roof areas • Check enhancement measures are intact 	<ul style="list-style-type: none"> • An annual monitoring programme by Greengage will measure the success of the roof for their biodiversity value, including surveying for dominant plant species - this will inform the need for any improvements/alterations • Survey for signs that invertebrates are inhabiting enhancement features and other fauna are using the site for foraging, nesting or perching • During the monitoring programme it will be necessary to check the enhancement measures are intact, such as the wire netting not been blown away and the rope coils nailed down
Year 3 – Autumn	<ul style="list-style-type: none"> • Re – plant or supplement planting if necessary • Weed out competitive species if necessary 	<ul style="list-style-type: none"> • Feedback from the monitoring programme will inform the need for any further planting or weeding if required
Year 3 – Winter	<ul style="list-style-type: none"> • Check if any litter needs removing and dispose where necessary 	-
Year 4 – Spring	-	-
Year 4 – Summer	-	-
Year 4 – Autumn	<ul style="list-style-type: none"> • Check enhancement measures are intact • Check if any litter needs removing and dispose where necessary 	<ul style="list-style-type: none"> • Check the enhancement measures are intact, such as the wire netting not been blown away and the rope coils nailed down

Year and Season	Action	Comments
Year 4 – Winter	-	-
Year 5 – Spring	<ul style="list-style-type: none"> • Biennial monitoring programme of dominant plant species, invertebrates and birds diversity & abundance (survey to be undertaken between May and August) 	<ul style="list-style-type: none"> • A biennial monitoring programme is recommended to continue to measure the success of the roof for their biodiversity value, including surveying for dominant plant species - this will inform the need for any improvements/alterations to the long term Ecological Management Plan (covering a period up to 25 years) • Survey for signs that invertebrates are inhabiting enhancement features and other fauna are using the site for foraging, nesting or perching • During the monitoring programme it will be necessary to check the enhancement measures are intact, such as the wire netting not been blown away and the rope coils nailed down
Year 5 - Summer	-	-
Year 5 – Autumn	<ul style="list-style-type: none"> • Re – plant or supplement planting if necessary • Weed out competitive species if necessary 	<ul style="list-style-type: none"> • Feedback from the monitoring programme will inform the need for any further planting or weeding if required
Year 5 – Winter	<ul style="list-style-type: none"> • Check if any litter needs removing and dispose where necessary 	-

The table outlines the necessary responsibilities and key objectives for the next 5 years. The actions should be repeated and edited as appropriate following the initial 5 years. This is the basis of the iterative plan, with edited/added actions decided upon by the ecologist as a function of any un-foreseen potential changes that may need to be addressed in the future). Should the Ecological Management Plan need to be extended beyond 10 years, it will be done so in appropriate stages, considered to be 5 – 10 years, 10 – 15 and up to 25 years.

Hence, the Ecological Management Plan is iterative and feedback from the monitoring exercises will inform and develop the Plan, which will be amended and updated accordingly to maintain the objectives.

Bio-diverse roof spec for Maygrove Road

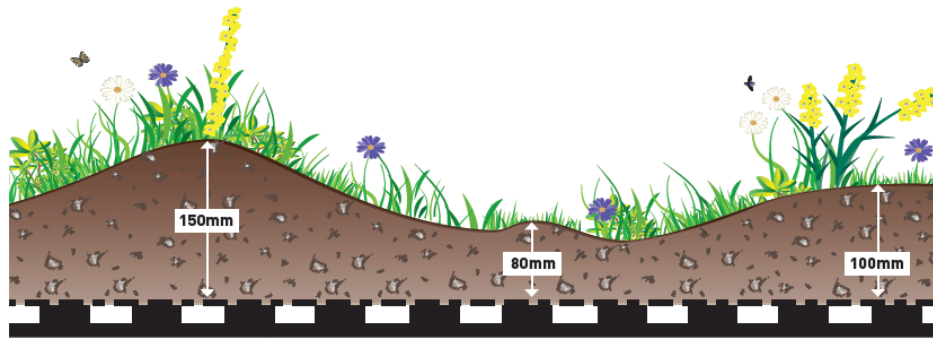
Enhancement: Biodiverse (brown) Roof

- 1.1 883sqm of bio-diverse roof area will be included in the development, the positioning of which is shown at Appendix 3.0.
- 1.2 This will compliment action All13 of the Camden BAP The Built Environment, that aims to increase the number of green roofs in Camden, targeting council buildings. Additionally, all recommendations fulfil Camden's requirements as outlined in CPG – Chapter 3 Sustainability (Section 10: Living Roofs and Section 13: Biodiversity).
- 1.3 As an overview, the biodiverse roof will comprise mounded substrate/growing medium between 80mm-150mm and will be supplemented with a wildflower seed mix to aid natural colonization. Biodiversity features such as deadwood logs will be included to enhance the biodiversity value.
- 1.4 Appendix 5.0 contains specification documents from the roof provider (Bauder).
- 1.5 A monitoring plan is included at Appendix 6.0, with notes on management included.

Substrate Specification

- 1.6 To maximise diversity in micro-climate across the roof, the substrate depth will be varied, between at least 80mm and 150mm (see Figure 1.1). This variation will result in differences in exposure, shading, diurnal temperatures, humidity and water content giving rise to localised diversity in species composition¹. This will also particularly benefit invertebrate species.

Figure 1.1 **Example cross section of bio-diverse roof showing change in substrate depth**



- 1.7 This substrate will be formed of a mineral component of recycled crushed brick and expanded clay shale and an organic component composted of pine bark. This mix provides a low nutrient substrate that will be suitable for the proposed seed mix. The low nutrient composition will prevent undesired weed species growing and dominating the sward.
- 1.8 Substrates evolve as part of their normal function, with generally a steady increase in organic content over the lifespan of the roof.

Biodiverse Roof floral Specification

- 1.9 Brown or bio-diverse roofs can be left to colonise naturally although this can be a slow and unpredictable process that relies on a source of propagules in the local vicinity; the nearest species rich habitats are those of Hampstead Heath, ~2.5km north east of the site. To facilitate rapid establishment and promote a more predictable mix of species of biodiversity benefit the decision has been taken to supplement the biodiverse roofs for the with specially chosen wildflower species. The species mix has been carefully chosen to optimise biodiversity across the roof spaces, to suit the substrate utilised, and importantly, to tolerate the drought and wind exposed conditions prevalent at the different roof levels.
- 1.10 The choice of plant has therefore, been based on the following criteria:
- Ability to grow in drought conditions and be wind tolerant;
 - Relatively low growth height (around 80cm maximum) to be able to survive the harsh conditions at proposed roof heights;
 - Range of vegetation heights (up to 80cm) for structural diversity;
 - They are of wildlife benefit, providing valuable nectar sources and attracting invertebrates;
 - Local to Camden and London, commonly found growing in this area and typical of brownfield habitat;

- Wide ranging corolla (shape/size of flower petals) that is vital to attract a number of different invertebrate species, and in particular BAP or Red Data book species;
- Will benefit local BAP species or have been referenced in the Camden BAP or London BAP; and
- Wide ranging flowering periods to enable a long and variable flowering season throughout the year.

1.11 The Table 1.1 below summarises the species mix that has been selected for the biodiverse roof at Maygrove road, and includes further details on the species overall height, wildlife benefit and growth conditions.

1.12 It should be noted that the maximum heights of the taller plants specified in Table 1.1 may not be achieved on the living roof as the conditions may not be optimal, thus heights will be restricted to what the conditions allow.

Table 1.1 Wildflower Species Mix with Characteristics

Species Name	Latin Name	Height	Wildlife Benefit	Growth Conditions
Agrimony	<i>Agrimonia eupatoria</i>	Up to 65cm	The food plants by the larvae of some Lepidoptera species including Grizzled Skipper and Large Grizzled Skipper	A hardy plant that prefers partial shade
Autumn Hawkbit	<i>Leontodon autumnalis</i>	15-30cm	Late flowering, attracts beetles and butterflies	Drought tolerant, low nutrients, wind tolerant, open conditions
Birds Foot Trefoil	<i>Lotus corniculatus</i> (do not confuse with introduced sown variety <i>L. Corniculatus var sativus</i>)	20-40cm	Mid flowering, good nectar source for many insects and a larval source for many species of Lepidoptera - beneficial for black redstarts	Drought and wind tolerant, low growing, sprawling habit. Common on grasslands and along roadsides. A member of the legume family therefore nitrogen fixing and will increase the nutrient value of the substrate over time
Biting Stonecrop	<i>Sedum acre</i>	10-15cm	Branched clusters of bright yellow flowers, which have long protruding stamens and are attractive to bees for pollen and nectar.	This is a spreading plant that thrives on virtually soil-less conditions. Favours full sunlight.
Black Medick	<i>Medicago lupulina</i>	Up to 50cm	Early flowering, attracts butterflies, hoverflies and bees. Beneficial for black redstarts	Low growing, ground hugging plants. Very common on roads and roadsides and is drought and wind tolerant, and can survive relatively cold conditions. A member of the legume family therefore nitrogen fixing and will increase the nutrient value of the substrate over time
Bladder Campion	<i>Silene vulgaris</i>	40-80cm	The Bladder Campion is an important nectar source for butterflies and a favourite food plant of frog hoppers, the insects which create cuckoo spittle	It prefers neutral, dry soils and is generally found alongside paths and in open grassy or rough ground.

Species Name	Latin Name	Height	Wildlife Benefit	Growth Conditions
Breckland Thyme	<i>Thymus serpyllum</i>	5-20cm	Flowers are attractive to bees	Easily grown in average, dry to medium, well-drained soils in full sun. Tolerates drought and poor soils of low fertility. Loose, sandy or rocky soils with excellent drainage are best habitat
Bugle	<i>Ajuga reptans</i>	10-25cm	The flower is an important early source of nectar for butterflies, especially the Duke of Burgundy, Marsh Fritillary and the Pearl-Bordered Fritillary.	A small, spreading plant that produces a ring of blue flowers on top of each set of leaves. Prefers sunny or semi-shaded conditions
Bulbous Buttercup	<i>Ranunculus bulbosus</i>	20-50cm	The food plant of the larvae of some Lepidoptera species including Hebrew Character and Small Angle Shades	Favours nutrient-poor, well-drained soils
Common Corncockle	<i>Agrostemma githago</i>	Up to 80cm	Attracts lady-beetles and parasitic wasps	Hardy plant found in many conditions. Likes disturbed, nutrient poor soils
Common Field Speedwell	<i>Veronica persica</i>	10-30cm	Flowers most of the year, attracts butterflies.	Low growing, hardy plant, nutrient rich
Common Forget-Me-Not	<i>Myosotis arvensis</i>	10-35cm	Food plant of the larvae of some Lepidoptera species including <i>Setaceous Hebrew Character</i>	Shows a preference for soils with low pH
Common Mouse Ear	<i>Cerastium fontanum</i>	Up to 50cm	Early to late flowering, flowers are self or insect pollinating	Low growing, likes dry grassland and wasteland conditions, prefers richer nutrient levels
Common Poppy	<i>Papaver rhoeas</i>	Up to 60cm	Has no nectar but the flowers provide pollen for bees. Beetles feed in the seed capsules and some species may overwinter here when the capsules are empty	Hardy plant grows on disturbed soils

Species Name	Latin Name	Height	Wildlife Benefit	Growth Conditions
Common Vetch	<i>Vicia sativa</i>	15-40cm	Mid flowering, attracts bees, wasps, butterflies and aphids – aphids are beneficial for house sparrows	Particularly attractive to aphids, an essential food source for house sparrow chicks. A member of the legume family therefore nitrogen fixing and will increase the nutrient value of the substrate over time
Corn Camomile	<i>Anthemis arvensis</i>	Up to 30cm	Attract a range of pollinating insects	Preference for light chalky or sandy soils
Cornflower	<i>Centaurea cyanus</i>	30-80cm	Attract many beneficial insects that come to nectar and feed on the pollen	A hardy plant which grows of many soil types and prefers full sun
Cowslip	<i>Primula veris</i>	Up to 25cm	Food plant of the Duke of Burgundy Fritillary butterfly, Plain Clary and Northern Rustic moths	A hardy plant preferring well drained soils and full sun
Cut Leaved Crane's-Bill	<i>Geranium dissectum</i>	10-40cm	Mid to late flowering, attracts beetles and butterflies.	Likes stony ground, wasteland, and thin soils. Low growing sprawling plant
Dove's-Foot Crane's-Bill	<i>Geranium molle</i>	Up to 20cm	Early flowering, attracts range of insects and beneficial for black redstarts	Low growing, sprawling habit. Drought tolerant and common on roadsides, wastelands and brownfield sites
Fox And Cubs	<i>Hieracium aurantiacum</i>	15-35cm	Mid flowering, attracts flies, good nectar source	Drought tolerant, hardy plant, low growing
Hares Foot Clover	<i>Trifolium arvense</i>	10-40cm	Late flowering, attracts flies, good nectar source	Drought and wind tolerant. A member of the legume family therefore nitrogen fixing and will increase the nutrient value of the substrate over time
Hoary Plantain	<i>Plantago media</i>	30-55cm	Mid flowering, large flowerhead, attracts bees and wasps	Drought tolerant, low growing
Kidney Vetch	<i>Anthyllis vulneraria</i>	Up to 60cm	Late flowering, attracts bees and wasps and butterflies. Beneficial for black redstarts.	Low growing, ground covering plant, found on wastelands, railway embankments etc. Drought tolerant. A member of the legume family therefore nitrogen fixing and will increase the nutrient value of the substrate over time

Species Name	Latin Name	Height	Wildlife Benefit	Growth Conditions
Knapweed	<i>Centaurea scabiosa</i>	Up to 50cm	Very attractive to butterflies and bees.	Tolerant of a wide range of soils. It's common throughout the British Isles.
Lemon-scented Thyme	<i>Thymus x citriodorus</i>	10cm	Very attractive to numerous species of butterflies and bees	Hardy low growing plant. Frost tolerant.
Musk Mallow	<i>Malva moschata</i>	Up to 80cm	Particularly attractive to several species of bees.	Prefers dry and fertile soils and full sun.
Ox Eye Daisy	<i>Leucanthemum vulgare</i>	Up to 60cm	Late flowering, attracts beetles and hoverflies.	Grows on disturbed soils and wastelands as well as wildflower meadows, tolerant of a wide range of environmental conditions including drought
Pale Toadflax	<i>Linaria repens</i>	Up to 80cm	Has pollen for bees and pollen beetles, <i>Brachypterus spp.</i> , in the flowers.	Grows on dry banks and stony ground over much of England and Wales.
Perforate St Johns Wort	<i>Hypericum perforatum</i>	20-50cm	Mid flowering, attracts bees, wasps and beetles. Beneficial for black redstarts.	Found on wastelands, dry stony ground, drought tolerant, robust plant
Red Campion	<i>Silene dioica</i>	30-80cm	The nectar of the flowers is utilised by bumblebees and butterflies, and several species of moth feed on the foliage	Grows in a variety of conditions but prefers to grow on damp, non-acid soils.
Red Clover	<i>Trifolium pratense</i>	20-60cm	Late flowering, attracts bumble bees, common carder bee, butterflies and weevils.	Low growing drought tolerant, hardy plant, low nutrient growth. A member of the legume family therefore nitrogen fixing and will increase the nutrient value of the substrate over time
Reflexed Stonecrop	<i>Sedum reflexum</i>	10cm	An excellent source of nectar for bees and butterflies	Low growing plant which grows in small bushes, spreading on the ground
Ribwort Plantain	<i>Plantago lanceolata</i>	10-40cm	Beneficial for black redstarts	Drought tolerant and very common on wasteland, brownfield sites and roadsides
Rough Hawkbit	<i>Leontodon hispidus</i>	20-50cm	Yellow flower attracts butterflies and bees	A slow-growing, rosette-forming perennial of dry, neutral or calcareous soils. Dislikes nutrient-rich soils.

Species Name	Latin Name	Height	Wildlife Benefit	Growth Conditions
Scented Mayweed	<i>Matricaria recutita</i>	15-50cm	This plant is a very good source of nectar for bees and flies. One small weevil, <i>Omphalapion hookeri</i> lives on the seedheads. Scented mayweed is highly attractive to ladybirds that feed on aphids	It thrives best on lighter soils but can grow on loams and heavy clays. Prefers full sun.
Self Heal	<i>Prunella vulgaris</i>	30-60cm	Mid flowering, good for bees. Beneficial for black redstarts	Prefers sun or semi-shade and some moisture but drought tolerant, low growing creeping plant.
Tunic Flower	<i>Petroraghia saxifraga</i>	10-15cm	Flowers attracts numerous butterfly and bee species.	Grows in sunny location in poor to moderately fertile soil, low water. Tolerates drought and neglect.
Viper's Bugloss	<i>Echium vulgare</i>	30-60cm	An important food source for species of bumblebee and butterflies.	Grows in dry, sunny position in well-drained or sandy soils.
White Clover	<i>Trifolium repens</i>	20cm	Late flowering, attracts, honey bee, bumble bees, weevils	Low growing, relatively drought tolerant, will not grow well in shade, low nutrient growth. A member of the legume family therefore nitrogen fixing and will increase the nutrient value of the substrate over time.
White Stonecrop	<i>Sedum album</i>	20cm	It provides nectar and pollen for bees including the buff-tailed bumble bee. Used as food plants by the larvae of some Lepidoptera species.	Grows well in a city environment. Is drought tolerant and prefers sunny positions.
Wild Basil	<i>Clinopodium vulgare</i>	30-70cm	Pollinated by bees and attractive to butterflies.	Very hardy plant and drought resistant.
Wild Marjoram	<i>Origanum vulgare</i>	30-60cm	Late flowering, attracts butterflies and bees	Drought resistant, low growing
Wild Mignonette	<i>Reseda lutea</i>	30-50cm	The green-yellow flowers are very attractive to bees.	Grows in waste, scrubby, disturbed soils that are well drained and in full sunlight.
Wild Pansy	<i>Viola tricolor</i>	Up to 40cm	Attractive to, and pollinated by, a variety of species of bee.	Prefers sandy substrates and partial shade.

Species Name	Latin Name	Height	Wildlife Benefit	Growth Conditions
Wild Thyme	<i>Thymus serpyllum</i>	2-10cm	It is an important nectar source plant for honeybees as well as the large blue butterfly which feeds exclusively on wild thyme	A hardy plant that thrives in full sun and often grows in pavement cracks. A low growing, creeping plant
Yarrow	<i>Achillea millefolium</i>	Up to 80cm	Attracts beneficial Syrphid flies.	Drought tolerant plant that prefers full sun and shallow, disturbed and nutrient poor soils.
Zigzag Clover	<i>Trifolium medium</i>	20-60cm	Attracts bumblebees and butterfly species.	Low growing drought tolerant, hardy plant, low nutrient growth. A member of the legume family therefore nitrogen fixing and will increase the nutrient value of the substrate over time
Mosses				
Springy Turf Moss	<i>Rhytidiadelphus squarrosus</i>	Up to 15cm		It tolerates a wide range of soils and colonises on man-made habitats.
Wall Screw Moss	<i>Tortula muralis</i>	5-10cm		Commonly found on stone and concrete areas.
Grey Cushion Moss	<i>Grimmia pulvinata</i>	2cm		Grows on rocks and concreted areas.

1.13 The seed mix list in Table 1.1 has been specified due to the wildflower's local provenance to the Camden and London area. The species are also commonly found on industrial, wasteland and brownfield sites in this region. We recommend if possible that the seed supplier has collected the seed from the London area from the wild and grown these on in their nursery to ensure a successful, viable seed that is capable of germination – many commercial seed suppliers do this routinely. It is important that this method of sourcing is used to lessen the risk of virus, low health and poor germination in flowers that may occur if the seed had been taken directly from the wild and planted straight onto the roof. The seed is carefully nurtured at the nursery to ensure a stable seed mix that is able to grow successfully without disease. The wildflower species will carry the same characteristics as those found growing wild in London, as the seed will have been originally sourced in this area and carefully grown to provide a healthy flower mixture.

- 1.14 To support the growth of the seed mix specified above, plug plants will be hand planted on each roof space. These will be established prior to the seed mix application and will be carefully chosen from the list above to provide balanced growth across the roof. Less vigorous plants such as the clovers and vetches will be plug planted so they are well established before stronger growing plants develop from the seed mix.
- 1.15 The plug plants will provide an immediate 'greening' of some parts of the roof but will not be planted all the way across as blanket coverage. If covering the entire roof area with plug plants these would need to be planted at a density of 20 plug plants per square metre (sqm). As it is important to allow space for the seed mix to develop it is determined that where both seeds and plug plants are used in combination, the plug plants will be planted at a density of only 5 plugs per sqm.
- 1.16 The hand planting of plug plants can be done all year round although it is best undertaken in autumn/winter, and planting is advised to be initiated before the seed mix is applied. Due to time constraints both the plug plants and seed mix are likely to be applied before this coming autumn. This will not significantly affect the rate of growth but there may be a greater number of plants that fail to establish and seeds that don't germinate successfully.
- 1.17 Another limitation to establishment may be loss of plug plants from seagulls eating them but the application advice of 5 plugs per sqm takes into account some loss of species and will be sufficient for the roof spaces.
- 1.18 The final number of plug plants will be determined when the seed mix is purchased - upon provision of sqm biodiverse roof space the seed supplier will determine the number of plug plants required according to the desired percentage of each species type.

Seed Application

- 1.19 As discussed above the plug plants will be manually installed into the prepared roof substrate to establish a mature plant layer in advance of the seed mix germinating. This can be done any time of the year although autumn/winter is preferable and the seed mix will be sown shortly after, as some of the seeds may require cold periods to germinate. Due to time constraints however, the mix will likely be sown before this time of year but some seeds that do not germinate as successfully due to the need for a cold snap – this can be overcome if the seeds are refrigerated for approximately two weeks before sowing (further advice will be sought from the seed supplier).
- 1.20 The seed mix will be sown by hand and will be applied with an appropriate, lightweight and dry seed carrier that will be low in nutrients. The use of a 'carrier' will not affect the overall nutrient level enough to dramatically change the overall growing conditions.

- 1.21 The seed carrier will be a different colour to the roof substrate and will act as a visual aid for seed application, highlighting areas that have been sown and areas that are still to complete, ensuring the application is level across all of the roof space. The seed carrier will consist of sand or perlite, and will encourage quicker germination with improved seedling growth. When the seed mix is purchased the amount of seed carrier suitable to the overall roof size and species will be specified and is usually provided as a percentage.
- 1.22 The seed mix will be applied by hand, and it is advised to aim for 1-2 grams of seed per sqm to provide good coverage across the roof for successful growth rates and good yields. When applying by hand the mix will be casted on to the roof over the prepared substrate in a measured and even fashion. Whilst this method is labour intensive it is successful to use, although practice may be required to sow evenly at a suitable rate.
- 1.23 All three mosses specified in Table 4.1 will be hand planted into shady crevices of the dead wood features such as the vertical log piles and the log and woodchip mounds.

Enhancement: Biodiverse Roof Enhancement Features

- 1.24 Maintaining the theme of diversity and variation, a range of additional ecological features have been specified for incorporation onto the living roof at the site to provide habitats suitable for invertebrates and further increase the range of micro niches and biodiversity. It is anticipated that these structural features will create micro climates around them that will also influence the floral establishment in the immediate proximity, leading to changes in floral composition and further increasing the diversity and mosaic of habitats across the roof areas.
- 1.25 There are no specific locations across the biodiverse roof for the placement of these enhancement features. Their placement will be informed by the description of where they are best placed assessed in terms of the final substrate topography. A suitably qualified ecologist will oversee the placement of these features and decide upon their location once the roof is finalised.

Invertebrate Sandy Piles

- 1.26 Bare ground is important for a range of insects which use open areas for nesting, chasing after prey and basking. Sandy piles provide warm, dry conditions that favour warmth-loving invertebrates and facilitate burrowing. Sandy piles should have open south-facing bare slopes to provide valuable nesting sites for colonies of burrowing solitary bees and wasps. It is essential that the sandy piles are regularly cleared to prevent any vegetation colonisation and ensure they remain clear.
- 1.27 Substrates such as gravel and sand will be taken from layers under the soil of the construction site or from a nearby area. The piles will be compacted to form a sand castle

effect, with sides angled to 30 degrees and cover an area of approximately 1m²; position in a sunny area with the broadest area facing south, preferably sheltered from the wind. Some of the sandy piles may change shape or decrease in size over time due to prolonged exposure to the wind, so to reduce this happening to all the piles and to increase diversity of the hibernacula, some of the piles will be covered with stones of approximately 10-15 cm in size loosely placed over the mound ensuring gaps are available for burrowing invertebrates^{Error!} **Bookmark not defined.** – the south facing slope will still remain relatively bare.

- 1.28 Three of these sandy piles will be included on the biodiverse roof at the site.

Invertebrate Habitat Walls

- 1.29 A habitat wall specifically designed to attract invertebrates will be included on the biodiverse roof (facing southwards where it will receive a high level of sunlight throughout the day, therefore enabling suitable conditions for bees to thrive. This feature will be approximately 1.5m high and 2m wide and will consist of warm, dry sheltered habitat which will be beneficial for mason bees, bumblebees, ladybirds, lacewings, beetles, centipedes, millipedes and ants as well as birds. The habitat within the wall will provide a variety of burrowing and nesting opportunities with recycled materials in different forms, for example, ventilation bricks, garden canes, guttering pipe, barks of broadleaved trees and wooden tubes stuffed with straw all with various size holes and openings; thus creating different sized spaces for invertebrates. An example of how the habitat wall for invertebrates can be designed is shown below.

Figure 1.2 **Example of Vertical Habitat Wall²**



Rope Coils

- 1.30 Rope coils are to be incorporated to create diverse hibernacula across the roof, encouraging a range of invertebrate species to burrow within the crevices produced. Rope made from natural fibres will be used such as Manila rope which is suitable for general outdoor use. Manila rope is made from the leaves of the plant *Musa Textilis* and will last up to 10 years, reducing maintenance requirements. The rope will be coiled in a spiral shape to cover an area of 1m²; the rope will be coiled loosely to ensure suitable gaps are created for invertebrates. Pegs will need to be used to harness the rope to the roof and ensure that it cannot blow away. Five rope coils will be incorporated in the design spread across the roof at the site.

Rocks & Stones

- 1.31 Several species of invertebrates favour warmth and shelter from wind and rain, therefore, shelter and sunny nooks are important to create across the roof. This can easily be done by using large rocks and stones positioned in circles or spirals to create a range of micro climates. Rocks and stones of varying size from 10cm to 40cm in diameter will be placed in circles and spirals ranging from 1m wide upwards; these will be widespread across the biodiverse roof and also provide beneficial visual effect, an example is shown in Figure 1.3.

Figure 1.3 **Stone swirl/circle**



Walls

- 1.32 Low level walls will have several beneficial effects, including diversification of micro climates by acting as wind breaks and creating areas of shelter and protection from the wind required

by invertebrates. Constructing S-shaped walls will offer the greatest diversity of microclimate and will create pockets of shade when located in open areas. This variation in micro climates will result in certain plant species colonising specific areas and producing the desired mosaic of habitats across the roof. Three walls will be placed across the biodiverse roof at the site. The walls will vary in height to a maximum of 1m and be approx 3m in length, constructed of natural stone such as limestone or sandstone, a single stone width wide, and bonded with lime mortar.

Bird Perches

- 1.33 Two bird perches comprising at least 2m high metal poles (approx. 30mm diameter – see **Error! Reference source not found.**) are to be attached to each wall; these are intended to be of particular benefit to black redstarts who like to sing from prominent and exposed perches see below.

¹ Buglife (2012), Creating Green Roofs for invertebrates: A Best practice guide.

² <http://greenroofshelters.co.uk/2011/02/habitat-walls-bee-hotels-for-green-roofs/>

(Greengage do not specifically endorse this product).