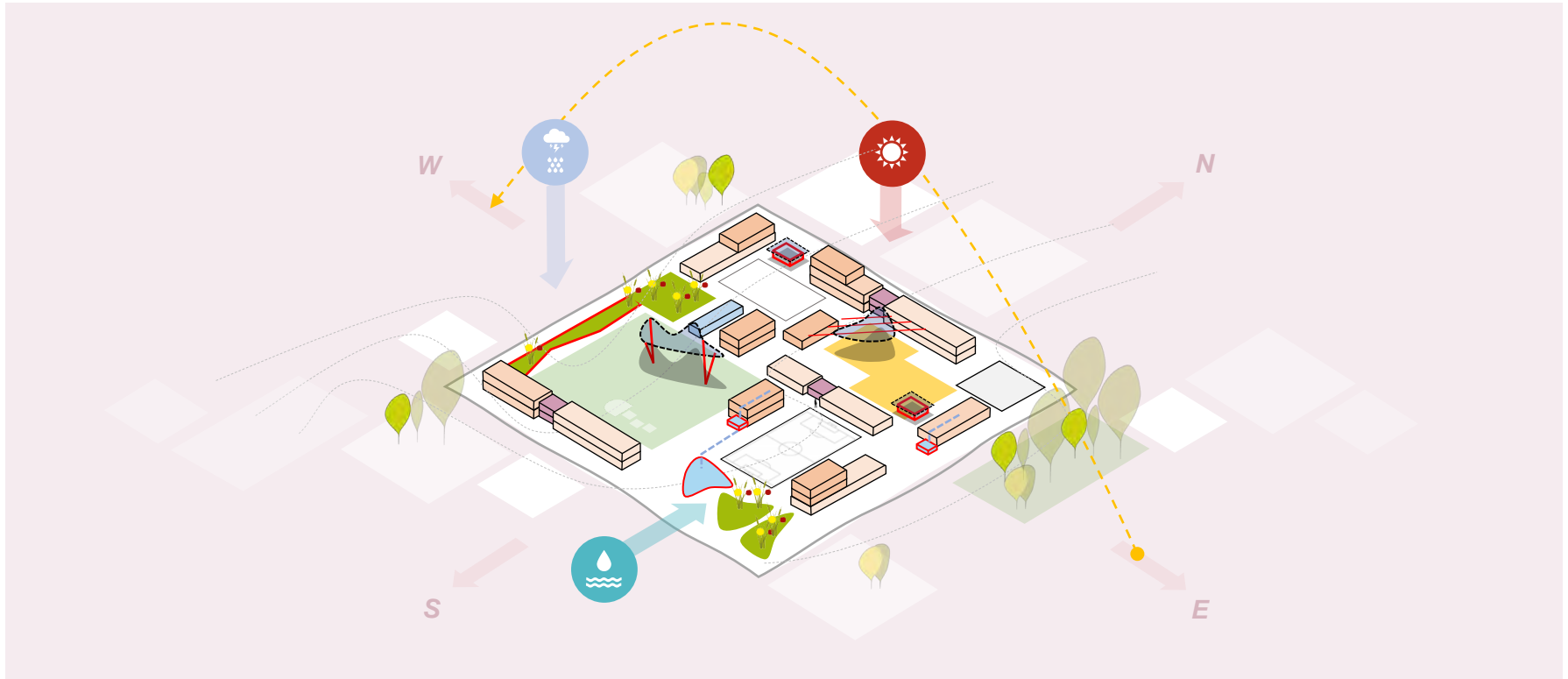


# MAYOR OF LONDON



## Compendium of adaptation and resilience measures for schools

April 2023

# Introduction

## Compendium of adaptation and resilience measures for schools

To inform and add value to the GLA Climate Adaptation Plans (CAPs) for Schools project, Arup has developed a 'Compendium of adaptation and resilience measures for schools'.

The Compendium sets out five categories of physical climate change adaptation and resilience measures relevant to schools in London, which can help to address the three main climate change impacts and risks of overheating, flooding and water scarcity.

Physical climate change adaptation and resilience measures are measures which relate to the form and function of school buildings and school grounds, and require a combination of capital funding, professional technical expertise, and time to install.

Measures have been included in the Compendium informed by the following criteria:

- a presumption in favour of passive design, nature-based solutions, and adherence to the 'cooling hierarchy';
- provides a significant reduction in climate change risk, addresses more than one climate change risk and has other environmental, social and economic co-benefits;
- makes a positive difference to educational outcomes, inequalities, and the health, safety and wellbeing of students, staff and families; and
- would be cost effective, represent value for money, and minimise disruption on site during the academic year.

Indicative capital cost ranges have been provided for all measures, along with consideration of installation and maintenance requirements. It should be noted that the full costs of professional fees required to plan, design and install bespoke versions of measures at each school have not been included.

The five categories within the Compendium are listed below and contain **41 physical measures** in total.

These categories and measures have been developed from existing good practice technical guidance and an understanding of the most relevant measures for schools based on the site surveys.

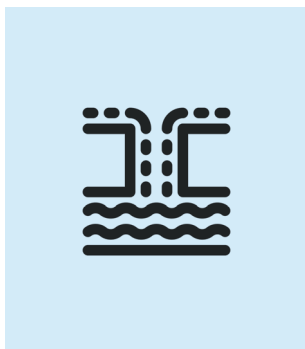
- **Sustainable Drainage Systems (SuDS)** measures: 10 measures
- **Hard flood resilience** measures: 6 measures
- **Ventilation and cooling** measures: 12 measures
- **Solar shading** measures: 11 measures
- **Water efficiency** measures: 2 measures

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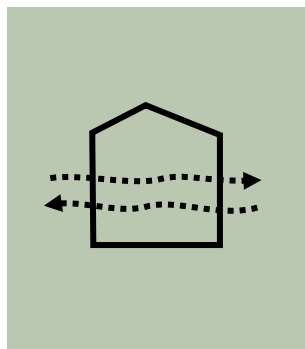
## Compendium of adaptation and resilience measures for schools



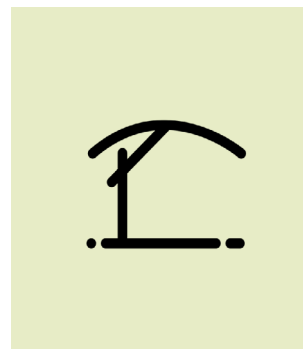
**Section A**  
Sustainable  
Drainage Systems  
(SuDS) measures



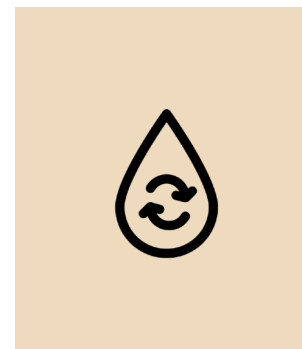
**Section B**  
Hard flood  
resilience measures



**Section C**  
Ventilation and  
cooling measures



**Section D**  
Solar shading  
measures



**Section E**  
Water efficiency  
measures



Sustainable Drainage  
(SuDS) measures

## **A.** Sustainable Drainage (SuDS) measures

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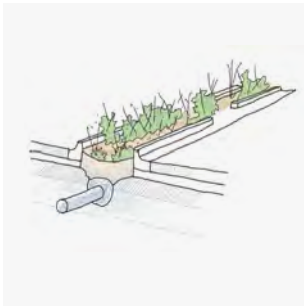
Compendium of adaptation and resilience measures for schools

# A. SuDS measures

## Index of SuDS measures



Sustainable Drainage (SuDS) measures



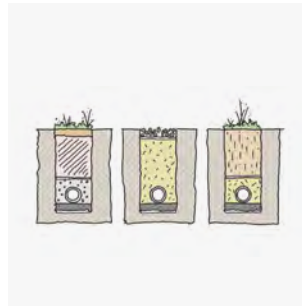
**A.1**  
Rain garden: linear



**A.2**  
Rain garden: non-linear



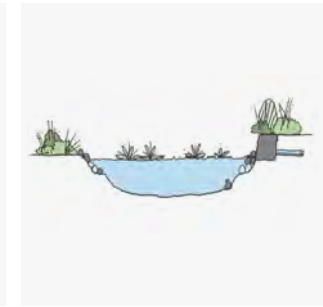
**A.3**  
Swale



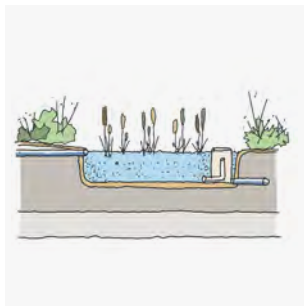
**A.4**  
Filter drain



**A.5**  
Detention basin



**A.6**  
Pond



**A.7**  
Wetland



**A.8**  
Permeable surface:  
grass



**A.9**  
Permeable surface:  
woodchip



**A.10**  
SuDS rain planters

# A. SuDS measures

## Descriptions of SuDS measures

### A.1

#### Rain garden: linear



### A.2

#### Rain garden: non-linear

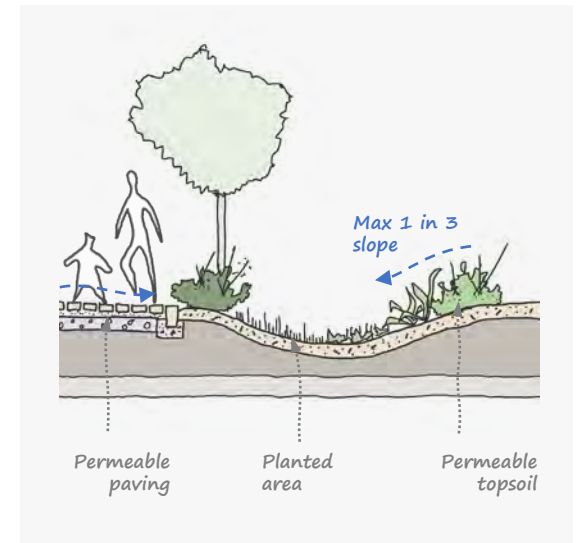
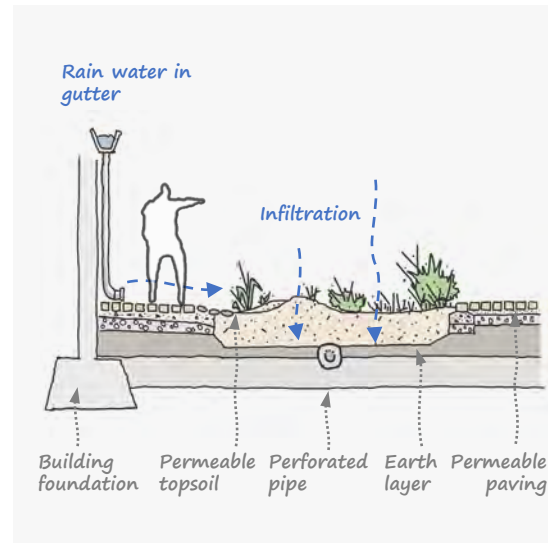
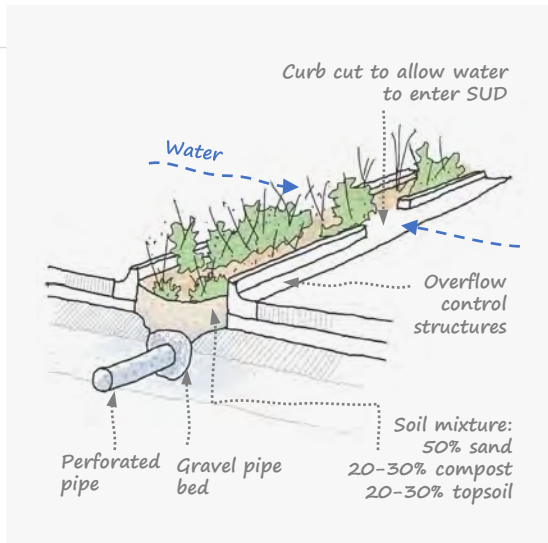


### A.3

#### Swale



### Illustrative sketch of measure



Note:  
Sketches and reference  
images for illustrative  
purposes only

### Description of measure

Planted linear areas in shallow depressions, with well-draining and engineered soil to encourage infiltration. They help remove pollution as well as reduce surface runoff to reduce the risk of exceeding drainage capacities and causing flooding.

Note:  
Generic description of  
measure

Rain gardens are shallow landscaped depressions that are designed to capture runoff from school roofs or hard surfaces. They can be planted with a wide range of low-maintenance plants that can survive occasional storms or heavy rainfall.

A swale is a shallow ditch with a flat base and gently sloping sides, that can store, transport and absorb runoff, and can be vegetated with grass or other plants. They are best located in areas of schools site that aren't frequently used.

# A. SuDS measures

## Costs of SuDS measures

Indicative cost of measure

### A.1

#### Rain garden: linear



##### Climate risks addressed

Flood, heat risk

##### Maintenance requirements

Regular, annual and annual maintenance required - please refer to [CIRIA SuDS Manual \(C753F\)](#)

##### Co-benefits

Biodiversity, carbon savings and educational opportunities

##### Indicative capital cost range

£60/m<sup>2</sup> - £120/m<sup>2</sup>

##### Cost assumptions

Costs include for breaking out hard surfaces and making good edging, forming a depression circa 1m deep with an area of circa 25m<sup>2</sup>: 3m wide by 8m long. Includes all excavation and materials to form new surfaces. Costs include sand layer and filter media layer, as well as soil, seeding and planting and all associated labour. Excludes drainage connections. Costs include for contractor preliminaries, overheads and profit, and risk.

### A.2

#### Rain garden: non-linear



##### Climate risks addressed

Heat and flooding

##### Maintenance requirements

Regular, annual and annual maintenance required - please refer to [CIRIA SuDS Manual \(C753F\)](#)

##### Co-benefits

Biodiversity and educational opportunities

##### Indicative capital cost range

£30/m<sup>2</sup>- £60/m<sup>2</sup>

##### Cost assumptions

Costs include for breaking out and removing from site existing hard surfaces, reducing levels and preparing ground for gardening. It is assumed 100m<sup>2</sup> for cost purposes. Includes for forming depression, soil and planting. Includes for interface / edging with adjacent hard and/or soft surfaces. Costs include for contractor preliminaries, overheads and profit, and risk.

### A.3

#### Swale



##### Climate risks addressed

Heat and flooding

##### Maintenance requirements

Regular, annual and annual maintenance required - please refer to [CIRIA SuDS Manual \(C753F\)](#)

##### Co-benefits

Biodiversity

##### Indicative capital cost range

£1,100/m<sup>2</sup> - £2,100/m<sup>2</sup>

##### Cost assumptions

Costs include for breaking out hard surfaces and making good edging, forming a depression circa 1m deep with an area of circa 25m<sup>2</sup>: 3m wide by 8m long. Includes all excavation and materials to form new surfaces. Costs include soil, seeding and planting and all associated labour. Excludes drainage connections. Costs include for contractor preliminaries, overheads and profit, and risk.

Note:  
Cost reference for  
indicative purposes only

# A. SuDS measures

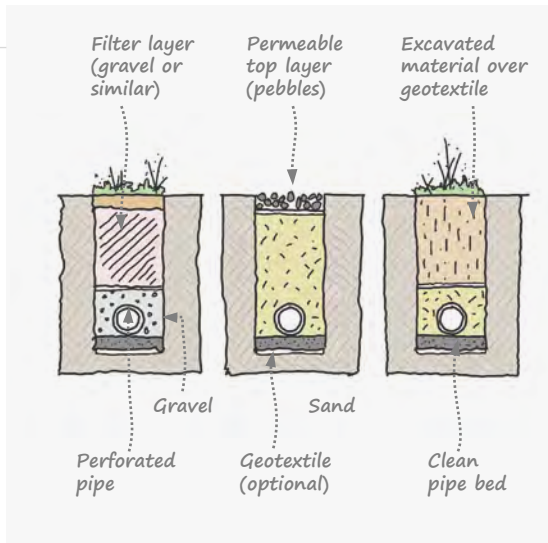
## Descriptions of SuDS measures

### A.4

#### Filter drain



#### Illustrative sketch of measure



Note: Sketches and reference images for illustrative purposes only

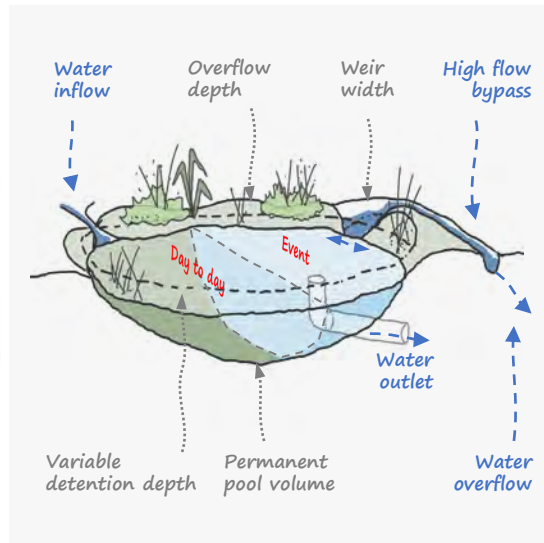
#### Description of measure

Filter drains are stone-filled trenches with perforated pipes that collect runoff from impermeable surfaces like playgrounds, directing flow away into the ground. They can also help drain groundwater, enabling runoff to soak into the ground.

Note: Generic description of measure

### A.5

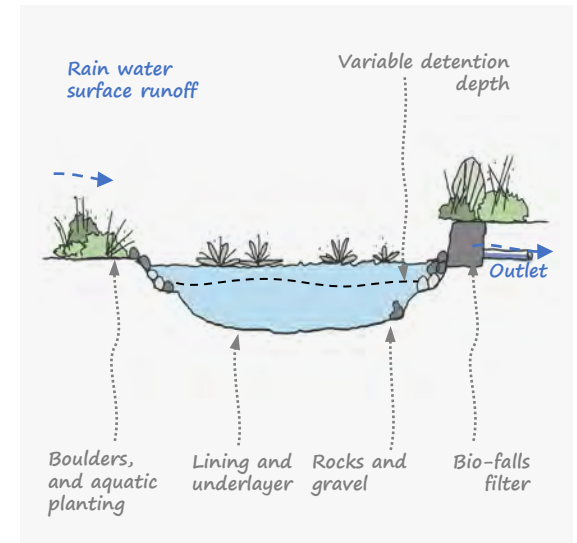
#### Detention basin



Basins, or detention basins, are typically shallow depressions, covered with amenity or meadow grass. Basins capture water and allow it to soak into the ground where possible, slowing the flow of runoff. Basins can receive swales' carrying water.

### A.6

#### Pond



Ponds can reduce flood risk by storing and attenuating surface runoff, and can help to regulate local temperature and reduce the urban heat island effect. Before entering the pond, runoff should pass through other SuDS features to clean it.



# A. SuDS measures

## Costs of SuDS measures

Indicative cost of measure

### A.4

#### Filter drain



##### Climate risks addressed

Flooding

##### Maintenance requirements

Regular, bi-annual and annual maintenance required - please refer to [CIRIA SuDS Manual \(C753F\)](#)

##### Co-benefits

n/a

##### Indicative capital cost range

£4,000 - £7,800

##### Cost assumptions

Costs includes for breaking out and removing from site existing hard surfaces, reduce levels and prepare ground for forming trench. Excavate trench; circa 8m long x 1m wide x 3m deep, machine dig, and remove materials. Supply and lay perforated clay pipe on base and backfill with filter (crushed stone) material. Costs include for contractor preliminaries, overheads and profit, and risk.

### A.5

#### Detention basin



##### Climate risks addressed

Heat and flooding

##### Maintenance requirements

Regular, bi-annual and annual maintenance required - please refer to [CIRIA SuDS Manual \(C753F\)](#)

##### Co-benefits

Biodiversity

##### Indicative capital cost range

£1,100/m<sup>2</sup> - £2,100/m<sup>2</sup>

##### Cost assumptions

Costs include for breaking out hard surfaces and making good edging, forming a depression circa 1m deep with an area of circa 25m<sup>2</sup>: 3m wide by 8m long. Includes all excavation and materials to form new surfaces. Costs include soil, seeding and planting and all associated labour. Excludes drainage connections. Costs include for contractor preliminaries, overheads and profit, and risk.

### A.6

#### Pond



##### Climate risks addressed

Heat and flooding

##### Maintenance requirements

Regular, bi-annual and annual maintenance required - please refer to [CIRIA SuDS Manual](#)

##### Co-benefits

Biodiversity and educational opportunities

##### Indicative capital cost range

£2,700 - £6,000

##### Cost assumptions

Costs include for forming a small pond / lake circa 25m<sup>2</sup>, including all excavation and materials to form new surfaces. Costs include aquatic plants and all associated labour. Costs include for contractor preliminaries, overheads and profit, and risk.

Note:  
Cost reference for  
indicative purposes only

# A. SuDS measures

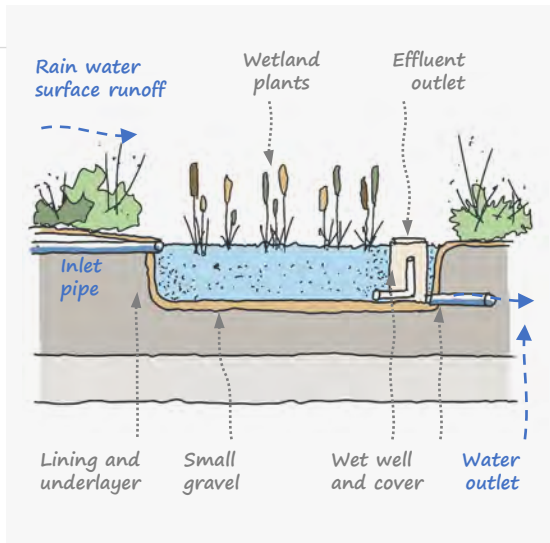
## Descriptions of SuDS measures

### A.7

#### Wetland



#### Illustrative sketch of measure



Note:  
Sketches and reference  
images for illustrative  
purposes only

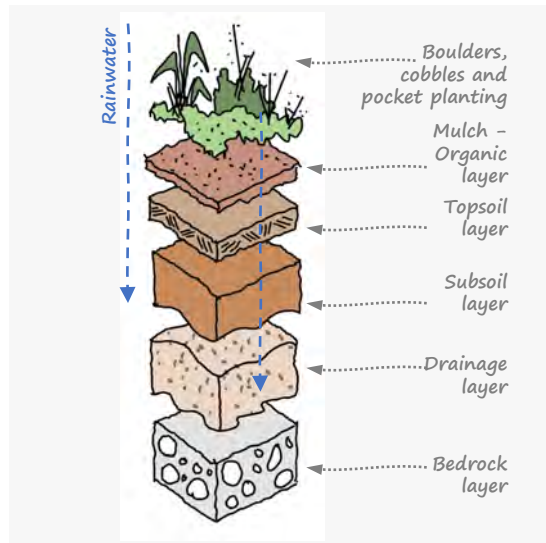
#### Description of measure

Wetlands are comprised of shallow ponds and marshy areas, and are covered almost entirely in aquatic vegetation. They hold water, allow sediments to settle and provide flood protection on school sites. They also help regulate local temperatures.

Note:  
Generic description of  
measure

### A.8

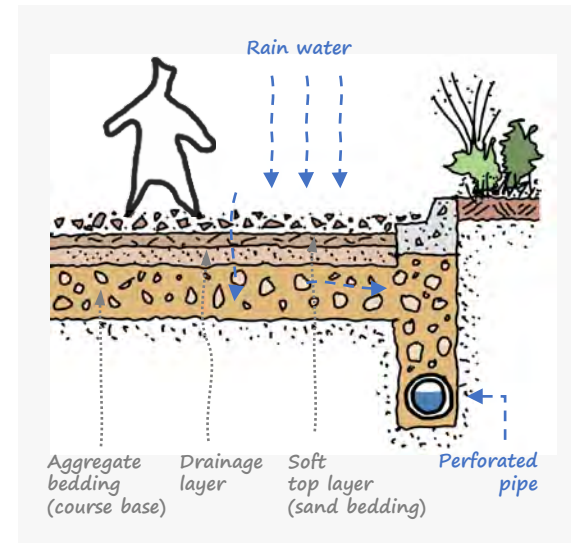
#### Permeable surface: grass



If replacing or upgrading existing hard impermeable surfaces like playgrounds, consider whether these can be planted (i.e. using hard-wearing grasses) as this will deliver wider cooling (and other) benefits.

### A.9

#### Permeable surface: woodchip



Permeable surfaces are made of materials that are impervious to water but allow infiltration. Wood chip is a good choice of permeable surface for schools. It is a natural, biodegradable material, which is cheap to source, install and maintain

# A. SuDS measures

## Costs of SuDS measures

Indicative cost of measure

### A.7

#### Wetland



##### Climate risks addressed

Heat and flooding

##### Maintenance requirements

Regular, bi-annual and annual maintenance required - please refer to [CIRIA SuDS Manual](#)

##### Co-benefits

Biodiversity, air quality, carbon savings and educational opportunities

##### Indicative capital cost range

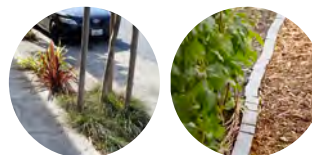
£1,600 - £3,100

##### Cost assumptions

Costs include for breaking out hard surfaces and making good edging, forming a depression circa 1m deep with an area of circa 25m<sup>2</sup>: 3m wide by 8m long. Includes all excavation and materials to form new surfaces. Costs include soil, seeding and aquatic planting and all associated labour. Excludes drainage connections. Costs include for contractor preliminaries, overheads and profit, and risk.

### A.8

#### Permeable surface: grass



##### Climate risks addressed

Heat and flooding

##### Maintenance requirements

Regular, bi-annual and annual maintenance required - please refer to [CIRIA SuDS Manual](#)

##### Co-benefits

n/a

##### Indicative capital cost range

£36/m<sup>2</sup> - £68/m<sup>2</sup>

##### Cost assumptions

Costs include for breaking out hard surfaces and making good edging, clearing and levelling area of circa 25m<sup>2</sup>: Costs include soil, seeding and planting and all associated labour. Excludes drainage connections. Costs include for contractor preliminaries, overheads and profit, and risk.

### A.9

#### Permeable surface: woodchip



##### Climate risks addressed

Flooding

##### Maintenance requirements

Regular, annual and annual maintenance required - please refer to [CIRIA SuDS Manual \(C753F\)](#)

##### Co-benefits

n/a

##### Indicative capital cost range

£70/m<sup>2</sup> - £140/m<sup>2</sup>

##### Cost assumptions

Costs includes for breaking out and removing from site existing hard surfaces, reduce levels and prepare ground for subbase and new woodchip surface course. Assumed 100m<sup>2</sup> for cost purposes. Includes for interface / edging with adjacent hard and/or soft surfaces. Costs include for contractor preliminaries, overheads and profit, and risk.

Note:  
Cost reference for  
indicative purposes only

# A. SuDS measures

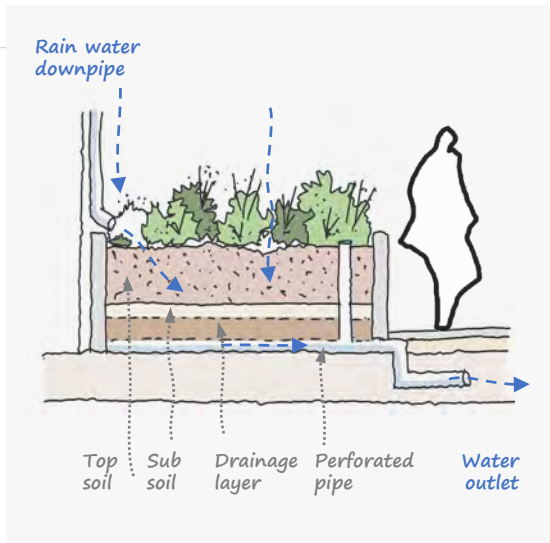
## Descriptions of SDS measures

### A.10

### SuDS rain planters



#### Illustrative sketch of measure



Note:  
Sketches and reference  
images for illustrative  
purposes only

#### Description of measure

Planters are located next to school buildings, connected to downpipes so rainwater can be collected, stored and used by the plants and various gravel and soil layers. Plant types should be chosen based on planter location and shade levels.

Note:  
Generic description of  
measure

# A. SuDS measures

## Costs of SuDS measures

### A.10

#### SuDS rain planters



#### Indicative cost of measure

##### Climate risks addressed

Flooding and heat

##### Maintenance requirements

Regular, annual and annual maintenance required - please refer to [CIRIA SuDS Manual \(C753F\)](#)

##### Co-benefits

Biodiversity, carbon savings and educational opportunities

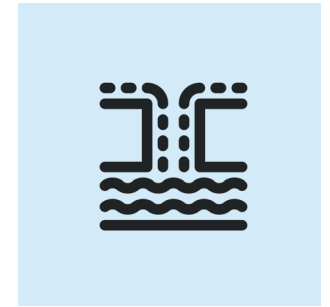
##### Indicative capital cost range

£2,000 - £4,500

##### Cost assumptions

Costs include for a single 1,000mm x 650mm x 900mm planter, SuDS compliant. Costs include the supply and installation of a SuDS planter positioned on hardstanding, with existing rainwater disposal pipework adjusted to re-direct flow through the planter. Includes for soil, gravel, plants and shrubs and the like, filling the planter. Includes for contractor preliminaries, overheads and profit, and risk.

Note:  
Cost reference for  
indicative purposes only



Hard flood resilience  
measures

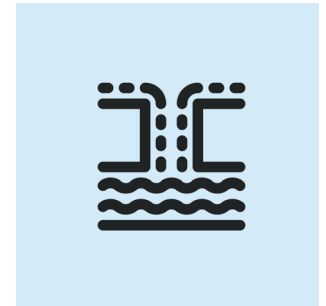
## **B.** Hard flood resilience measures

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**Compendium of adaptation and resilience measures for schools**

# B. Hard flood resilience measures

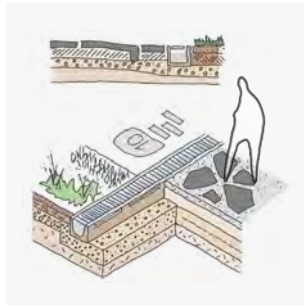
## Index of hard flood resilience measures



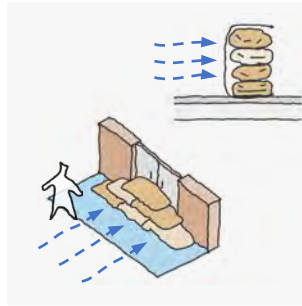
Hard flood resilience measures



**B.1**  
Permeable surface: hard



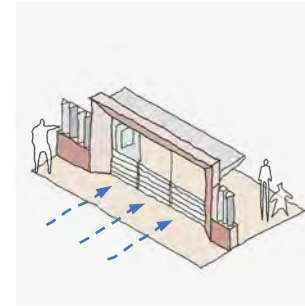
**B.2**  
Channel drains



**B.3**  
Sandbags



**B.4**  
Below ground  
attenuation tank



**B.5**  
Flood door barrier



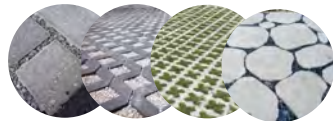
**B.6**  
Waterproof  
canopy

# B. Hard flood resilience measures

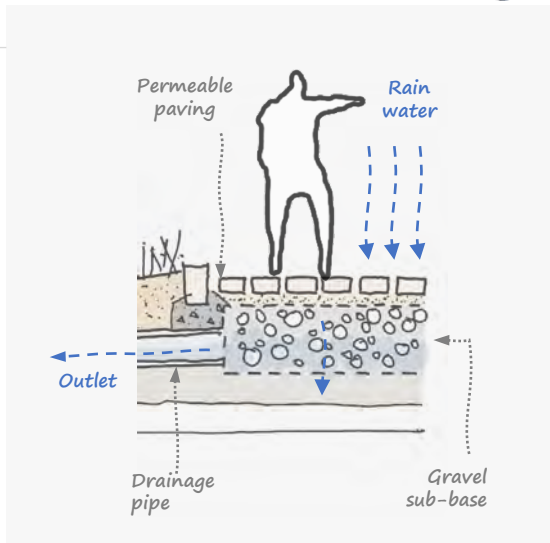
## Descriptions of hard flood resilience measures

### B.1

#### Permeable surface: hard



#### Illustrative sketch of measure



Note:  
Sketches and reference  
images for illustrative  
purposes only

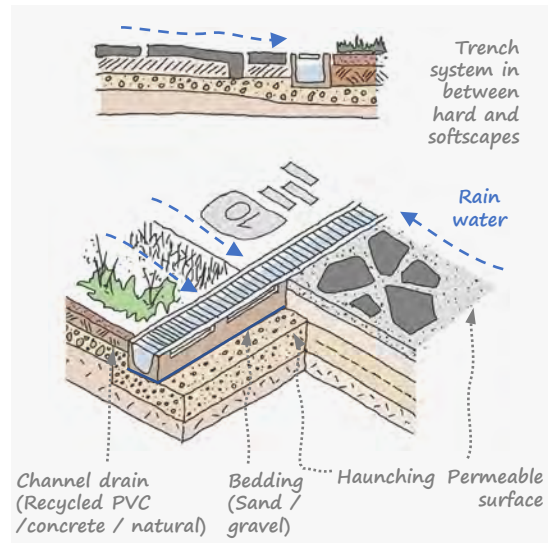
#### Description of measure

Using permeable materials e.g. grasscrete, permeable tarmac or 3G astroturf, to replace impermeable surfaces e.g. tarmac, allows rain to infiltrate reducing runoff that causes surface water flooding. Can be used for play, sports and parking areas.

Note:  
Generic description of  
measure

### B.2

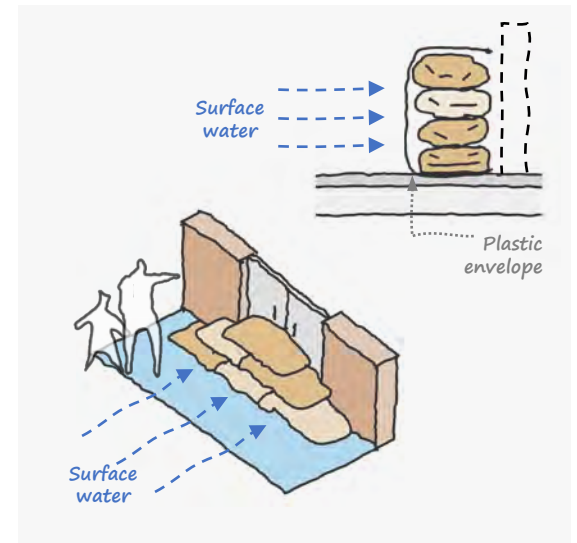
#### Channel drains



Channel drains catch, collect and convey surface water away from hard surfaced areas like playgrounds or school car parks into the main drainage system. They are typically made of concrete, metal and plastic components.

### B.3

#### Sand bags



Sand bags are used to absorb and act as a barrier to flood water. Typically made of hessian and sand, lightweight alternatives are made from woven polypropylene filled with a gel. Both types are effective, and can be dried out and re-used.

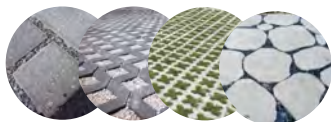


# B. Hard flood resilience measures

## Costs of hard flood resilience measures

### B.1

**Permeable surface: hard**



#### Climate risks addressed

Flooding

#### Maintenance requirements

Regular, annual and annual maintenance required - please refer to [CIRIA SuDS Manual \(C753F\)](#)

#### Co-benefits

n/a

#### Indicative capital cost range

£140/m<sup>2</sup> - £290/m<sup>2</sup>

#### Cost assumptions

Costs includes for breaking out and removing from site existing hard surfaces, reduce levels and prepare ground for new permeable surface; grasscrete and resin bound permeable materials. Assumed 100m<sup>2</sup> for cost purposes. Includes for interface / edging with adjacent hard and/or soft surfaces. Costs include for contractor preliminaries, overheads and profit, and risk.

### B.2

**Channel drains**



#### Climate risks addressed

Flooding

#### Maintenance requirements

Ad-hoc clearance if experiencing blockages

#### Co-benefits

n/a

#### Indicative capital cost range

£250/m - £488/m

#### Cost assumptions

Costs includes for breaking out and removing from site existing hard surfaces, reduce levels and prepare ground for forming trench. Excavate trench; circa 8m long x 0.1m wide x less than 0.3m deep, hand dig, and remove materials. Supply and lay concrete base and brick slot drainage products (metal) and backfill. Costs include for contractor preliminaries, overheads and profit, and risk.

### B.3

**Sand bags**



#### Climate risks addressed

Flooding

#### Maintenance requirements

Need to be stored in a dry place

#### Co-benefits

n/a

#### Indicative capital cost range

£50 - £100

#### Cost assumptions

Costs include for the supply and installation of sandbags for flood defences. Assumed heavy duty re-useable woven polypropylene sandbags (long lasting); single and double. Costs include for contractor preliminaries, overheads and profit, and risk. Note: cost per door.

Indicative cost of measure

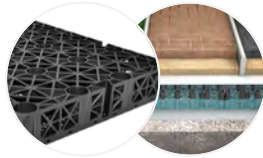
Note:  
Cost reference for  
indicative purposes only

# B. Hard flood resilience measures

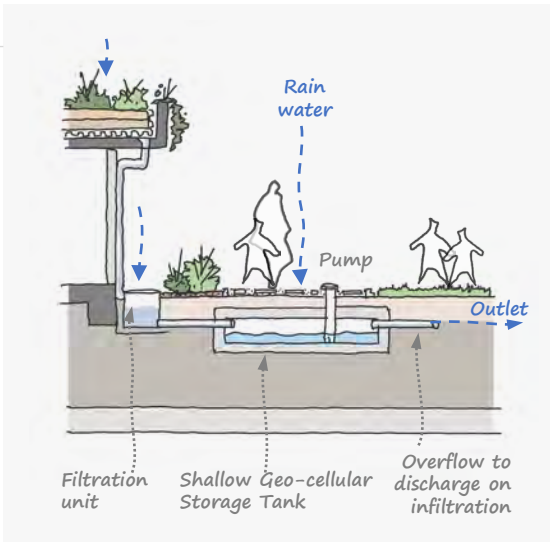
## Descriptions of hard flood resilience measures

### B.4

#### Below ground attenuation tank



#### Illustrative sketch of measure



Note:  
Sketches and reference  
images for illustrative  
purposes only

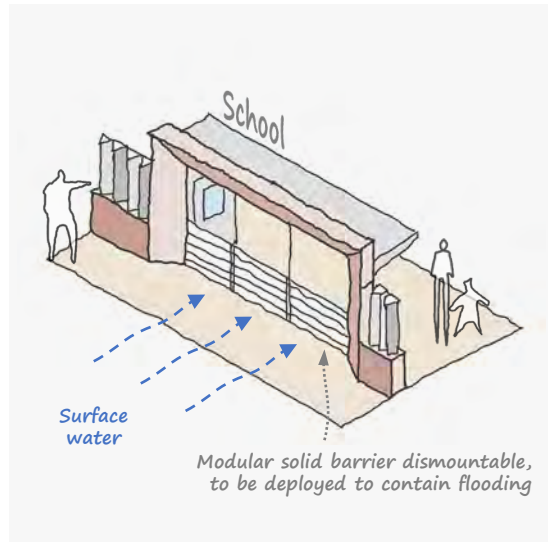
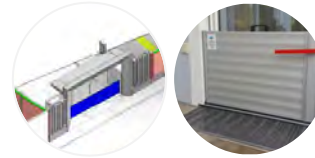
#### Description of measure

Attenuation tanks can reduce schools' surface water flood risk by storing excess rainwater and slowly releasing it to the drainage system. They can receive water directly through drainage systems or via networks of SuDS measures.

Note:  
Generic description of  
measure

### B.5

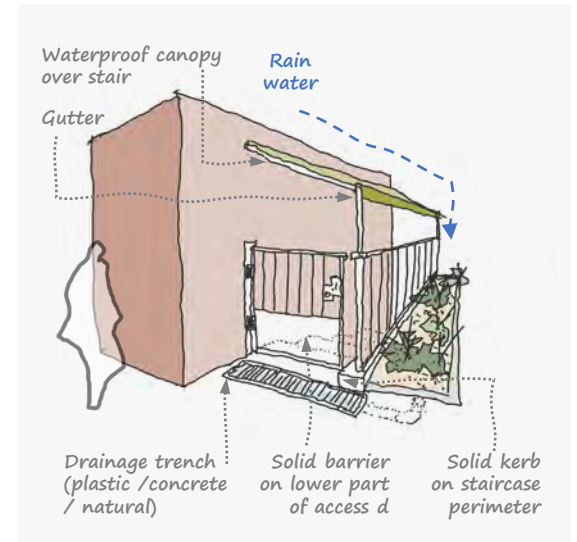
#### Flood door barrier



Door barriers are temporary flood defences that can be deployed to external doors on school sites where surface water flooding tends to occur. These can help avoid internal flooding of classrooms, corridors and other school rooms.

### B.6

#### Waterproof canopy



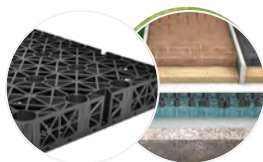
A waterproof structure that reduces rainfall directly beneath the canopy while also providing shade. These can be strategically mounted so runoff is directed to a preferable location (e.g. away from a building, towards a planted area).

# B. Hard flood resilience measures

## Costs of hard flood resilience measures

### B.4

#### Below ground attenuation tank



##### Climate risks addressed

Flooding

##### Maintenance requirements

Specialist

##### Co-benefits

n/a

##### Indicative capital cost range

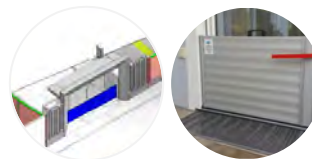
£6,000 - £13,500

##### Cost assumptions

Assumes rainwater tank is to be installed below ground and includes for site clearance, excavation and backfill. Assumes the tank will have a circa 4,500 litres capacity and requires connections to the existing rainwater disposal installation. Costs include for pipework, filters and connections and the like. Costs include for contractor preliminaries, overheads and profit, and risk.

### B.5

#### Flood door barrier



##### Climate risks addressed

Flooding

##### Maintenance requirements

Limited

##### Co-benefits

Educational opportunities

##### Indicative capital cost range

£400 - £900

##### Cost assumptions

Costs include for the supply and installation of door barriers for flood defences. Assumed and metal / resin composite material flood board mounted in a fixed frame mechanically attached to a door frame; single and double. Manually operated. Costs include for contractor preliminaries, overheads and profit, and risk. Note: cost per door.

### B.6

#### Waterproof canopy



##### Climate risks addressed

Heat and flooding

##### Maintenance requirements

Annual cleaning of canopy

##### Co-benefits

n/a

##### Indicative capital cost range

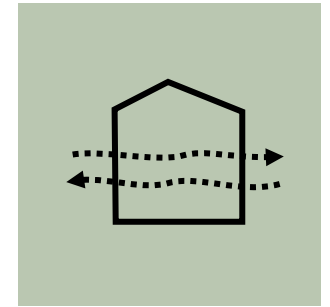
£1,800 - £3,500

##### Cost assumptions

Costs include for removing obstructions to staircase / wall immediately surrounding surfaces to facilitate the installation of external shading. It is assumed that no works are required to staircase(s). Supply and install externally mounted; elevation mounted and ground supported waterproof canopy; circa 2.5m-3.0m long by 2.0m-2.5m deep, metal frame and solid roof covering. Costs include for access equipment externally only. Costs do not include for any drainage or SuDS works. Costs include for contractor preliminaries, overheads and profit, and risk. Note: rate is a single product.

Indicative cost of measure

Note:  
Cost reference for  
indicative purposes only



Ventilation and cooling measures

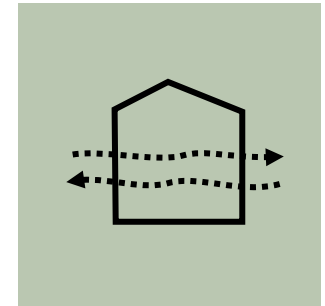
## C. Ventilation and cooling measures

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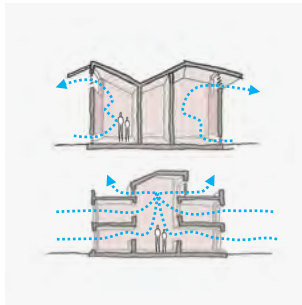
Compendium of adaptation and resilience measures for schools

# C. Ventilation and cooling measures

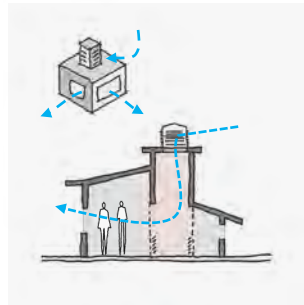
## Index of ventilation and cooling measures



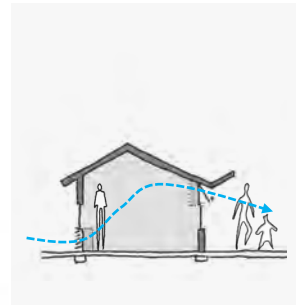
Ventilation and cooling measures



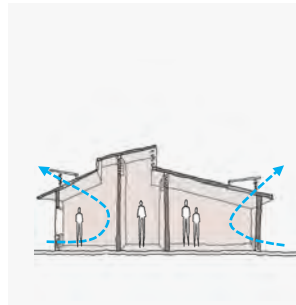
**C.1**  
Natural ventilation:  
stack



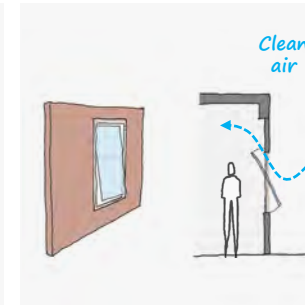
**C.2**  
Natural ventilation:  
wind catchers



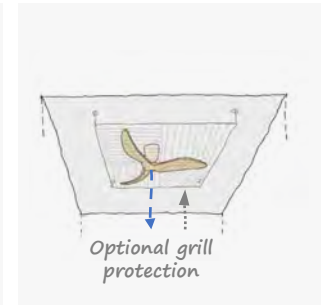
**C.3**  
Natural ventilation:  
grill vents



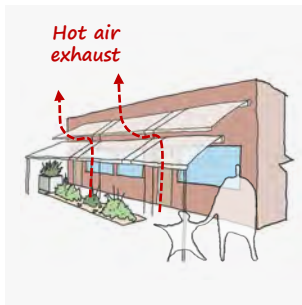
**C.4**  
Natural ventilation:  
skylights



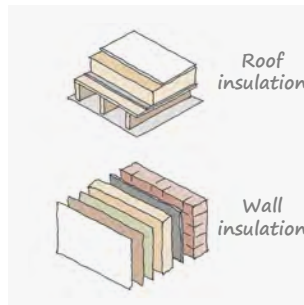
**C.5**  
Natural ventilation:  
openable windows



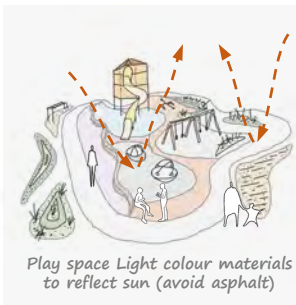
**C.6**  
Natural ventilation:  
ceiling fans



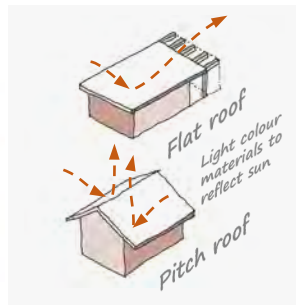
**C.7**  
Ventilate weatherproof  
awnings



**C.8**  
Insulation: walls and  
roofs



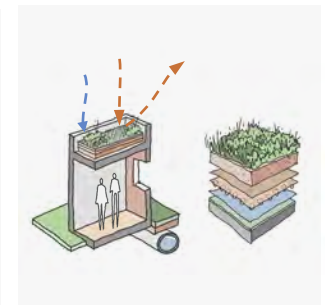
**C.9**  
Cool surfaces



**C.10**  
Cool roof



**C.11**  
Planted beds



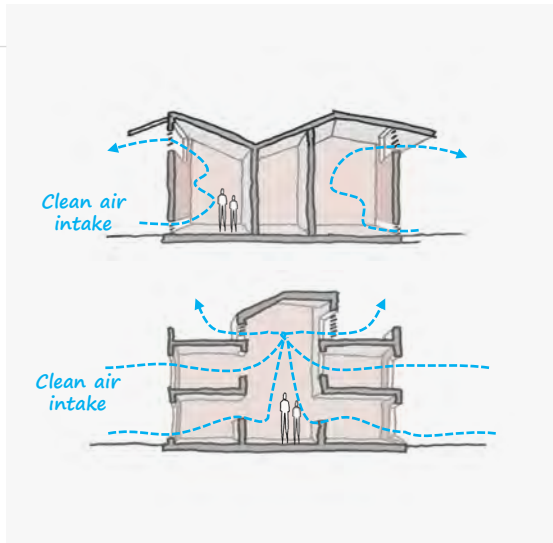
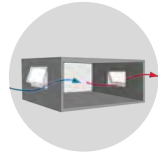
**C.12**  
Green roof

# C. Ventilation and cooling measures

## Descriptions of ventilation and cooling measures

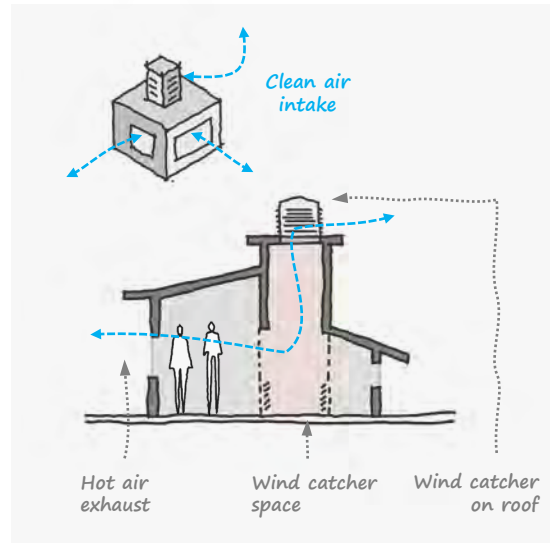
### C.1

#### Natural ventilation: stack



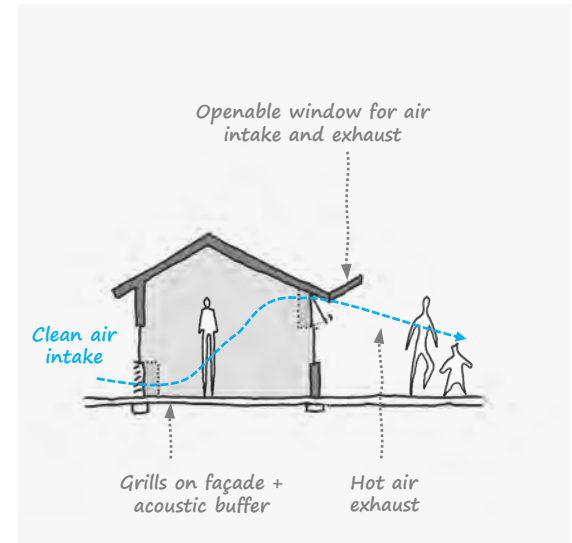
### C.2

#### Natural ventilation: wind catchers



### C.3

#### Natural ventilation: grill vents



Illustrative sketch of adaptation measure

Note: Drawings and reference image for illustrative purpose only

Description of measure

Note: Generic description of measure

Natural stack ventilation uses extract vents in warm areas to suck the air out via outlet vents. These tend to be installed on roofs, with warm air escaping to encourage cooler air to enter on lower floors. This improves airflow and thermal comfort.

Windcatchers harness wind blowing in any direction for ventilation. They are effective and energy-efficient for indoor cooling and avoid night security risks - important for temperature regulation, particularly in warm or well-insulated buildings.

Small vents that can increase air flow into and out of classrooms or other internal rooms to reduce thermal discomfort. Noise-proof vents are also available to reduce noise travelling into classrooms.

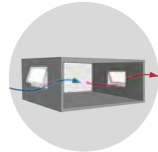
# C. Ventilation and cooling measures

## Costs of ventilation and cooling measures

Indicative cost of measure

### C.1

#### Natural ventilation: stack



##### Climate risks addressed

Heat

##### Maintenance requirements

Specialist - cleaning once a year

##### Co-benefits

Energy bills savings and improved air quality

##### Indicative capital cost range

£4,300 - £8,400

##### Cost assumptions

Costs include the supply, delivery and installation of a ventilation turret, at roof level (assumed flat roof), to offer single storey / upper floor rooms natural ventilation. Includes for forming opening in roof structure and installation of roof mounted turret, ductwork, automatic air flow damper and internal facing grille. Costs for a single unit. An allowance for access to the roof space and edge protection included. Costs include for contractor preliminaries, overheads and profit, and risk.

### C.2

#### Natural ventilation: wind catchers



##### Climate risks addressed

Heat

##### Maintenance requirements

Specialist - recommended annual service

##### Co-benefits

n/a

##### Indicative capital cost range

£4,300 - £8,400

##### Cost assumptions

Costs include the supply, delivery and installation of a ventilation turret, at roof level (assumed flat roof), to offer single storey / upper floor rooms natural ventilation. Includes for forming opening in roof structure and installation of roof mounted turret, ductwork, automatic air flow damper and internal facing grille. Costs for a single unit. An allowance for access to the roof space and edge protection included. Costs include for contractor preliminaries, overheads and profit, and risk.

### C.3

#### Natural ventilation: grill vents



##### Climate risks addressed

Heat

##### Maintenance requirements

Monthly clean of vents to prevent dust build-up

##### Co-benefits

Improved air quality

##### Indicative capital cost range

£600 - £1,300

##### Cost assumptions

Costs include the supply, delivery and installation of a single ventilation grill, wall mounted (high level). Includes for forming opening in wall structure and installation of wall mounted grille. Costs for a single unit. An allowance for mobile access equipment to the wall space. Costs include for contractor preliminaries, overheads and profit, and risk.

Note:  
Cost reference for  
indicative purposes only

# C. Ventilation and cooling measures

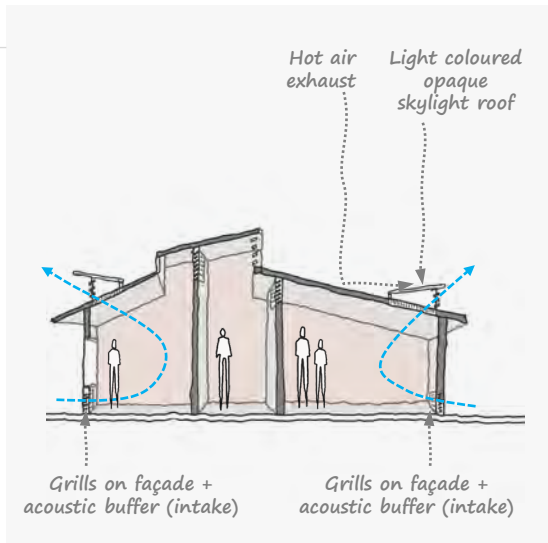
## Descriptions of ventilation and cooling measures

### C.4

#### Natural ventilation: skylights



Illustrative sketch of measure



Note: Sketches and reference images for illustrative purposes only

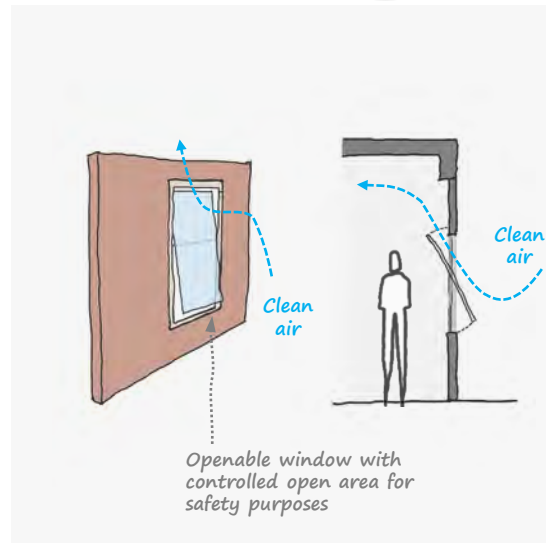
Description of measure

A skylight (sometimes called a rooflight) is a light-permitting structure or window, usually made of transparent or translucent glass, that forms all or part of the roof space of a building for daylighting and ventilation purposes.

Note: Generic description of measure

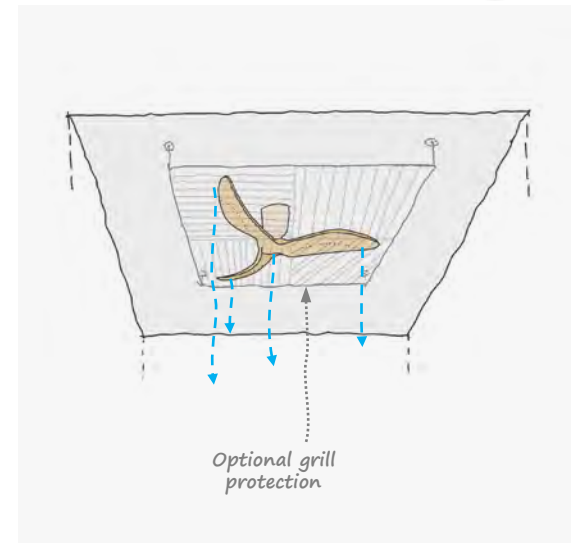
### C.5

#### Natural ventilation: openable windows



### C.6

#### Natural ventilation: ceiling fans



Ceiling fans can have a significant cooling effect to increase thermal comfort of occupants by increasing air flow. They should only be installed in classrooms with high ceilings to avoid health and safety issues.



# C. Ventilation and cooling measures

## Costs of ventilation and cooling measures

Indicative cost of measure

### C.4

#### Natural ventilation: skylights



**Climate risks addressed**  
Heat

**Maintenance requirements**  
Semi-regular window cleaning

**Co-benefits**  
Energy bills savings

**Indicative capital cost range**  
£2,100 - £4,200

**Cost assumptions**  
Costs include the supply, delivery and installation of a rooflight, at roof level (assumed flat roof), to offer single storey / upper floor rooms natural light ingress. Includes for forming opening in roof structure and installation of roof mounted rooflight, recess, actuator and electrical works. Costs for a single unit. An allowance for access to the roof space and edge protection included. Costs include for contractor preliminaries, overheads and profit, and risk.

### C.5

#### Natural ventilation: openable windows



**Climate risks addressed**  
Heat

**Maintenance requirements**  
Ad-hoc if issues arise

**Co-benefits**  
n/a

**Indicative capital cost range**  
£900/m<sup>2</sup> - £1,800/m<sup>2</sup>

**Cost assumptions**  
Costs include for the removal of existing window units and installation of openable window units; assumed minimal works to adjacent units and building façade. Includes for scaffold access equipment, externally. Rates assume more than one units will be replace at any one time. Costs may vary depending on exact specification required. Costs include for contractor preliminaries, overheads and profit, and risk. Note: rate is £/m<sup>2</sup> of window area.

### C.6

#### Natural ventilation: ceiling fans



**Climate risks addressed**  
Heat

**Maintenance requirements**  
Regular dusting or cleaning; ad-hoc inspection

**Co-benefits**  
n/a

**Indicative capital cost range**  
£210 - £420

**Cost assumptions**  
Costs include for the supply and installation of an internal ceiling fan, including electrical connections to an existing distribution board. Allowance for making good surfaces and all necessary materials. Costs include for contractor preliminaries, overheads and profit, and risk. Note: cost per fan.

Note:  
Cost reference for  
indicative purposes only

# C. Ventilation and cooling measures

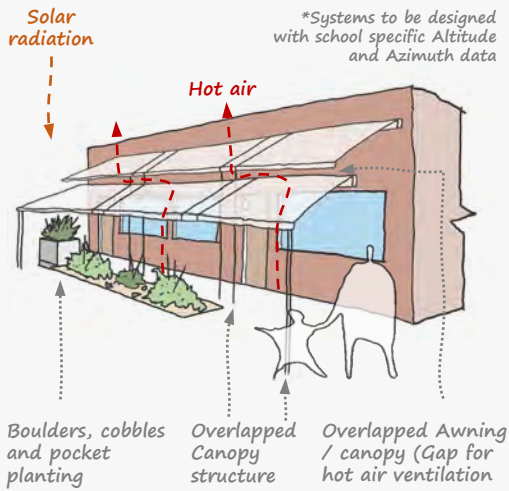
## Descriptions of ventilation and cooling measures

### C.7

#### Ventilate weatherproof awnings



Illustrative sketch of measure



Note: Sketches and reference images for illustrative purposes only

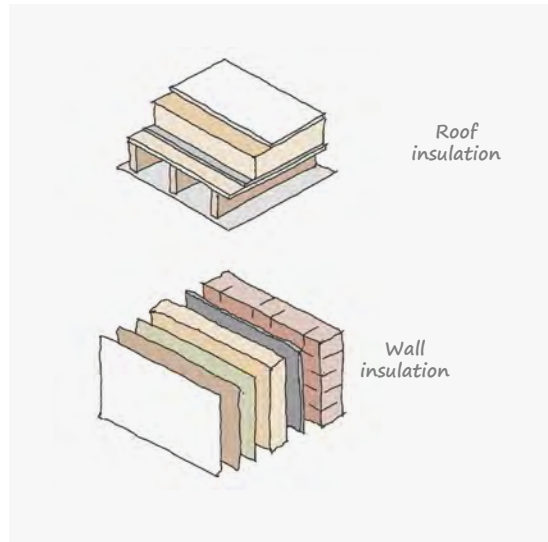
Description of measure

Plastic awnings provide effective protection from rain and offer shade, but can trap hot air during very hot periods. Allowing hot air to escape through greater upwards airflow can alleviate this (e.g. by creating holes in or staggering panels).

Note: Generic description of measure

### C.8

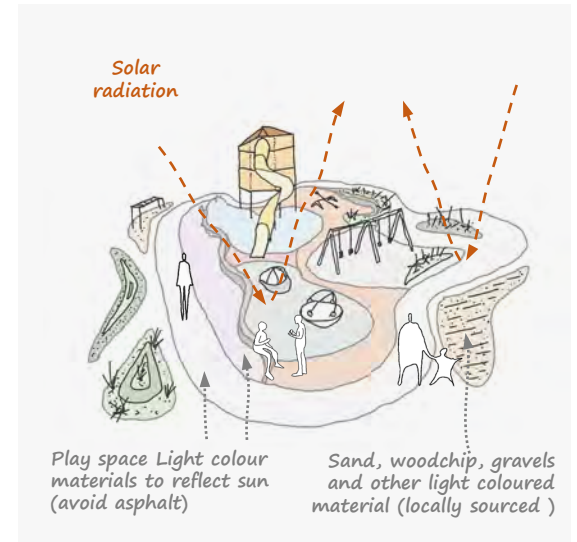
#### Insulation: walls and roofs



Insulation of walls and roofs is an important way of avoiding heat gain and heat loss in school buildings, contributing to thermal comfort, long-term energy efficiency and financial savings.

### C.9

#### Cool surfaces



Playgrounds with dark tarmac or rubber surfaces absorb heat and can be very hot during summer term, creating heat islands. Using light coloured playground tiles or surfaces can reduce the amount of heat they absorb.

# C. Ventilation and cooling measures

## Costs of ventilation and cooling measures

Indicative cost of measure

### C.7

#### Ventilate weatherproof awnings



**Climate risks addressed**  
Heat

**Maintenance requirements**  
Ad-hoc cleaning

**Co-benefits**  
n/a

**Indicative capital cost range**  
£800 - £1,500

**Cost assumptions**  
Fixed building mounted awning; costs include for removing obstructions to windows and immediate surrounding surfaces to facilitate the installation of external shading. It is assumed that no works are required to windows. Supply and install externally mounted; elevation mounted retractable awning; circa 2.5m-3.0m wide by 2.0m-2.5m deep, manually operated, metal frame and fabric. Costs include for access equipment externally and it is assumed that external access will be required only. Costs include for contractor preliminaries, overheads and profit, and risk.

### C.8

#### Insulation: walls and roofs



**Climate risks addressed**  
Heat

**Maintenance requirements**  
Annual inspection recommended; replacement every 5-20 years

**Co-benefits**  
n/a

**Indicative capital cost range**  
£100/m<sup>2</sup> - £1,000/m<sup>2</sup>

**Cost assumptions**  
Costs include for measures such as cavity wall insulation, external wall insulation, internal roof insulation and external roof insulation. Costs include for clearing surfaces of all debris and obstructions. It is assumed that no works are required to external and internal plant and equipment mounted to roof and/or wall surfaces. Costs allow for all edging, trims and flashing, as necessary. Costs include for access equipment and for contractor preliminaries, overheads and profit, and risk.

### C.9

#### Cool surfaces



**Climate risks addressed**  
Heat

**Maintenance requirements**  
May require repainting every few years

**Co-benefits**  
n/a

**Indicative capital cost range**  
£10/m<sup>2</sup> - £30/m<sup>2</sup>

**Cost assumptions**  
Costs include for clearing debris from existing surface, and making good minor damage in preparation for paint finish. Costs exclude temporary and/or permanently moving plant, equipment and other structures. Costs exclude scaffold access equipment, but include contractor preliminaries and overheads and profit. Costs include allowances for risk.

Note:  
Cost reference for  
indicative purposes only

# C. Ventilation and cooling measures

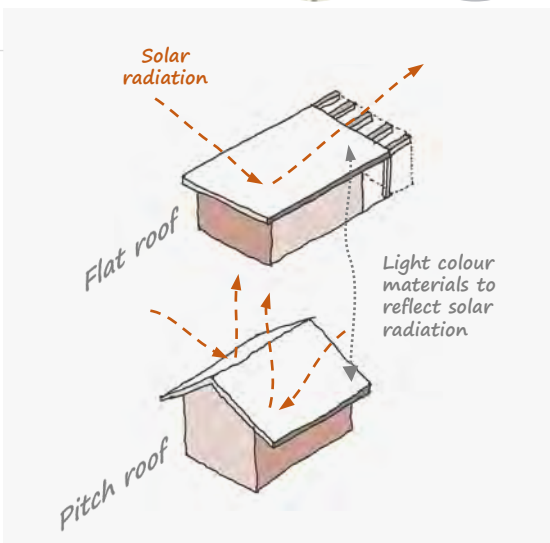
## Description of ventilation and cooling measures

### C.10

#### Cool roof



#### Illustrative sketch of measure



Note:  
Sketches and reference  
images for illustrative  
purposes only

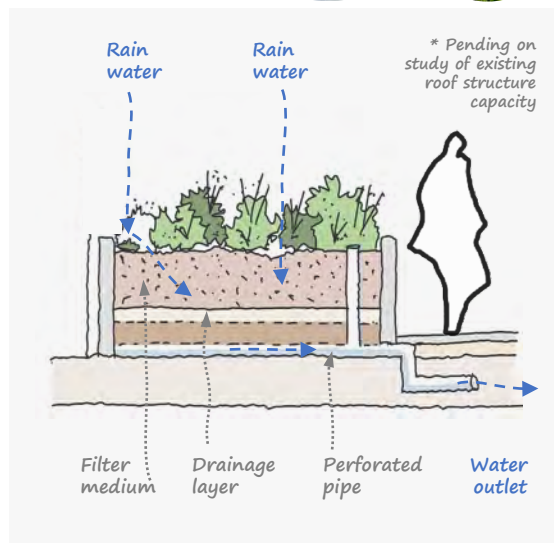
#### Description of measure

Reflective or light coloured roofs reflect more sunlight and absorb less heat than standard roofs, reducing heat gain in the top floors of school buildings that tend to suffer from overheating. They can be highly effective and affordable.

Note:  
Generic description of  
measure

### C.11

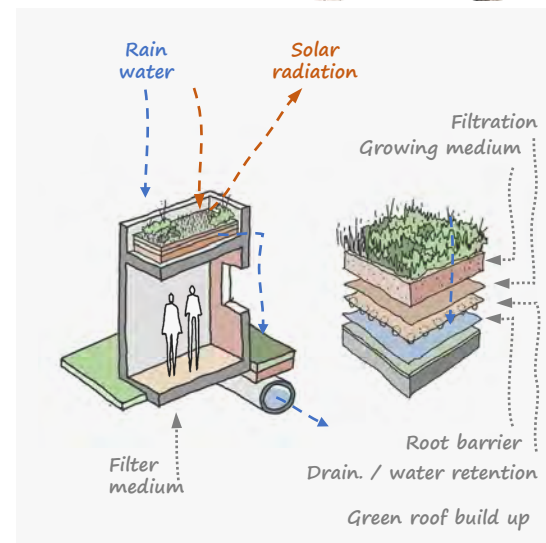
#### Planted beds



Grounded planting is preferable as it helps alleviate flooding, but raised planted beds help to green and cool spaces. Considering required shade levels is important in choosing suitable locations and/or plant types.

### C.12

#### Green roofs



Green roofs are partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. They can reduce external and internal air temperatures, slow rainwater flow and reduce surface runoff on school sites.

# C. Ventilation and cooling measures

## Costs of ventilation and cooling measures

### C.10

#### Cool roof



##### Climate risks addressed

Heat

##### Maintenance requirements

Biannual inspections (before and after wetter months) and ad-hoc cleaning

##### Co-benefits

n/a

##### Indicative capital cost range

£50/m<sup>2</sup> - £330/m<sup>2</sup>

##### Cost assumptions

Costs include for measures such as reflective / light coloured paint and/or tiles; costs include for clearing debris from existing roof surface, and making good minor damage in preparation for paint / tile finish. Costs exclude temporary and/or permanently moving plant, equipment and other structures. Costs include for scaffold access equipment, contractor preliminaries and overheads and profit.

### C.11

#### Planted beds



##### Climate risks addressed

Heat and flooding

##### Maintenance requirements

Semi-regular weeding and replacement of dead plants. Regular watering.

##### Co-benefits

Biodiversity, carbon savings and educational opportunities

##### Indicative capital cost range

£36/m<sup>2</sup> - £70/m<sup>2</sup>

##### Cost assumptions

Costs include for breaking out hard surfaces and making good edging, clearing and levelling area of circa 25m<sup>2</sup>. Costs include soil, seeding and planting and all associated labour. Excludes drainage connections. Costs include for contractor preliminaries, overheads and profit, and risk.

### C.12

#### Green roofs



##### Climate risks addressed

Heat and flooding

##### Maintenance requirements

Initial watering when becoming established

##### Co-benefits

Biodiversity, carbon savings, energy bills savings and educational opportunities

##### Indicative capital cost range

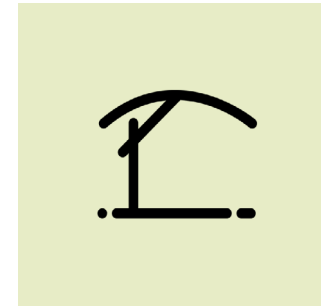
£200/m<sup>2</sup> - £400/m<sup>2</sup>

##### Cost assumptions

Costs based on average rate for supplying and installing a Green Roof system (costs from SPON'S pricing book) to flat and pitched roofs. Costs exclude any structural alterations to buildings / roofs. Assumes a green roof 'system' and all planting requirements. Excludes irrigation systems. Costs include for contractor preliminaries, overheads and profit, and risk.

Indicative cost of measure

Note:  
Cost reference for  
indicative purposes only



Solar shading  
measures

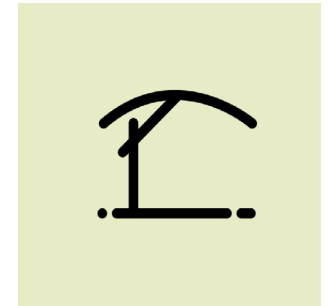
## **D.** Solar shading measures

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Compendium of adaptation and resilience measures for schools

# D. Solar shading measures

## Index of solar shading measures



Solar shading measures



**D.1**  
Grounds shade: sail



**D.2**  
Grounds shade: pergola



**D.3**  
Grounds shade: lunch benches



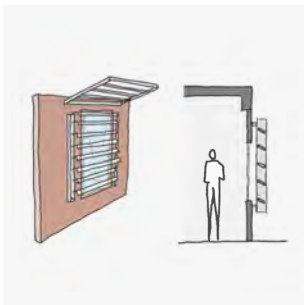
**D.4**  
Trees



**D.5**  
Green screen



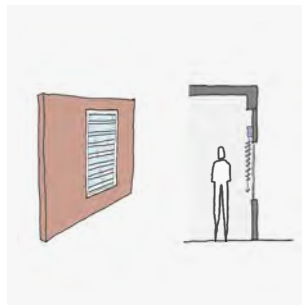
**D.6**  
Green wall



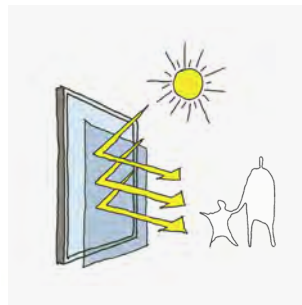
**D.7**  
Louvres or brise soleil



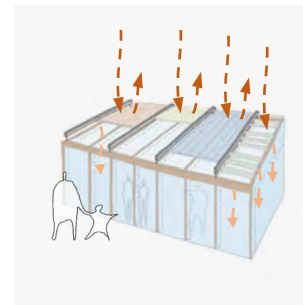
**D.8**  
Awning or canopy



**D.9**  
Internal blinds



**D.10**  
Window solar protection



**D.11**  
External roof blind

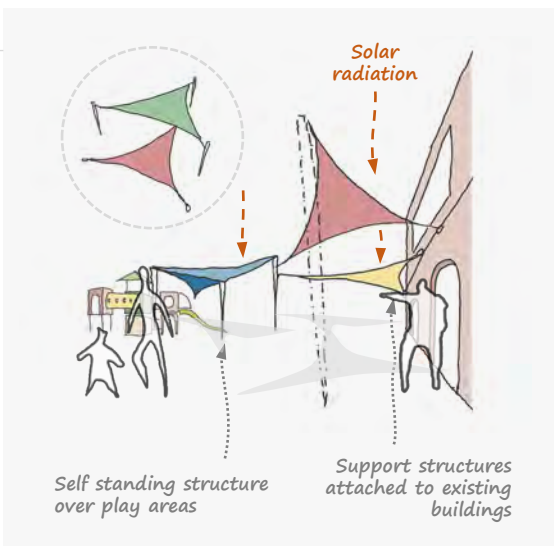
# D. Solar shading measures

## Descriptions of solar shading measures

Illustrative sketch of measure

**D.1**

**Grounds shade: sail**



Note:  
Sketches and reference images for illustrative purposes only

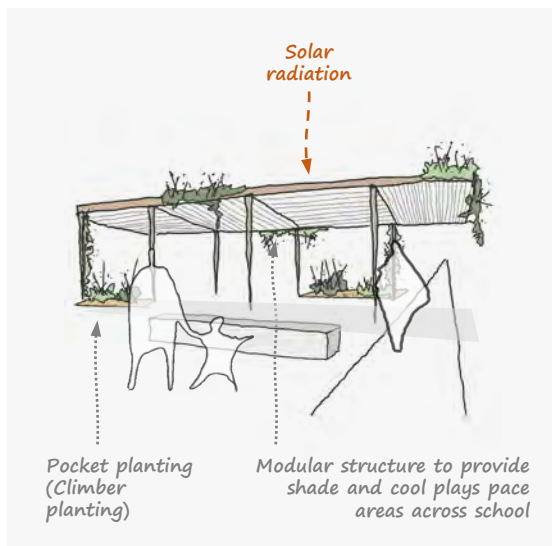
Description of measure

A shade sail is a device to create outdoor shade using a flexible membrane tensioned between several fixed points. They are usually provided above seating areas and playgrounds in areas exposed to direct sun. They can also be waterproof.

Note:  
Generic description of measure

**D.2**

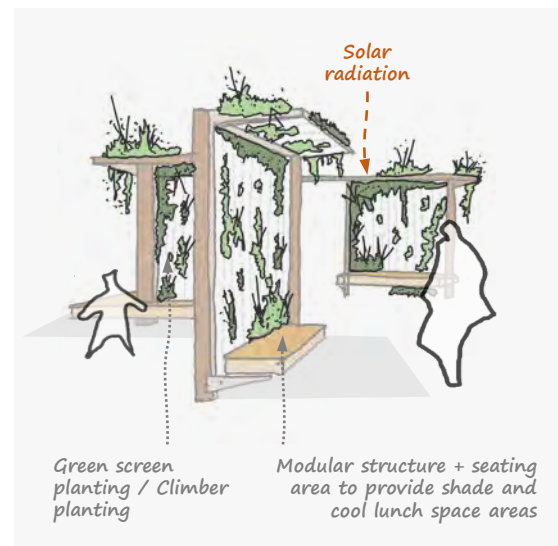
**Grounds shade: pergola**



A pergola is an arched structure in a outdoor space consisting of a framework covered with climbing or trailing plants. Depending on materials, size and choice of plants pergolas can provide shade and cooling in school playgrounds.

**D.3**

**Grounds shade: lunch benches**



Creating seated areas covered with a shade structure or a planted trellis creates spaces in the playground for students to eat their lunch or rest throughout summer months.



# D. Solar shading measures

## Costs of solar shading measures

### D.1

**Grounds shade:  
sail**



**Climate risks addressed**

Heat

**Maintenance requirements**

Ad-hoc cleaning of shade-giving fabric

**Co-benefits**

n/a

**Indicative capital cost range**

£2,700 - £5,300

**Cost assumptions**

Costs include for metal frame structure, circa 3m x 3m, with fabric stretching between poles, no walls, fixed to solid base. Includes supply, delivery and installation; solid base not included and assumes will be available (concrete, block paving, pavers, etc.). Costs include for contractor preliminaries, overheads and profit, and risk.

### D.2

**Grounds shade:  
pergola**



**Climate risks addressed**

Heat

**Maintenance requirements**

Ad-hoc cleaning of shade-giving structure

**Co-benefits**

n/a

**Indicative capital cost range**

£1,800 - £3,400

**Cost assumptions**

Costs include for softwood timber structure, circa 3m x 3m, with solid wooden / tiled roof finish, no walls, fixed to solid base. Includes supply, delivery and installation; solid base not included and assumes will be available (concrete, block paving, pavers, etc.). Costs include for contractor preliminaries, overheads and profit, and risk.

### D.3

**Grounds shade:  
lunch benches**



**Climate risks addressed**

Heat

**Maintenance requirements**

Ad-hoc cleaning of shade-giving structure

**Co-benefits**

n/a

**Indicative capital cost range**

£900 - £1,700

**Cost assumptions**

Costs range includes for bench type seating (2 seater) to picnic table, all with integrated shading structures. Costs include for supply, delivery and construction. Costs include for securely fixing to ground. Costs include for contractor preliminaries, overheads and profit, and risk.

Indicative cost of measure

Note:  
Cost reference for  
indicative purposes only

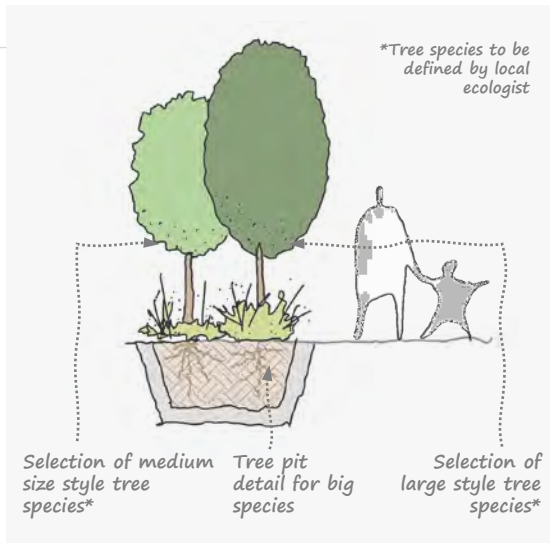
# D. Solar shading measures

## Descriptions of solar shading measures

### D.4 Trees



#### Illustrative sketch of measure



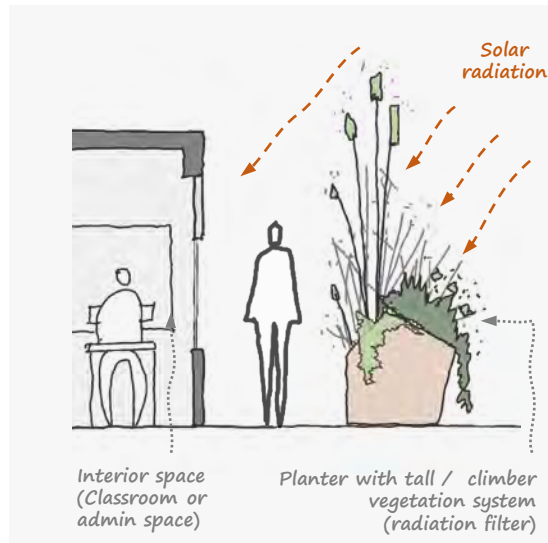
Note:  
Sketches and reference  
images for illustrative  
purposes only

#### Description of measure

Trees can provide shading in school grounds. They also reduce flood risk by intercepting rain and help rain infiltrate in the ground. SuDS tree pits maximise flood benefits by taking runoff from surrounding areas.

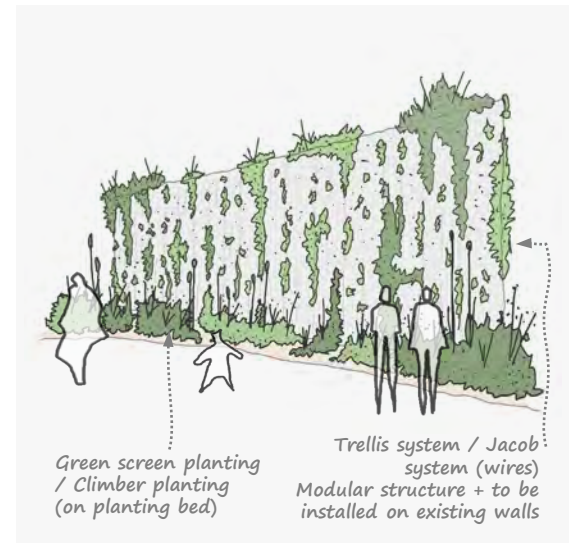
Note:  
Generic description of  
measure

### D.5 Green screen



Green screens often consist of a system on which tall / climber vegetation grows, such as ivy. The screens reduce the urban heat island effect and help reduce overheating risk. They can also reduce local air pollution.

### D.6 Green wall



Green walls provide cooling benefits as the plants absorb solar radiation. They include both walls which support climbing plants and vines rooted in the ground, as well as living wall systems where plants are artificially supported and irrigated.

# D. Solar shading measures

## Costs of solar shading measures

### D.4

#### Trees



##### Climate risks addressed

Heat and flooding

##### Maintenance requirements

Initial watering before becomes established.  
Annual pruning.

##### Co-benefits

Biodiversity, carbon savings, educational opportunities and improved air quality.

##### Indicative capital cost range

£210 - £2,000

##### Cost assumptions

For lower cost, works include supplying and planting a single tree; extra heavy standard: 14-16 cm girth. Costs assume tree(s) will be planted in soft ground and will NOT require a SuDS tree pit. For upper cost, works include breaking out hard surfaces, excavation, supplying and installing SuDS cells (1 layer) and preparing pit to receive tree(s). Assumed a 4m<sup>2</sup> pit area (2m x 2m) per tree for 14-16 cm girth. Costs assume tree(s) will be planted in hard ground e.g. playgrounds or perimeter of highways / pavements. All costs include for contractor preliminaries, OH&P and risk.

### D.5

#### Green screen



##### Climate risks addressed

Heat and flooding

##### Maintenance requirements

Regular watering when establishing (first 2 years), less after

##### Co-benefits

Biodiversity, educational opportunities and improved air quality

##### Indicative capital cost range

£400/m - £800/m

##### Cost assumptions

Costs include for fully installed vertical green screen of Hedera hibernica; 65 plants per linear m; all on 5 mm galvanized steel weldmesh; attached to existing wall fence or hoarding; circa 1.8m high fence / wall. Excludes irrigation. Includes access. Costs include for contractor preliminaries, overheads and profit, and risk. Note: rate is £/m (linear length) of living screen.

### D.6

#### Green wall



##### Climate risks addressed

Heat, flooding and water scarcity

##### Maintenance requirements

Ad-hoc to manage irrigation and plant growth

##### Co-benefits

Biodiversity, educational opportunities and improved air quality

##### Indicative capital cost range

£900/m<sup>2</sup> - £1,800/m<sup>2</sup>

##### Cost assumptions

Costs include for a soil based system; Scotscape Living Walls; self counted, irrigated vertical planting system; fabric modules; fully established upon installation. Costs include for all plant and equipment and pipework; and rain harvesting provisions. Costs include for access equipment externally. Costs include for contractor preliminaries, overheads and profit, and risk. Note: rate is £/m<sup>2</sup> of living wall coverage.

Indicative cost of measure

Note:  
Cost reference for  
indicative purposes only

# D. Solar shading measures

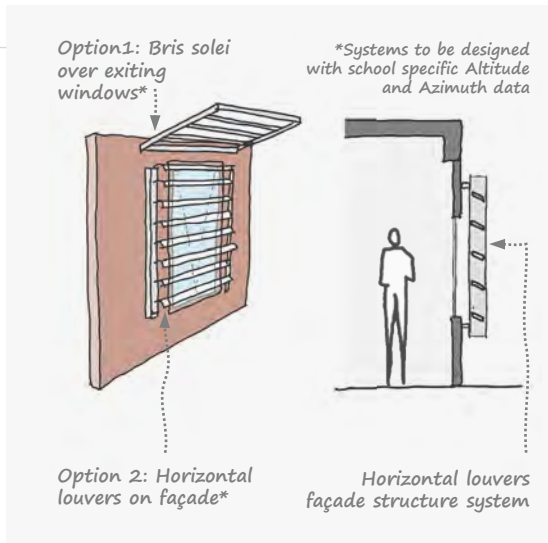
## Descriptions of solar shading measures

### D.7

#### Louvres or brise soleil

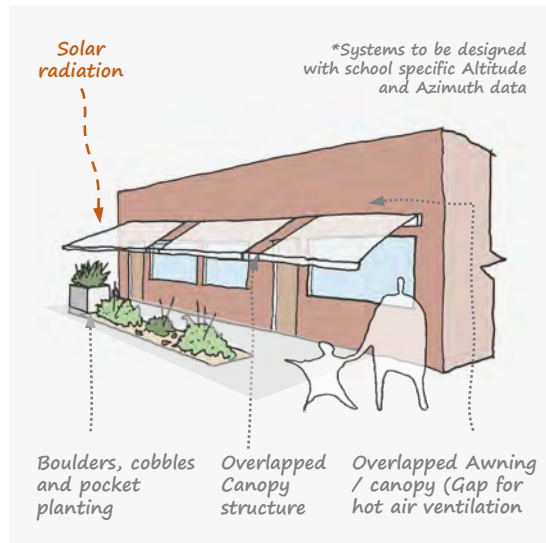


#### Illustrative sketch of measure



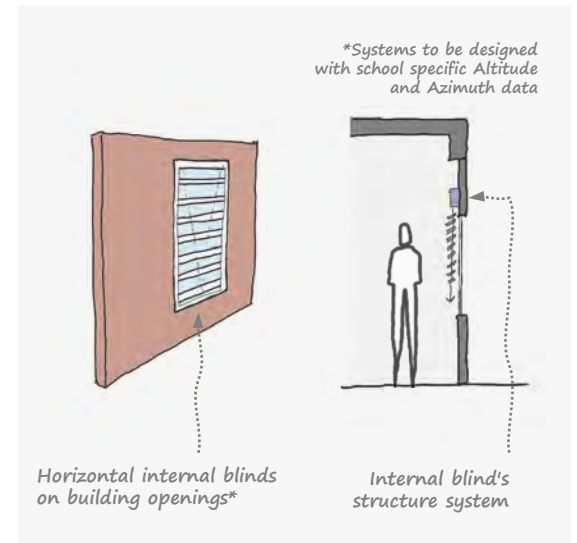
### D.8

#### Awning or canopy



### D.9

#### Internal blinds



#### Description of measure

Brise soleil are fixed horizontal shading devices and are best placed on south facing facades of schools. Louvres are fixed vertical shading devices and are best placed on schools facades facing east or west.

Awnings or canopies are relatively easy to-install shade structures for school buildings. They are best placed on facades above ground floor windows or on single story school buildings. They need to be well ventilated to avoid overheating.

Internal blinds can partially or fully block out direct sunlight, reducing overheating risk or glare. They are effective in south-facing classrooms. On hot, sunny days, blind usage may need to be balanced with maximising window ventilation.

Note:  
Generic description of measure

Note:  
Sketches and reference images for illustrative purposes only

# D. Solar shading measures

## Costs of solar shading measures

Indicative cost of measure

### D.7

#### Louvres or brise soleil



**Climate risks addressed**  
Heat

**Maintenance requirements**  
Cleaning every 3-5 years

**Co-benefits**  
n/a

**Indicative capital cost range**  
£550/m<sup>2</sup>- £1,500/m<sup>2</sup>

**Cost assumptions**  
Costs include measures such as fixed awnings, external shutters and vertical ladder / louvre systems; costs include removing obstructions to windows and immediate surrounding surfaces to facilitate the installation of external shading solution(s). It is assumed that no works are required to windows. Supply and install externally mounted solution. Costs include access equipment externally. Costs include contractor preliminaries, overheads and profit, and risk.

### D.8

#### Awning or canopy



**Climate risks addressed**  
Heat

**Maintenance requirements**  
Ad-hoc cleaning

**Co-benefits**  
n/a

**Indicative capital cost range**  
£800 - £1,500

**Cost assumptions**  
Fixed building mounted awning; costs include for removing obstructions to windows and immediate surrounding surfaces to facilitate the installation of external shading. It is assumed that no works are required to windows. Supply and install externally mounted; elevation mounted retractable awning; circa 2.5m-3.0m wide by 2.0m-2.5m deep, manually operated, metal frame and fabric. Costs include for access equipment externally and it is assumed that external access will be required only. Costs include for contractor preliminaries, overheads and profit, and risk.

### D.9

#### Internal blinds



**Climate risks addressed**  
Heat

**Maintenance requirements**  
Ad-hoc if issues arise

**Co-benefits**  
n/a

**Indicative capital cost range**  
£120/m<sup>2</sup> - £230/m<sup>2</sup>

**Cost assumptions**  
Costs include removing existing blinds, curtains and the like necessary to install new blinds, and make good surfaces disturbed. Includes the supply, delivery and installation of roller blinds to internal window faces; full reveal width and drop (height) and all necessary safety brackets and ties. Costs include contractor preliminaries, overheads and profit, and risk.

Note:  
Cost reference for  
indicative purposes only

# D. Solar shading measures

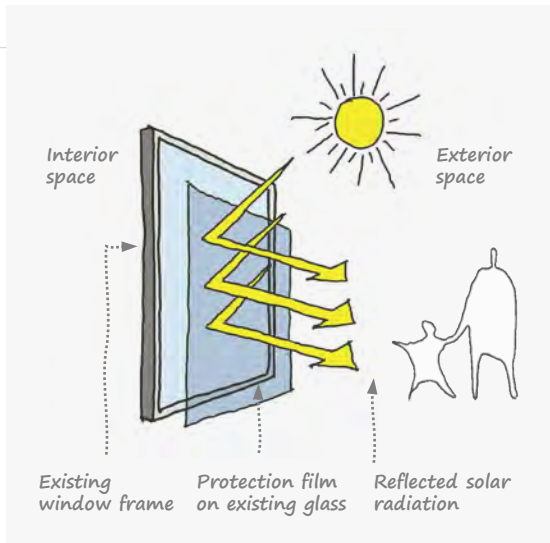
## Descriptions of solar shading measures

### D.10

#### Window solar protection



#### Illustrative sketch of measure



Note:  
Sketches and reference images for illustrative purposes only

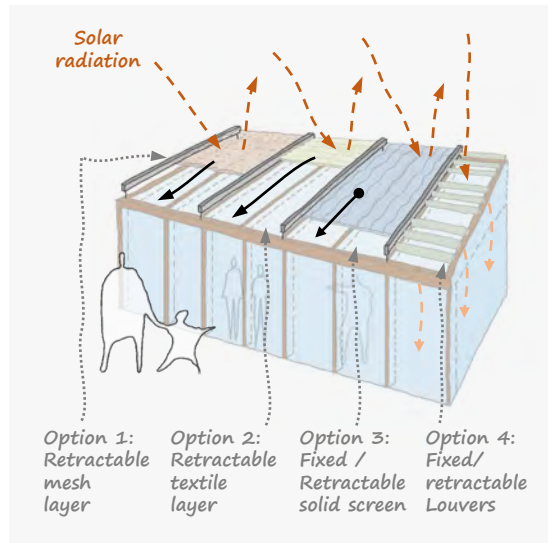
#### Description of measure

Solar protection window film can be fitted onto flat glazing, including rooflights. Some types of film can reduce winter solar gain and daylight but others reflect infra-red radiation and admit visible light, controlling overheating and light levels.

Note:  
Generic description of measure

### D.11

#### External roof blind



External roof blinds prevent direct solar heat gain through large areas of translucent (i.e. glazed or ethylene tetrafluoroethylene) roof space. They can be fixed or retractable, and can be installed on sloping or horizontal glazing or skylights.

# D. Solar shading measures

## Costs of solar shading measures

### D.10

#### Window solar protection



Indicative cost of measure

##### Climate risks addressed

Heat

##### Maintenance requirements

Limited change from without film

##### Co-benefits

Energy bills savings

##### Indicative capital cost range

£120/m<sup>2</sup> - £230/m<sup>2</sup>

##### Cost assumptions

Costs include preparing the internal face of existing windows to receive new solar protection film. Includes supply, delivery and installation of film to full internal area of window panes, excluding frame. Assumed all works can be achieved from inside the building. Assumed no working at height is required. Costs include contractor preliminaries, overheads and profit, and risk. Note: rate is £/m<sup>2</sup> of window area.

### D.11

#### External roof blind



##### Climate risks addressed

Heat

##### Maintenance requirements

Seasonal maintenance to ensure material is clean and retractable mechanisms work.

##### Co-benefits

Energy bills savings

##### Indicative capital cost range

£1,700 - £3,400

##### Cost assumptions

Costs include for removing obstructions to roof windows and immediate surrounding surfaces to facilitate the installation of external roof shading. It is assumed that no works are required to windows / roof panels. Supply and install externally mounted window blinds, motorised, metal framed and fabric shade. Costs include for access equipment externally. Costs include for contractor preliminaries, overheads and profit, and risk.

Note:  
Cost reference for  
indicative purposes only



Water efficiency  
measures

## **E.** Water efficiency measures

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Compendium of adaptation and resilience measures for schools

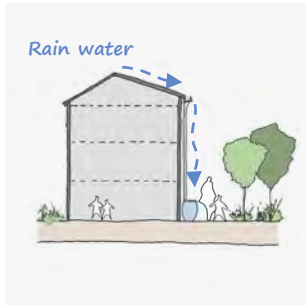


# E. Water efficiency measures

## Index of water efficiency measures



Water efficiency measures



**E.1**  
Rainwater harvesting:  
water butt



**E.2**  
Internal water  
efficiency measures

# E. Water efficiency measures

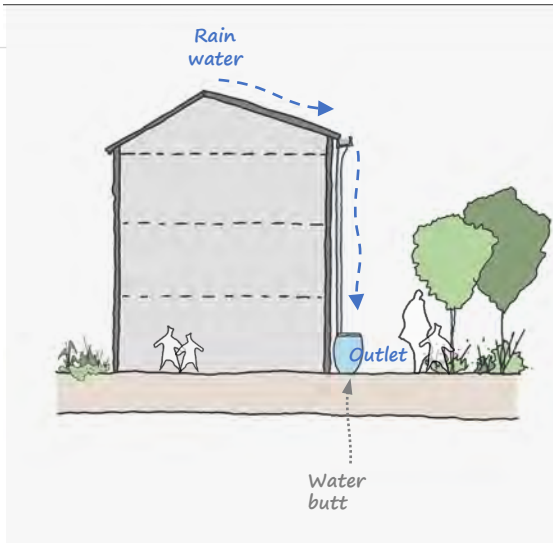
## Descriptions of water efficiency measures

### E.1

#### Rainwater harvesting: water butt



Illustrative sketch of measure



Note:  
Sketches and reference images for illustrative purposes only

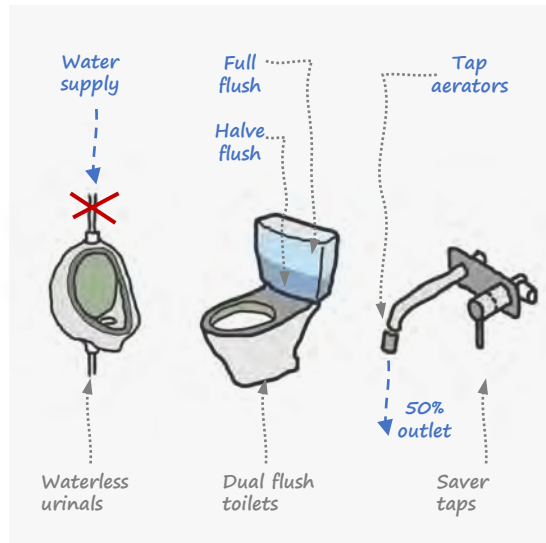
Description of measure

Note:  
Generic description of measure

Rainwater harvesting is the process of collecting, storing and using rainwater as an alternative to mains water. A water butt is a simple rainwater harvesting system, capturing and storing rainwater ready to be used in a school garden.

### E.2

#### Internal water efficiency measures



Low flow taps, dual flush toilets and low flush urinals can all reduce water consumption in schools. Taps fitted with aerators can reduce the flow of water by up to 50%. The low flush options for toilets and urinals encourage users to save water.

# E. Water efficiency measures

## Costs of water efficiency measures

### E.1

#### Rainwater harvesting: water butt



##### Climate risks addressed

Water scarcity

##### Maintenance requirements

Inspect water in butt before use.

##### Co-benefits

Educational opportunities

##### Indicative capital cost range

£380 - £860

##### Cost assumptions

Includes free standing, resin water butt, circa 1,300 litre. Includes fixing to adjacent structure and all necessary pipework connections. Costs include for contractor preliminaries, overheads and profit, and risk.

### E.2

#### Internal water efficiency measures



##### Climate risks addressed

Water scarcity

##### Maintenance requirements

Ad-hoc if issues arise

##### Co-benefits

Educational opportunities

##### Indicative capital cost range

£2,000 - £12,000

##### Cost assumptions

Costs assume that on average 10 positions will be upgraded. Assumed separate hot and cold taps (not mixer), and that all other sanitaryware or appliances will remain as existing. For dual flush toilets, it is assumed that 'back to wall' style will be required and that the existing internal plumbing system will be retained. Assumed that cold water supply and drainage will be re-used where possible. These costs include for the removal of sanitaryware and the supply and installation of new. Costs include for minimal materials, as necessary, and contractor preliminaries, overheads and profit, and risk.

Indicative cost of  
measure

Note:  
Cost reference for  
indicative purposes only