PERMAVOID MULTIFUNCTIONAL ROOF SYSTEMS

living roofs
for climate
resilient cities

permavoid
the Foundation for our Future

PERMAVOID SOLUTIONS FOR MULTIFUNCTIONAL ROOFS

Challenges

Cities around the world face many challenges. People continue to move to large metropolitan areas. Today, 55% of the world's population live in urban areas and this is expected to increase to 68% by 2050 according to the United Nations. At the same time weather patterns are changing. The average temperature is rising, dry spells are more frequent and rain falls in shorter and more intense rainstorms.

Population growth in cities leads to more buildings and paved areas, in turn decreasing the amount of green infrastructure. This reduces the capacity for rainwater infiltration which, in combination with an increasing quantity of rainstorms, leads to more frequent and severe occurrences of urban flooding. At the same time these built areas collect energy from the sun during the day and radiate this back into the city as heat during the night.

In metropolitan areas the night-time temperature can be as much as 8 to 10 degrees warmer than the surrounding countryside. Where nature creates a microclimate in which it thrives, human settlements suffer from this Urban Heat Island effect, negatively impacting human lives and well-being.

Permavoid's mission is to bring green infrastructure back into the cities. By returning healthy plant growth into the built environment, natural ecosystem services can help mitigate the effects of increased urbanization and climate change. Multifunctional roof systems allow people to develop a healthy city, while enjoying the ecological and economic benefits of green infrastructure.

IN NATURE
ALL MATTER
IS RECYCLED
AND NOTHING
IS WASTE

NATURE AS SOURCE OF INSPIRATION

Circular on-site water management and energy absorption

Ecosystems offer great examples of how to prevent excessive heat and floods. Land based ecosystems capture rainwater, as much as possible, where it falls. Rainwater is retained in vegetation and soil to sustain plant growth during later dry spells. Evaporation of stored rainwater by plants creates an adiabatic cooling effect, preventing overheating of the plants and the ecosystem. Secondly, plants absorb only usable wavelengths of light for photosynthesis. A substantial proportion of incoming sunlight is reflected and returned into the atmosphere before it can be transformed to heat, which is another natural mechanism to prevent overheating of the ecosystem.

In contrary to nature, humans develop cities, which drain rainwater as quickly as possible in linear systems and build large energy absorbing, heat-generating black surfaces on rooftops and in streets.

It is obvious that we can learn from nature by treating rainwater as a local resource rather than a nuisance and use nature-based functionality of plants to create circular, energy efficient and liveable cities.

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From unexploited natural capital to functional green space

Space for green infrastructure is disappearing in ever denser cities. Yet, cities feature vast areas of unused or 'unexploited' rooftops. These empty spaces can be reclaimed for stormwater management (Blue) in combination with plant growth (Green) by creating blue-green roofs and roof gardens.

Rooftops can be transformed into functional landscapes or roofscapes, designed to conserve and/or generate energy, manage rainwater, create space for biodiversity and space for people to stay in, or any smart combination thereof.

With this approach, roofs are no longer just there to keep out the rain, but become an integral and functional part of the building they are on, and the city they are in.

Creating valuable real estate: an extra floor available on every building

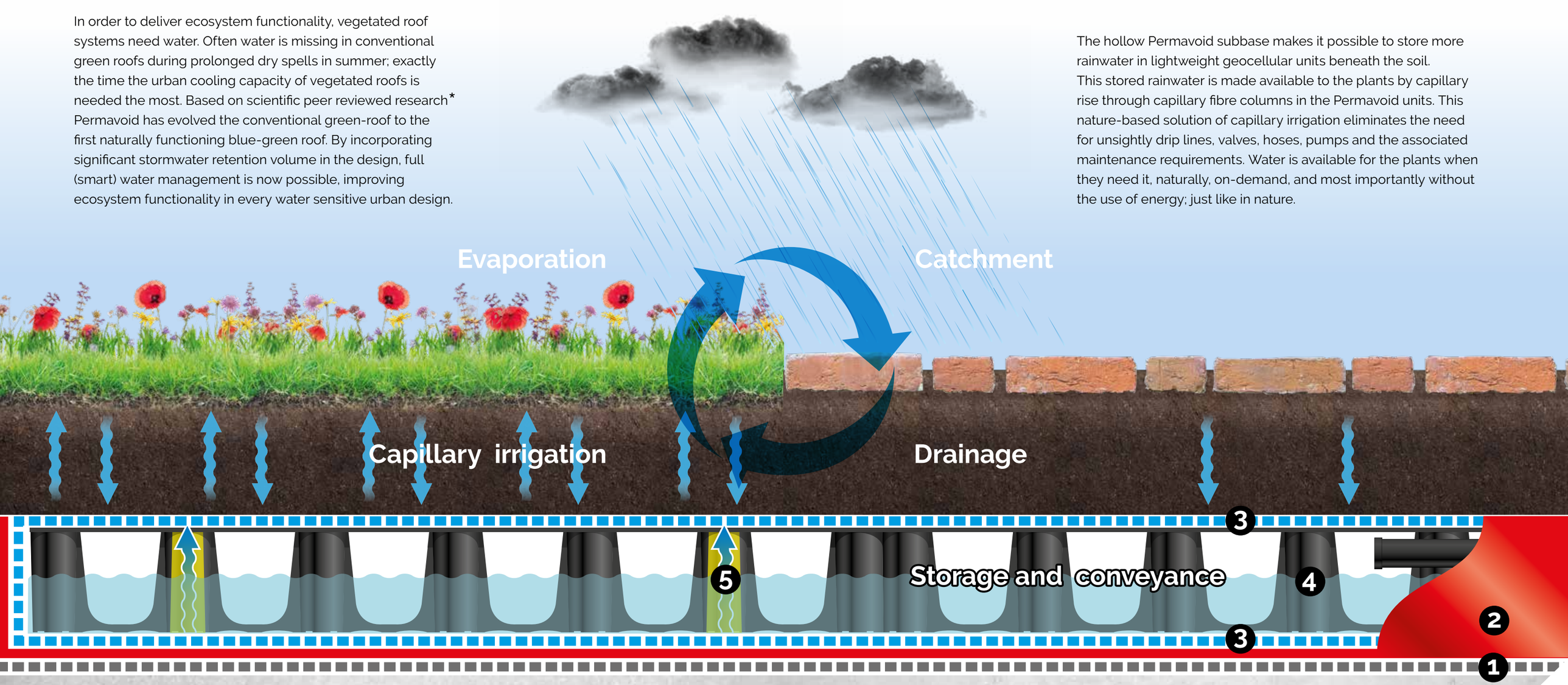
Vegetated roofscapes for people to look out on increase human well-being and productivity and can become gardens in which people can spend time and relax. This greatly enhances the real estate value, while simultaneously improving biodiversity. The roof can be regarded a previously unused 'floor' of the building, now transformed into a valuable, multifunctional and usable space.

HOW PERMAVOID LEARNS FROM NATURE

In order to deliver ecosystem functionality, vegetated roof systems need water. Often water is missing in conventional green roofs during prolonged dry spells in summer; exactly the time the urban cooling capacity of vegetated roofs is needed the most. Based on scientific peer reviewed research* Permavoid has evolved the conventional green-roof to the first naturally functioning blue-green roof. By incorporating significant stormwater retention volume in the design, full (smart) water management is now possible, improving ecosystem functionality in every water sensitive urban design.

Water is the key to successful green infrastructure at any level, in every green design. Keep rainwater out of the sewer and put it to work to help cool the urban environment.

The hollow Permavoid subbase makes it possible to store more rainwater in lightweight geocellular units beneath the soil. This stored rainwater is made available to the plants by capillary rise through capillary fibre columns in the Permavoid units. This nature-based solution of capillary irrigation eliminates the need for unsightly drip lines, valves, hoses, pumps and the associated maintenance requirements. Water is available for the plants when they need it, naturally, on-demand, and most importantly without the use of energy; just like in nature.



1. Protective geotextile
2. Waterproof membrane
3. Capillary geotextile
4. Permavoid 85/150 mm unit
5. Capillary column

*Cirkel, D.G.; Voortman, B.R.; Van Veen, T.; Bartholomeus, R.P. Evaporation from (Blue-)Green Roofs: Assessing the Benefits of a Storage and Capillary Irrigation System Based on Measurements and Modeling. Water 2018, 10, 1253.

ADVANTAGES PERMAVOID SYSTEM

Plant growth

Plants no longer experience the extreme wet-dry cycle they would otherwise experience in rooftop plantings because of the continuous natural capillary feed of water to the soil from storage in the Permavoid units. This provides for better growth and enables the designer to use a broad range of plant species. Gardens can be designed with shallower (lighter) substrate layers since the soil no longer needs to act as primary water storage medium.

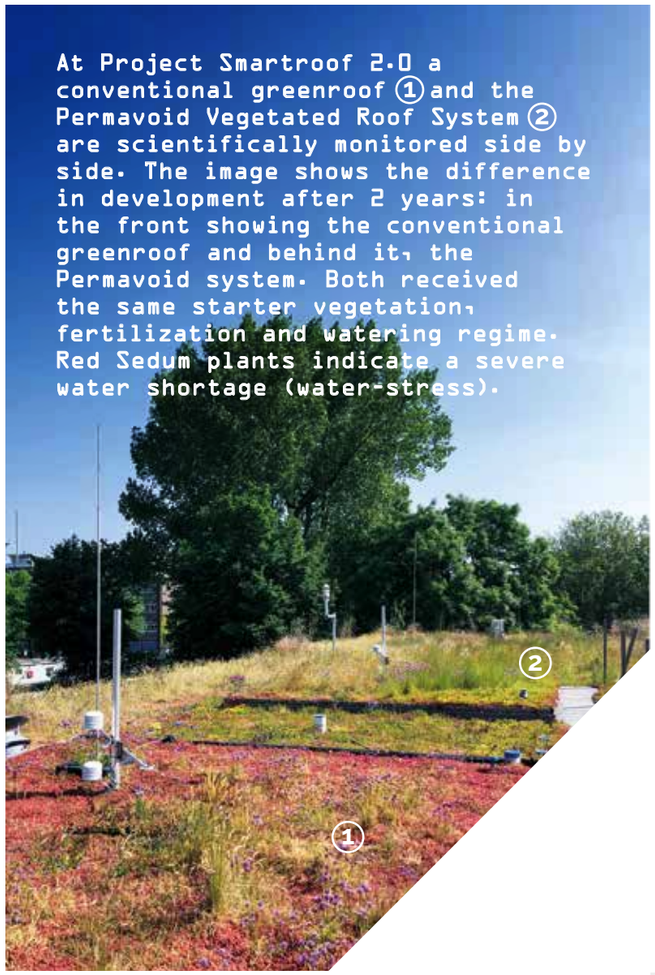
Providing plants with ample rainwater on blue-green rooftops enables them to achieve maximum potential evapotranspiration, which for temperate climates can be up to 70% of annual precipitation.

Irrigation water savings

The total amount of water needed for irrigation can be reduced without hampering plant growth because capillary irrigation does not experience surface evaporation losses. Independent research by STRI in Australia, the UK and the Gulf region showed irrigation water savings ranging up to 60%.

Water level management

The actual water level in the Permavoid units can be set, measured, recorded and passively (by means of overflow) or actively (sensor) adjusted and controlled. This greatly helps with justification of the system's detention or retention performance for local building-code requirements during the design and operational phase. Using sensor data to actively control an electronic valve, small quantities of extra water can



At Project Smartroof 2.0 a conventional greenroof ① and the Permavoid Vegetated Roof System ② are scientifically monitored side by side. The image shows the difference in development after 2 years: in the front showing the conventional greenroof and behind it, the Permavoid system. Both received the same starter vegetation, fertilization and watering regime. Red Sedum plants indicate a severe water shortage (water-stress).

be automatically added to the Permavoid system to maintain healthy plant growth even during prolonged dry spells.

The system can also be set to discharge water in anticipation of an oncoming peak rain event, based on rain-radar data, ensuring the detention and retention capacity of the system is available at the time it is needed most.

These artificial intelligent controls ensure that Permavoid systems are ready for the SMART cities of the future, today.

Retention and detention combined

It is possible to combine water retention for plant irrigation, and detention for temporary storage and controlled release, in one and the same system with either passive or artificial intelligent overflows and outlets. This combination enables the customer, the structural engineer and the landscape architect to design a garden which complies with local stormwater management guidelines, while minimising the impact on the building and maximising plant growth opportunities.

The system can also receive water from other (higher) roof levels, so stormwater can be harvested as source of irrigation water for the roof garden while at the same time keeping water out of the sewer. In this respect the Permavoid system is no longer exclusively for the benefit of the building, but becomes an integral part of urban stormwater management, creating a water sensitive urban design for entire city blocks.

This mixed grasses and herbs vegetation is growing in just a 40 mm deep substrate layer with the Permavoid Capillary Irrigation system installed beneath. This image was taken on May 13th 2015, in the midst of a prolonged dry spell. Thanks to capillary available water, the vegetation continues to thrive and flower, without signs of growth reduction.

Retention and Detention
In urban water management, a clear distinction is made between water retention and detention. Retention means the permanent collection and storage (and use) of stormwater on-site, without being drained to the sewer, groundwater or open water. Detention refers to the temporary collection and buffering of rainwater, for later soil infiltration or discharge to the sewer or stormwater, usually at a specified flow rate, or within a set time limit.

Biodiversity

The reliable capillary availability of water for the vegetation enables the landscape architect to choose from a wider array of plant species. This broadened plant species selection, in combination with reliable natural irrigation, supports a wider variety of insect species year-round. Project Smartroof 2.0 in Amsterdam scored highest on flower count and bee-species diversity in an ecological study including 21 different green roofs and roof gardens in the summer of 2018 and 2019.

Harvesting extra sources of water

The Permavoid system provides the ability to harvest supplemental sources of water such as washdown, HVAC condensate and treated grey water for irrigation purposes, without the installation of tanks or pipes. Focusing on surface area rather than depth, the Permavoid subbase on the roof is the tank providing the required storage volume.

For example, in the desert climate of the Gulf region it pays to harvest HVAC condensate: these AC units can produce up to 50 liters of usable condensate per room, per day.

Less weight

The Permavoid system weighs only 6 kg/m², this means the designer can focus the maximum allowable load on the rooftop to retain and manage water on the roof. For comparison: the water stored to weight ratio of Permavoid is 12,5 kg H_2O per 1kg Permavoid whereas for gravel this ratio equals 0,2 kg H_2O per kg of gravel. Permavoid Blue-Green roof systems can be designed to match the load bearing capacity of the roof, starting at 100 kg/m² with just 40 mm of soil and 25 mm of water retention in the Permavoid drainage and capillary irrigation layer.

When the roof structure has a greater load bearing capacity more water can be retained and more soil can be used, supporting an even more resilient and biodiverse roof garden.

Building advantages

The Permavoid subbase protects the building roof membrane from extreme daily temperature fluctuations and UV radiation, lengthening the roof's lifespan. The insulation value of the combined layers of water, air, soil and vegetation greatly reduces the heat influx into the building, minimising the required HVAC capacity for the top floor.

At Project Smartroof the AC cooler on the roof became an 'old-world ornament' for it was not used again since the construction of the Permavoid blue-green roof garden.

Development of vegetation on the Permavoid system, on the foreground the standard Sedum mix vegetation in bloom on 40 mm of soil and in the background a seeded grasses and flowering herbs mix on 60-80 mm of soil. The inserts show species inhabiting the vegetation.

Project Boelelaan in Amsterdam, a 700 m² communal roof garden created on an 8-story apartment building, using the Permavoid 85S Retention and Capillary Irrigation System under the wooden decks and 80 mm deep substrate for the vegetation.

Creating a courtyard roofgarden on top of an underground parking garage. This garden is a 100% Permavoid water-managed surface with hardscaped and vegetated areas on top. It allows the elderly in the assisted living facility to enjoy the gardens, the outdoor restaurant, gardening and growing their own herbs.

Multifunctional subbase

The Permavoid System is designed to be strong enough to support landscaped designs with soils up to several metres deep and hardscaped designs with block pavers, concrete or asphalt.

If traffic loading is desired, the Permavoid units can be fitted underneath the driveway in order to maintain a continuous water management surface on the entire podium deck, or in the subbase of the roof garden.

Versatile mounting platform

A reliable connection to attach various elements to the Permavoid units is available with the addition of the PermaLock.

The PermaLock is inserted into the unit in one of the many available openings and secured with a bayonet type lock, without drilling into the roof. The PermaLock houses a standard 5/16" (8 mm) steel threaded nut, in which bolts can be screwed to attach a variety of components e.g. fencing, solar panel systems or wooden decks. Also, as with all parts of the Permavoid system; the PermaLock can be removed almost as easily as it was installed, to be reused elsewhere.

The safety fence used to delimit the viewing deck is boulted directly to the Permavoid subbase units using the PermaLock, without drilling into the roof. This setup has been tested and found to comply with the NEN-EN 1991-1-1 safety standards for rooftop safety fencing.

Construction advantages summarised

The nature-based design of 'storing water where it rains' simplifies roof and podiumdeck design and construction.

- The roof or podium deck no longer needs to be constructed with slopes to ensure rainwater flows towards the outlets. The roof is constructed level, rainwater is managed and conveyed to the outlets in the Permavoid subbase beneath the constructed hard and softscapes
- There is no need for drainage outlets to be taken through the roof or deck (limitations apply) because of the horizontal waterflow capacity with low velocity flow. The Permavoid subbase conveys water to the edge of the slab where rainwater downpipe connections can be made This reduces construction time, leak potential and can eliminate or, at least, significantly reduce underslung pipework.
- The system acts as a combined drainage, retention and irrigation system and is easily integrated into the overall SuDS strategy. Surface drip lines or irrigation sprayers are no longer necessary, saving installation and maintenance costs
- In comparison to conventional subbase materials, Permavoid Systems save time and labour because it is lightweight, quick & easy to install
- Permavoid reduces the number of truck movements to and from site at least 20-fold when compared to an equivalent water retention volume provided by a conventional gravel subbase.

PERMAVOID ROOF SYSTEMS

Water sensitive vegetated roofs with mixed Sedum vegetation

When water conservation in a water sensitive design is the most important goal, the Permavoid subbase can be used under a mixed Sedum (succulent) vegetation in a lightweight setup with a shallow soil.

The system can be set to retain any amount of rainwater from 20 up to 80 mm of rainwater which, in a temperate climate, suffices for 48 days of unrestricted growth, without supplemental irrigation.

Sedum species are drought tolerant, but they do grow a denser carpet and produce more flowers when grown on the Permavoid Capillary System with reliable capillary water availability. And this impacts biodiversity: more flowers equal more nectar, which is common knowledge among invertebrates.

Roof gardens

The Permavoid system allows the placement of hard and softscape on the same Permavoid subbase.

Water management is guaranteed in the continuous Permavoid subbase regardless of the landscape use or type. Fencing, furniture and wooden terraces can be secured to the Permavoid units using the PermaLock system, and block pavers can be paved on a normal sand bed on top of the Permavoid units.

Even, if years after construction, the design or arrangement of the roof garden or podium deck needs to be changed, the Permavoid subbase can be left untouched as it is use-independent, saving time and money.

Vivaldi, Amsterdam. A Blue-Green roof garden on top of an office building providing 2150 m² of extra space for the employees to enjoy.

Hotel Barbizon Vermeer Restaurant, Amsterdam.

The result of seeding a mix of annual flowers on just 30 mm of soil on the Permavoid Capillary System, about 8 weeks after seeding.

Biodiverse vegetation sustained with capillary available water

Capillary irrigation creates a stable soil moisture content. Therefore, the designer is no longer restricted to just sedum or drought tolerant species.

It is possible to create an annual or perennial species composition from seeds, even in limited soil depths on the Permavoid capillary subbase.

Urban farming

The Permavoid Blue-Green Roof System is extremely well suited to support urban farming in cities. The capillary available water prevents dehydration of the vegetables for many days, and water availability can be easily checked and replenished in the Permavoid subbase, either manually or with sensor driven automated irrigation systems.

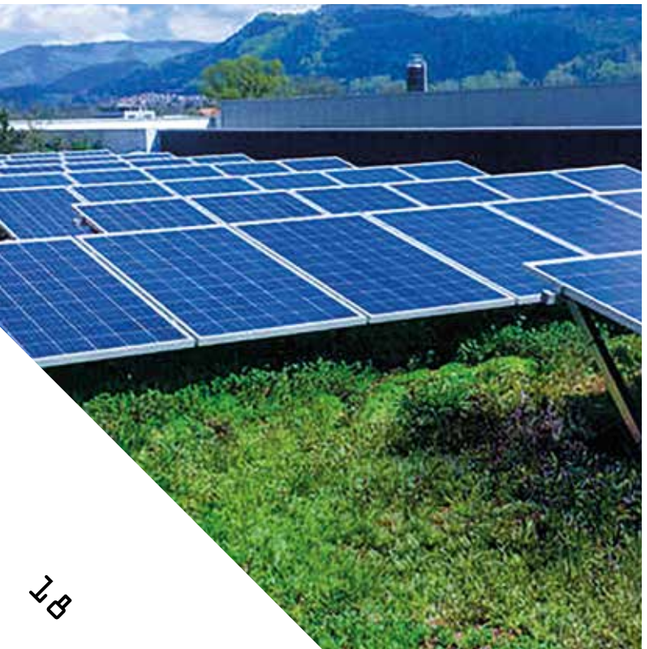
It is possible to use the system for personal vegetable gardens of any size, in containers or full scale, or for professional restaurant rooftop vegetable farms: The best way to promote and produce a truly day-fresh 'salad of the day', with a 100% fit in the local circular economy paradigm.

Trafficked solutions

The high loadbearing capacity of the Permavoid subbase facilitates not only the formation of vegetated roof systems but paved parking decks or access roads also.

Combining the functions of stormwater management and traffic saves space and manages rainwater at source, preventing overloaded sewer systems.

Conventional 'End-of-line' water management is converted to Source-Control designs. Combined with oil absorption and natural bacterial treatment in Permafilter geotextile the system not only reduces water quantities but also contributes to improved water quality in SuDS designs.



PermaSol; your own solar power plant

When solar panel frames are attached directly to the Permavoid subbase using PermaLocks, the plant evaporative adiabatic cooling helps to reduce solar panel temperatures, in turn increasing solar panel efficiency.

The system is entirely independent, regardless of the selected solar panel type. The soil in which the plants grow acts as a ballast above the Permavoid to keep the solar system in place during high winds.

The water stored in the Permavoid units maintains plant evapotranspiration even during prolonged periods of drought.

Sports with a view

The Permavoid lightweight design makes it a superb subbase beneath sports facilities on rooftops or podium decks. Roofs normally have a limited load bearing capacity, using crushed stone for subbase drainage is often impossible or impractical in these locations in these applications.

Most surfacing types for sports can be used atop Permavoid including amongst others living grass and synthetic turf. Running track surfacing or fall arrest safety surfacing used around playground equipment for children can also be used.

The White Collar Factory in London incorporated a novel and innovative rooftop running track. The Permavoid system is a fully approved sport subbase, selected for this project because it is lightweight, did not require a crane to move the materials and ensures high performance drainage to prevent flooding or pooling on the running track surface.

The sky is the limit

Permavoid can accommodate almost any landscape design, combining shallow soils, deeper profiles for trees and hardscaped areas such that the entire surface acts as an efficient water catchment and storage reservoir for subsequent use by capillary irrigation.

This was particularly evident in Project Maanplein in Heerlen, where mature trees were planted in 1.5 m high mounds of soil on a rooftop, using the Permavoid subbase as catchment, retention and capillary irrigation on the entire publicly accessible podium deck.

Project Maanplein Heerlen, a forested podium deck constructed in 2017, won the 'Tree Project of the Year' award in 2017, awarded by the Trade Association for Gardeners and Landscapers in the Netherlands.
As a distinctive feature, it was praised that this project is low-tech, nature based, without complicated and maintenance-sensitive technology.

The roof is 'optional'

Although the Permavoid blue-green subbase is designed and developed to create better plant growth in combination with urban stormwater management on roofs and podium decks, the entire system can also be used at ground level to achieve the same goals. Permavoid can assist in creating circular on-site water management at all levels of the city.

Project Staring-Square in Rotterdam where the Permavoid 150 System is used as rainwater retention and capillary irrigation system beneath a public park at ground level in an area prone to urban flooding during peak rain events. The system has a capacity of retaining 42.000 litres of rainwater from adjacent roofs and walkways, before overflowing into the deep infiltration units below the Permavoid subbase for groundwater recharge purposes.

permavoid

BLUE GREEN ROOFS FOR FUTURE-PROOF CITIES

A CLOSER LOOK: PROJECT SMARTROOF 2.0

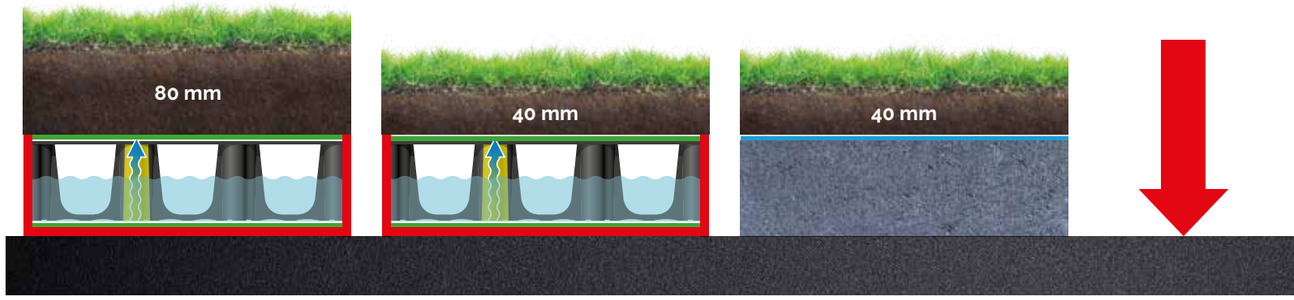
Project Smartroof 2.0 was constructed in 2017 and aimed at determining hydrological, thermal and biodiverse functioning of Blue-Green roof systems in the urban environment. The Permavoid Blue-Green vegetated roof has been scientifically and independently tested against a conventional green roof system and a standard black bituminous roof.

Client : Topsector Water Research Consortium - Project Smartroof 2.0
Vegetation : Mixed sedum blanket, seeded with local grasses and flowering herbs
Size : 440 m²
Roof weight capacity : 90 kg/m²
Water storage : Limited to 25 mm water retention in the Permavoid 85s (due to limited loadbearing capacity of the roof)

Total water retention capacity : 15.400 litres (Soil + Permavoid)
Water management : Automated intelligent water level control
Applied substrate : 40 mm standard lightweight green roof substrate
Waterproof membrane : Permavoid Flex 700, prefabricated to size
Capillary Geotextile : PermaTex CAP, used above and below the Permavoid units
Construction : 2017

The Research project, executed by KWR Water Research Institute, was operated from 2017 to 2020. The most important results summarised:

- The average temperature difference between the measured standard black roof and the vegetated Blue-Green roof system is 40˚C on summer days.
- Where the conventional green roof evaporated 18 litres of water per m² in a period of 14 days, the Blue-Green roof system evaporated 42 litres of water per m² in the same period.
- Soil moisture content in the Permavoid Blue-Green roof with capillary irrigation is extremely stable, resulting in the fact that plants no longer experience the extreme wet-dry cycle in the soil that plants normally encounter on standard green roofs. The consequence of this is clearly visible vegetation differences: the Permavoid System features a mixed vegetation of grasses and herbs, whereas the conventional green roof does not develop beyond the stage of mixed succulent Sedum plants.
- The water storage capacity in the Permavoid system makes it possible to store water to the extent that plants almost reach full potential evapotranspiration potential (= maximum urban cooling capacity). This has been modelled and scientifically published in the international journal 'Water'.
- In the energy balance, the Permavoid system transforms 50% more incoming (solar) energy into adiabatic cooling through plant evaporation than conventional green roofs. This helps to cool the roof and its immediate environment.
- Since the installation of Project Smartroof 2.0, the air-conditioning units for the floor below the roof have not been used. The blue-green roof arrangement on top of the (un-insulated) roof kept enough heat out of the building to eliminate the need for air-co.



Schematic representation of the different systems tested at Project Smartroof 2.0: Permavoid capillary with 8 and 4 cm of soil, a conventional green roof and a black bituminous reference roof.

In 2018 and 2019 independent ecologists sampled Project Smartroof 2.0 for presence of insects and spiders. Despite a long dry spell in 2018, in a sampling period of just 24 hours, 42 different species of insects were found, with a remarkably high number of flying insects and a vivid multi-species population of spiders, indicating they all find enough insects on which to predate. Even a rare species of wasp was found, predating the spiders on the roof (*Pompilidae*). All this evidence indicates a flourishing ecosystem with multiple prey-predator relations. In 2019 Project Smartroof scored highest on flower count and bee-species diversity in the second ecological study, including 21 different green roofs and roof gardens.

The project has produced results strongly supporting the development and inclusion of Blue-Green vegetated systems on existing buildings and in new developments in the urban environment. Blue-Green infrastructure enables the city to benefit more from nature's functions such as urban cooling, biodiversity, amenity, human health and real-estate value. All without using energy and based on the nature-based solution of circular on-site water management.

The City of Amsterdam decided to amend their green roof policy and subsidy following the results of Project Smartroof 2.0 to focus on Blue-Green vegetated roof systems rather than conventional green roofs. In the UK a partial duplicate of Project Smartroof 2.0 was built in Aylesford to assess the water management properties of Permavoid for UK and London weather patterns. Project Smartroof 2.0 has since inspired new (European) R&D initiatives such as Project Resilio, in which blue-green vegetated roof systems are implemented on interconnected city blocks, not just individual roofs.

Project Smartroof 2.0 in september 2018, still green, lush and flowering, after an extraordinarily dry summer with a precipitation deficit of 300 mm over a period of 5 months.

A CLOSER LOOK: PROJECT ORLYSQUARE

Orlysquare is a former bus terminal, located on the roof of Trainstation Sloterdijk in Amsterdam. The Bus station was moved to a new location and at the end of 2012 it was decided to transform the vacant empty “grey” roof-square into a more attractive, people-oriented environment. Ultimately, a roof park was realised where rainwater is collected and reused for irrigation, with space for biodiversity, many flowering plants and possibilities for a pleasant stay for people in a green environment, supported by the necessary catering establishments.

Client	: Westpoort District, City of Amsterdam
Vegetation	: Mix of flowering perennial plants, bulbs and shrubs
Size	: 1.566 m²
Roof weight capacity	: 400-600 kg/m²
Water storage	: 60 mm water retention in the Permavoid 85
Total water retention capacity	: 223.400 litres (Soil + Permavoid)
Water management	: Passive overflow
Applied substrate	: 260 mm sand based black garden soil with 8% organic matter and a natural mulch layer on top
Waterproof membrane	: Permavoid Flex 700, prefabricated to size
Capillary Geotextile	: PermaTex CAP, used above and below the Permavoid units
Construction	: 2015

In this project the City of Amsterdam treated rainwater as a resource, being one of the most important success factors for liveable cities. And why not? Rain is perfectly usable water that falls from the sky, on-site and for free! The municipality of Amsterdam took the opportunity with Orlysquare to create new green infrastructure to improve human wellbeing.

However, the effect of the transformation from grey to green stretched well beyond water management, biodiversity and wellbeing alone: “this change is also positively affecting the use of the surrounding real estate; the hotels surrounding the square have expanded, new shops have been established and new tenants now occupy the former empty offices”, according to Michiel Bosman, Manager Urban Projects with the City of Amsterdam.

Smart transformation from grey to multifunctional greenery with the right techniques has a positive effect on cyclical water management, the quality of life, visitor experience, biodiversity, urban cooling and economic activity in the immediate vicinity.

Water is at the core of this positive development, with Permavoid as the connecting element.

Orlysquare, before and after the Blue-Green transformation.

Orlysquare’s blue-green roof park is built with a Permavoid 85 subbase to capture, store, distribute and reuse rainwater for capillary plant irrigation. The Permavoid capillary system for irrigation is “on-demand”; only when the plants actively evaporate water during growth will the capillary columns replenish the evaporated water from storage.

The park is a publicly accessible square with the main entrance to the train station, the invisible Permavoid sub-surface capillary irrigation system offers several advantages: it is vandalism proof, maintenance free and does not use vulnerable valves or unsightly driplines.

Cross-section of Orlysquare buildup.

OUR SUSTAINABLE JOURNEY

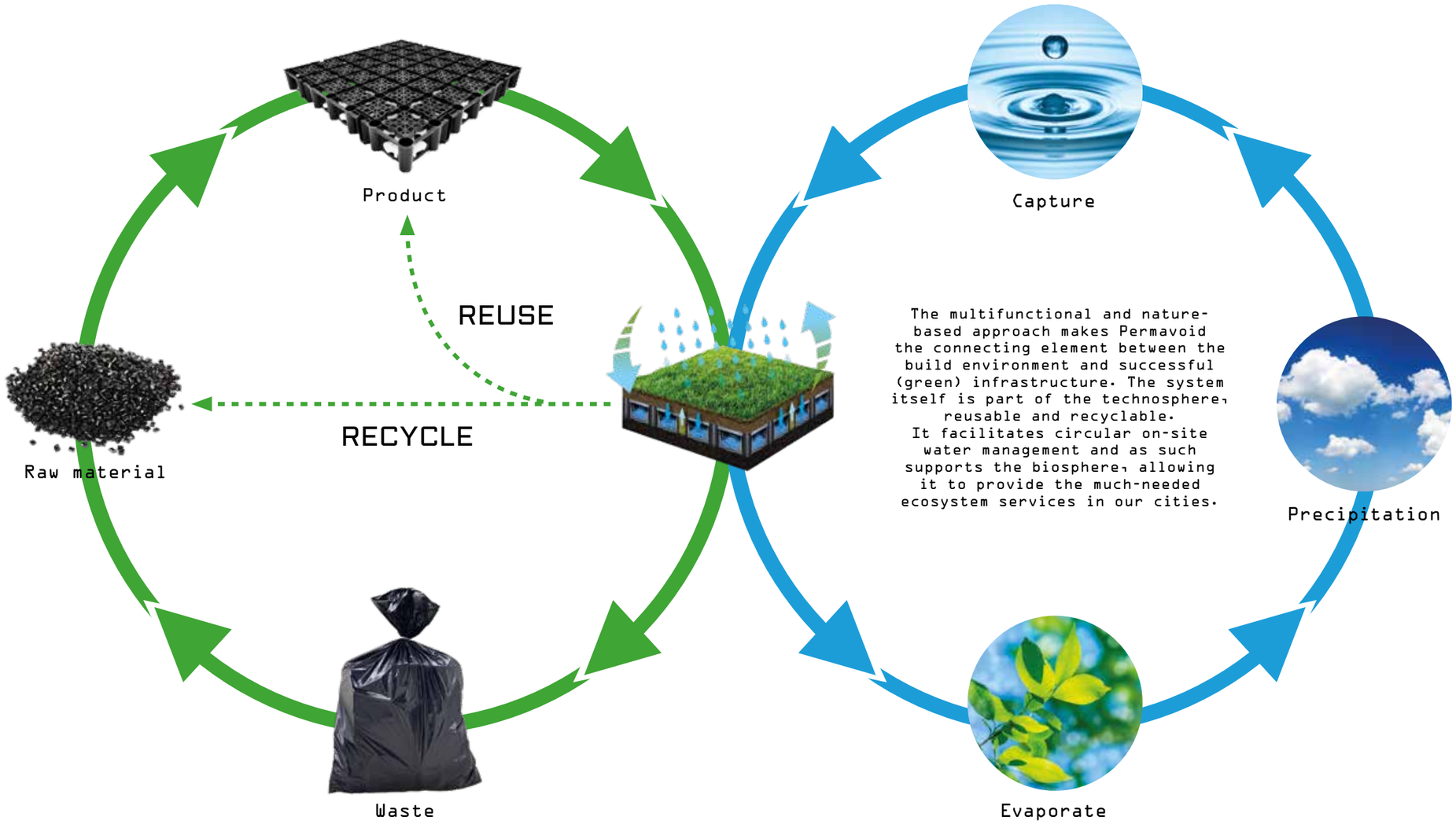
Circular thinking forms the basis of all our products and designs. This concerns both the materials used and functionality of our systems. For urban water management we collect, store and reuse rainwater on location as much as possible and minimise use of drinking water.

The units are made from high quality recycled materials and therefore fit 100% in the cradle-to-cradle philosophy. The plastics used can be fully recycled, but in practice they rarely are since the units can easily be disconnected and reused elsewhere thanks to their construction and the removable PermaTies. We aim at local manufacturing, preventing unnecessary worldwide shipping, shortening transport distances, further reducing our carbon footprint.

Developing multifunctional systems can only be accomplished in close corporation with valued partners. Based on equality and willingness to share, we work with market leaders in R&D like KWR-Water, STRI, University of Coventry and Wageningen University and Research, manufactures like Veolia, Ten Cate, Sioen and Lapinus and distributors like Polypipe, Optigruen, Perflow, ABT and many others. Together with local stakeholders, governments, cities and institutes we invest in pilot projects to ascertain the local challenges and create perfectly adapted multifunctional solutions.

The solutions designed with Permavoid can function for decades and will continue to fulfil their function for generations. The materials and designs used by Permavoid have been thoroughly tested by independent institutes for strength, reliability, pollution and temperature resistance and have been approved and used for subbase replacement in structural engineering for more than twenty years.

In our vision waste is upcycled to integrated solutions for future-proof cities.
C.H. van Raam, 2020.

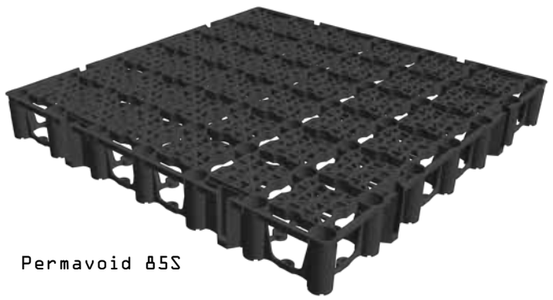


The multifunctional and nature-based approach makes Permavoid the connecting element between the build environment and successful (green) infrastructure. The system itself is part of the technosphere, reusable and recyclable.
It facilitates circular on-site water management and as such supports the biosphere, allowing it to provide the much-needed ecosystem services in our cities.

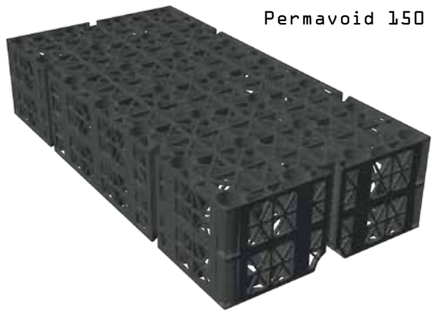
PRODUCTS

Permavoid units

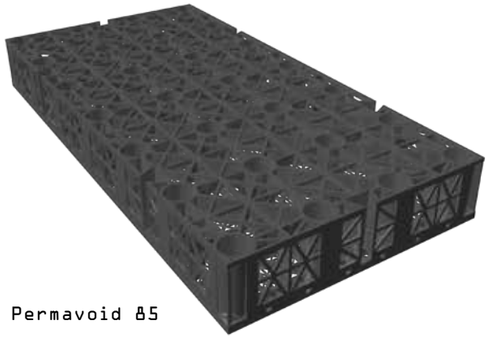
Permavoid units are high strength, lightweight hollow subbase units able to support sports, landscaped and paved surfaces on rooftops, podium decks and at ground level. In combination with the Permavoid capillary columns the system can be used in water sensitive urban designs, enabling stormwater attenuation, conveyance, infiltration and natural capillary (passive) irrigation.



Permavoid 85S



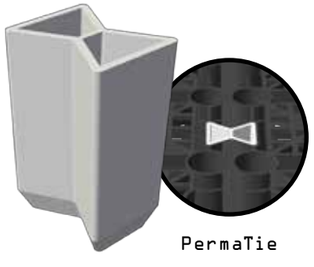
Permavoid 150



Permavoid 85

Ancillaries

Various Permavoid ancillaries are used to tie units/panels together into stable rafts, create stable stacks, enable capillary irrigation and allow the attachment of components and products directly to the Permavoid units.



PermaTie

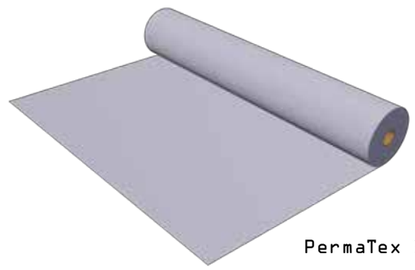
PermaLock

Capillary Column

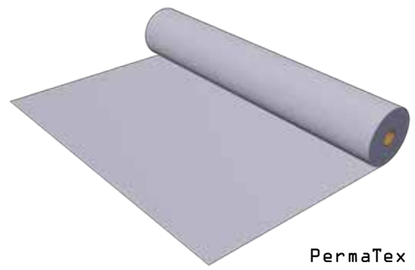
The products displayed are a selection of the full range of Permavoid products most relevant to the applications discussed in this brochure.

Geotextiles and membranes

Geotextiles are an integral part of every Permavoid design, protecting the waterproof membrane from punctures, determining the water infiltration rates and quality and facilitating successful capillary irrigation. The waterproof membrane is used to determine the attenuation, retention or detention functionality of the designed system.



PermaTex 300HD



PermaTex CAP

Permavoid Flex 700

PVOD components

Permavoid "PVOD" components are designed to provide easy to install connections and access points into the Permavoid system, essential for reliable integration in SuDS schemes and access for maintenance.

Podium Deck Gully

Podium Deck Gully

Full product range information and detailed datasheets are available upon request.

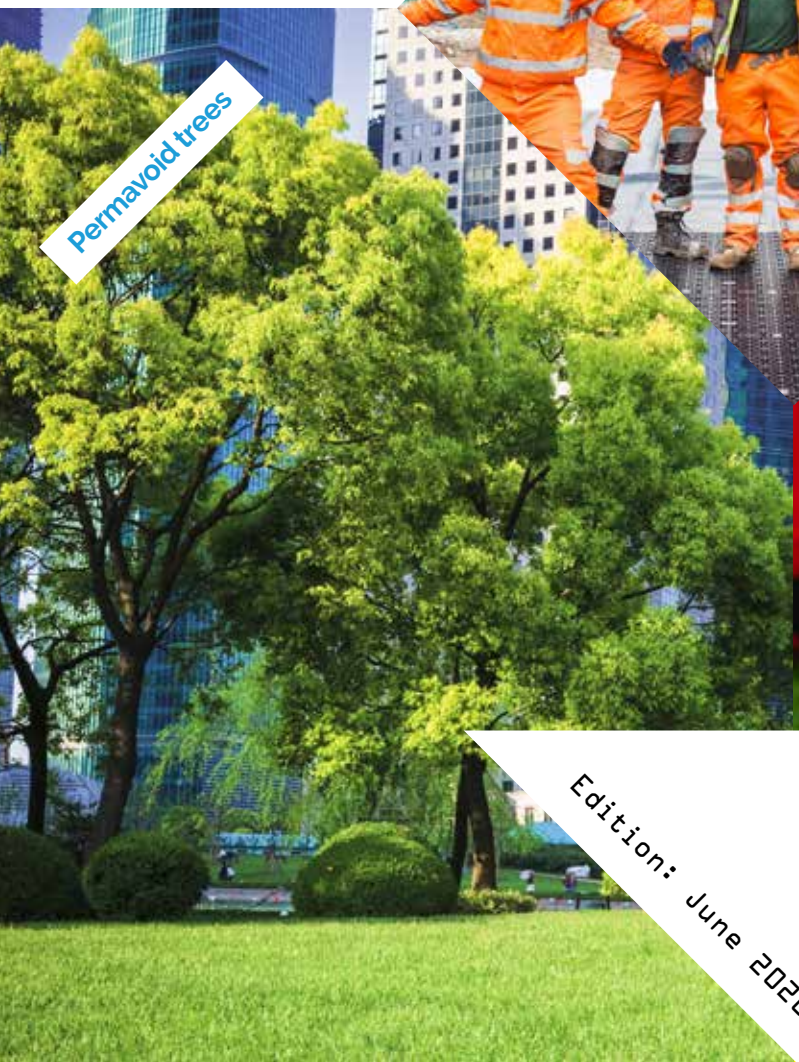
permavoid

THE FOUNDATION FOR OUR FUTURE

The Permavoid range of products and systems are capable of creating circular, nature-based solutions for sustainable water management in metropolitan areas. Solutions encompass urban trees, Blue-Green roofs, podium decks, gardens, sports pitches and SuDS aiming at water-sensitive design.

Permavoid source control ensures that no precious water goes to waste by catching, storing and reusing stormwater for irrigation, evaporation or infiltration. For more information about Permavoid solutions please contact us or visit permavoid.com to find your local Permavoid distributor.

Other solutions by Permavoid



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