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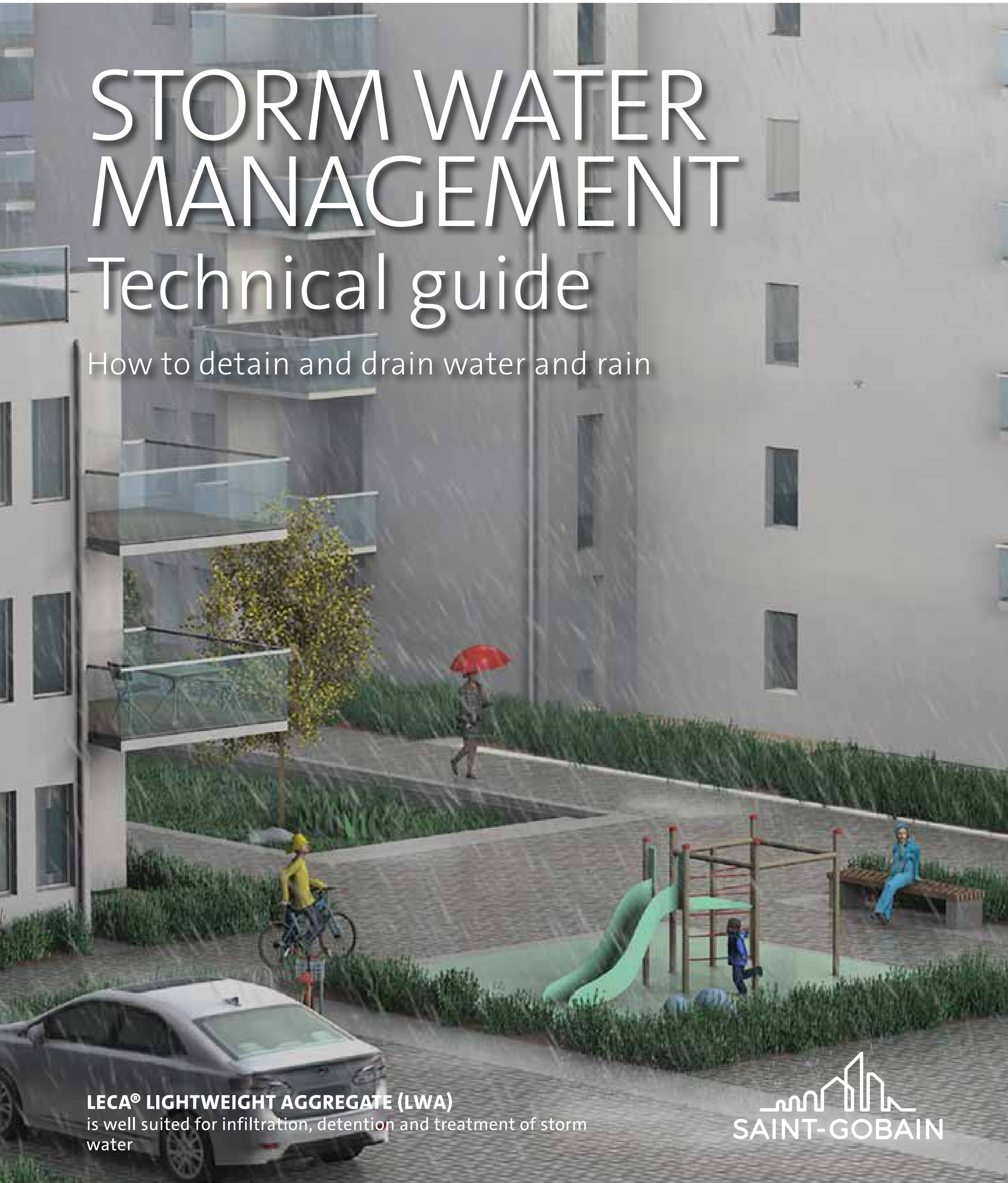
STORM WATER MANAGEMENT

Technical guide

How to detain and drain water and rain



LECA® LIGHTWEIGHT AGGREGATE (LWA)
is well suited for infiltration, detention and treatment of storm water

SAINT-GOBAIN

Water management with Leca® LWA

Local water management strategies are cost efficient alternatives for prevention of runoff, flooding and sewage overflows.

This guideline illustrates how to handle stormwater runoff where it first falls with Leca LWA as sub-surface detention media. Correct dimensioning and design parameters are crucial for high performance water management solutions and the purpose of this in this guideline is to provide both information and inspiration for the application of Leca LWA in water management systems such as rainbeds, green roofs and permeable pavements.

Why handle rainwater?

Climatic changes followed by increased rainfalls are transforming our traditional ways to prepare for extreme weather. Focus has shifted from simply coping with regular weather events to how we can reduce societal risks associated with climate change. Preparing for consequences caused by extreme weather are on the political agenda, and most governments have started ambitious programs to deal with the challenges. As an increased amount of precipitation and flood water within the built environment must be handled, new innovations and solutions can be seen worldwide.

Due to urban densification, stormwater runoff in larger cities can cause major problems for the existing infrastructure. Runoff water accumulates rapidly when natural areas are replaced by impermeable surfaces, such as asphalt and roofscapes. Additionally, excess runoff results in proliferation of pollutants and pathogens that may pose a public health risk. In order to increase city resilience against stormwater, local authorities usually encourage local water management efforts. Especially cities have initiated official water management strategies and introduced incentives or regulations towards the reduction of overflows of drainage- and sewer systems..

A governing parameter for water efficiency is the capability to manage water by using sustainable and ecological methods with small environmental footprints. A healthy water cycle can be maintained by implementing measures that simulate mechanisms in natural environments such as forests and grasslands, for example water detention, retention and infiltration.

Local water management strategies can prevent surface runoff, ponding and overflows of drainage pipes and sewer systems.

Utilising green outdoor areas for water management

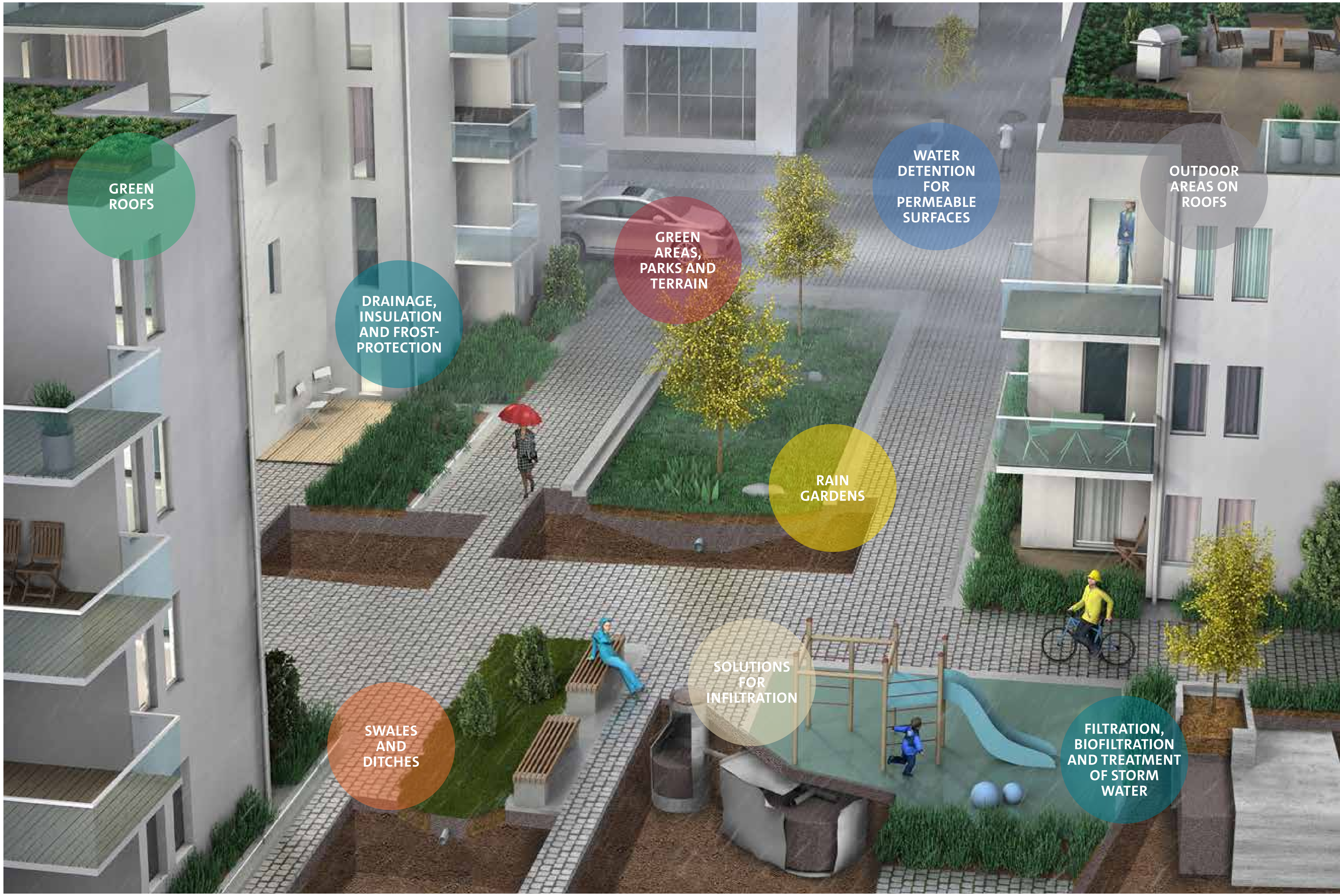
Leca® LWA contributes to infiltration, drainage and detention.

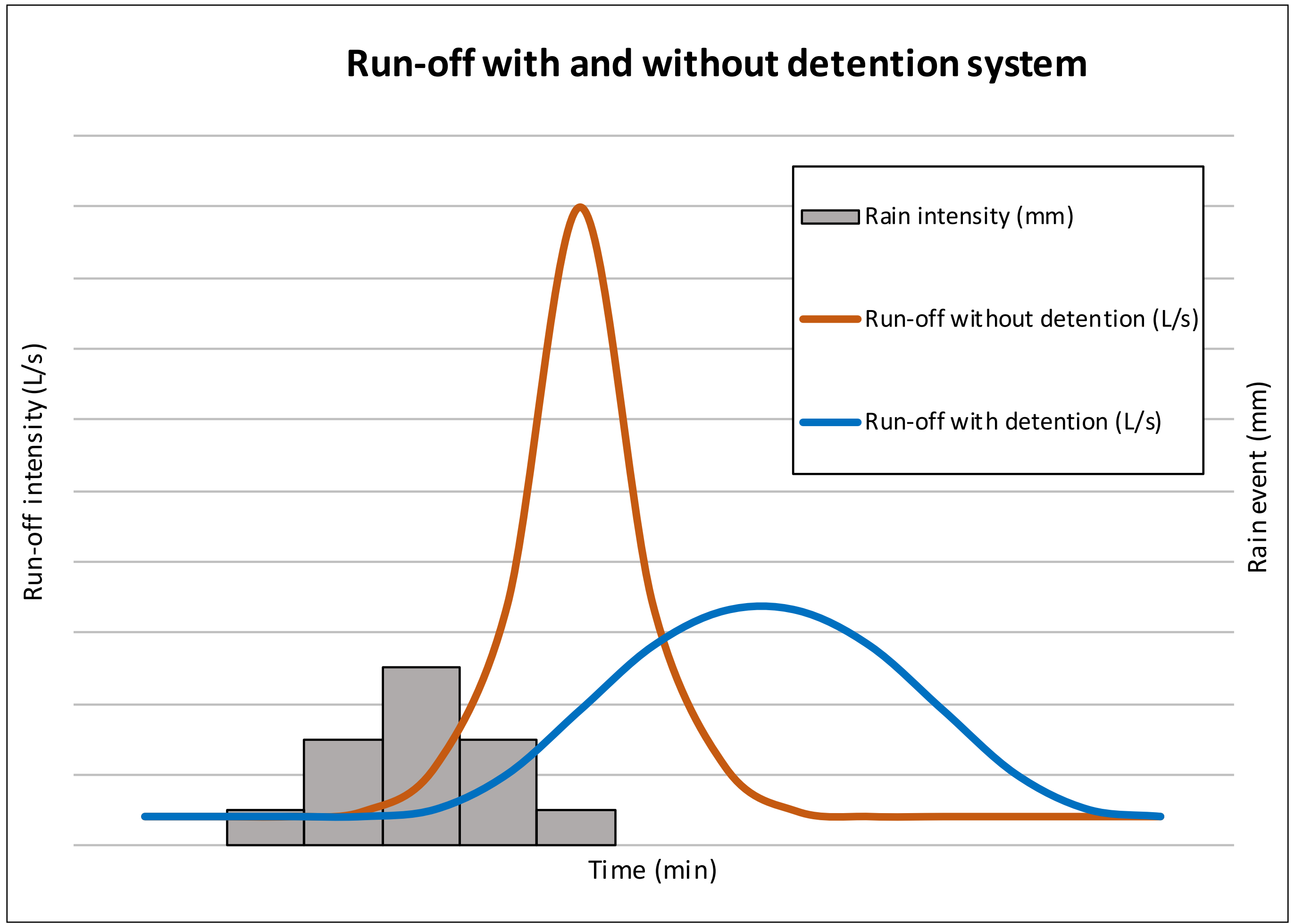
Handling of stormwater by solely draining the water through pipes or combined sewer systems is an outdated method. Nowadays, limitations in geography, infrastructure and wastewater treatment have dramatically increased the cost of building new reservoirs and drainage pipes. Although many alternative solutions have become available, identifying the best and most sustainable water management practice is a challenging for both city and community planners.

Leca LWA can be used to manage the rainwater from a catchment. Water interacts with Leca LWA in a way that allows the material to provide water detention. In addition, Leca LWA can facilitate infiltration processes of water into the ground. By using Leca LWA, suitable areas can become functional reservoirs and temporary storage places for catchment areas.

Leca LWA can help cities fulfil their climate adaptation strategies – and by using water management areas as recreational spaces, a community can build healthy and aesthetically pleasing surroundings that promote well-being and biological diversity.

Assessments of stormwater runoff reduction, flood risk and pollution control should all be included in the cost-benefit analyses, as well as the added benefits of having appealing outdoor areas.





The diagram shows the basic water detention principle with Leca LWA. Reduction of runoff intensity with for an area managed with Leca LWA (blue line) is compared with an impermeable, unmanaged area (red line).

The orange line represents the quantity of water run off on the impermeable area with no water management. The water rapidly saturates and the peak intensity discharge is proportional to the peak rain intensity. Illustrated by the blue line, the porous Leca LWA detains the water, decreases the peak flow intensity, and reduces the average runoff intensity by slowly releasing water during an extended time period. The Leca LWA will rapidly regenerate its capacity for water, even when exposed to successive extensive rainfall.

Leca® LWA and water management

What is Leca® LWA?

Leca LWA is a lightweight aggregate from burnt, expanded clay. The raw clay is dried and burned in large kilns and expands at about 1200 °C. The resulting product is a strong ceramic material with a hard shell and an inner structure of small, air filled pores. Both crushed and round grains are very strong and light. The applications described in this brochure uses both round and crushed Leca LWA with different grains sizes.

General characteristics

All kinds of Leca LWA can be used in most solutions for storm water management. Small, large, crushed or round Leca LWA grains have different characteristics, but they all have this in common:

- Natural products
- Lightweight
- Neutral and chemically inert
- Good root growth for plants
- High air permeability
- High hydraulic permeability
- Stable quality
- Sound and heat insulating
- Completely fire resistant

The water management strategy for flood management is usually defined by local requirements. Contractors and land owners are obliged to follow regulations, but physical limitations, such as topography, ground conditions and meteorological trends are equally important when choosing a water management design.

Detention
Leca LWA has the ability to delay water runoff by a principle known as water detention. Proper detention provides a steady and manageable flow of water and reduces the risk of flooding. Leca LWA has a highly porous internal structure and an abundance of voids between the grains. This property allows Leca LWA to detain a flow and reduce the peak intensity of runoff from an area. Thus, Leca LWA will diminish the intensity of water from downpours and moderate loads through the slow release of water during and after a rain event. Without a detaining sublayer the advantage from a vegetated or permeable surface can be limited, and with Leca LWA, the use of such surfaces can be maximised. Leca LWA constitutes a dependable and robust sublayer, and its intrinsic water detention works regardless of ground infiltration.

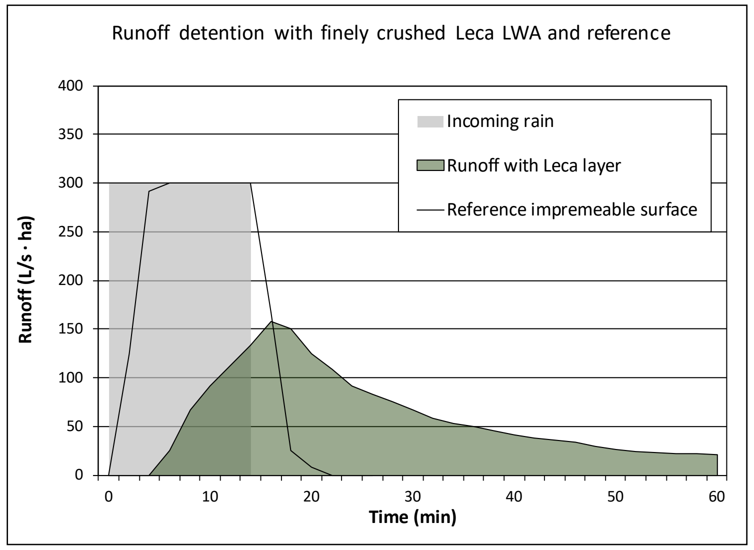
Infiltration
Ideal ground conditions allow for infiltration of surface water to the groundwater level. Air-filled voids and pores in the Leca LWA act as temporary storage space for water. After adsorption, water can seep into the ground by infiltration or be discharged to a nearby recipient. By facilitating infiltration, a more manageable quantity of water is achieved through steady volume reduction of the total runoff.

Drainage
Leca LWA is great for drainage applications. There are ample space for water to flow between the grains and fillings. Leca LWA can divert water to more suitable locations, for example if used in construction of swales or closed drainage diches. If the preservation of natural drainage lines of an area is important, i.e. the preferred pathways of water, Leca LWA can be installed as a load bearing backfill material without disrupting existing drainage plans. The hydraulic conductivity of Leca LWA will prevent waterfronts or surface ponding. Uncrushed Leca-materials have the highest conductivity and allow large volumes of water to quickly drain during extreme events.

Leca® LWA and water detention

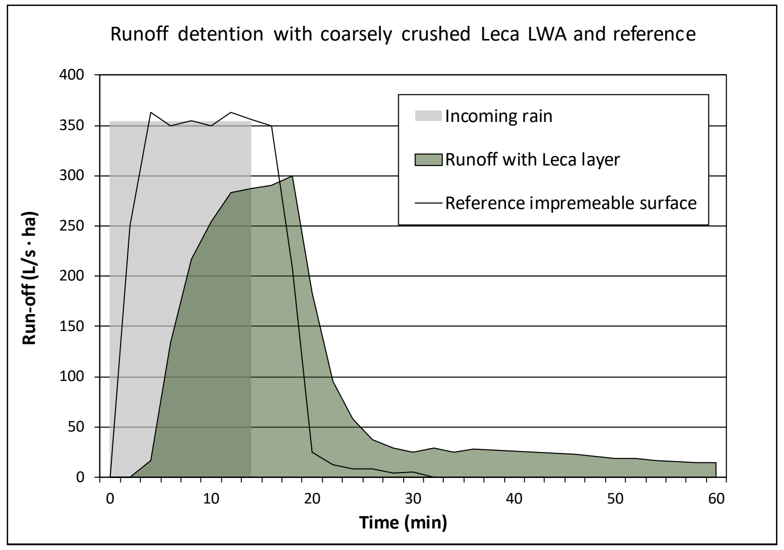
The following diagrams show the laboratory results of runoff for three different Leca-materials according to tests described in the FLL Guideline (FLL 2008). The tests demonstrate the peak runoff intensity reduction and the detention capacity of various types of Leca LWA. Its ability to continuously detain or drain large volumes of water can clearly be observed.

As part of the testing, the Leca-samples was soaked for 15 min and left to drip off for 24 h. It follows that the absorption capacity for long term storage of water was somewhat saturated preceding the execution of the tests. There was no contribution from infiltration or any other unaccounted loss of total water. The results have been scaled up to match an area in hectares (ha).



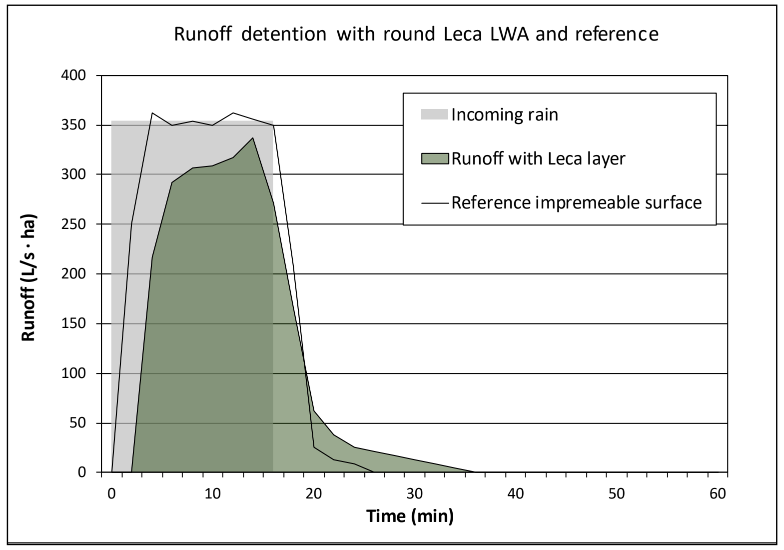
Finely crushed Leca

The diagram shows laboratory results of runoff behaviour for a finely crushed Leca-fraction. An extreme event of 27 L/m2 for a 15 minutes rain interval, in a 2 % slope, is simulated. The grey area represents the corresponding, incoming rain period, and the single black line is the runoff intensity of a reference area without detention measures. The green area shows runoff of water detained by a 200 mm layer of fine, crushed Leca LWA. The detention effect can clearly be seen, and the total amount of delayed runoff is calculated to be 71 % compared with the reference. In addition, the maximum peak intensity of the runoff is reduced by 53 %.



Coarsely crushed Leca LWA

The diagram shows laboratory results of runoff behaviour for a coarsely crushed Leca-fraction. An extreme event of 36 L/m^2 for a 15 minutes rain interval, in a 2% slope, is simulated. Coarsely crushed Leca LWA has properties similar to finely crushed Leca LWA, but the larger grains support faster drainage in addition to a water detention effect. 41 % of the incoming water is detained, and the peak intensity is reduced by 35 % compared with the reference.



Round Leca LWA

The diagram shows laboratory results of runoff behaviour for a large, round, uncrushed Leca-fraction. An extreme event of 36 L/m^2 for a 15 minutes rain interval, in a 2% slope, is simulated. The primary behaviour is drainage, but water detention can be observed. The high permeability will ensure a steady and almost unrestricted flow of water through the medium. This is ideal for systems where high volumes of water must be readily drained or diverted through the subsurface Leca LWA.

Finely crushed Leca® LWA

(e.g. < 6 mm) optimal for maximum water detention. The material is especially suited for green roofs and as a substrate for permeable paving stones. All fractions of Leca LWA have high resistance towards clogging and settlements.

Coarsely crushed Leca® LWA

(e.g. 4-10 mm) is without fines and has larger particles with higher hydraulic permeability. This is an advantage when large weight variations due to water absorption should be avoided. Coarsely crushed Leca LWA maintains a low bulk density.

Round Leca® LWA

(e.g. 10-20 mm) is good for drainage and water storage. Between the grains there are large voids with space for water when used in subterranean storage solutions. Round, coarse Leca LWA are also commonly used as a draining backfilling and for landscaping.

Applications	Finely crushed Leca LWA	Coarsely crushed Leca LWA	Round coarse Leca LWA
Filtering and biofiltration	●●●	●●	●
Infiltration	●●	●●●	●●●
Water detention in green roofs	●●●	●●●	●
Water detention in rain gardens, ditches and swales	●●●	●●	●
Detention under permeable surfaces	●●●	●●●	●
Frost protection and insulation	●	●●	●●●
Drainage	●	●●	●●●

●●● WELL-SUITED ●● SUITED ● LIMITED USE

Rainwater detention by Leca LWA

The table summarizes approximations of behaviours of Leca LWA with varying gradings at 200 mm and 100 mm layer depths. The data is from controlled laboratory experiments of extreme rain scenarios and show the contribution (%) on water detention from the Leca LWA compared with an impermeable, reference surface. The peak intensity reduction is the reduction of maximum outflow intensity. This is important, as unrestricted discharges with high intensity cause overflows of drainage pipes. The amount of delayed water is directly related to the runoff coefficient (C), and it represents the total water that is temporarily held back after a 15 minutes, intense rainfall. Detention and runoff properties will change if the rain intensity and the gradient is changed.

Leca-type	Finely crushed Leca LWA		Coarsely crushed Leca LWA		Round Leca LWA	
Rain intensity	300 L/s ha		350 L/s ha		350 L/s ha	
Thickness of Leca-layer	200 mm	100 mm	200 mm	100 mm	200 mm	100 mm
Peak runoff intensity reduction	53%	45%	35%	18%	17%	6%
Delayed water after 45 min.	70%	55%	40%	30%	20%	15%

In order to adapt to the changing climate, new and innovative methods must be employed to manage water runoff.

The runoff coefficient (C)

Calculations are important in order to predict surface runoff from an area. This is a necessary precaution to avoid flooding and to meet other requirements. A basic indicator used for quantifying the intensity of runoff from a surface is the runoff coefficient (C).

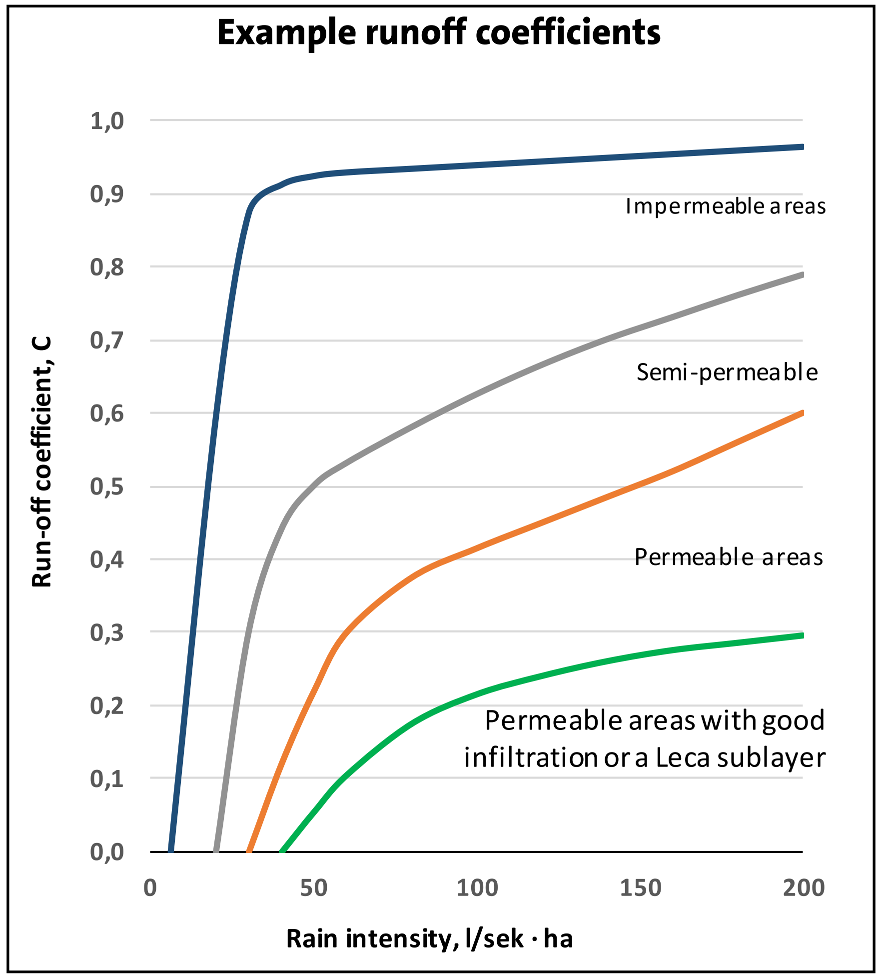
The runoff coefficient (C) is a dimensionless value from 0 to 1 that indicates the surface runoff from a catchment. C relates to the amount of runoff versus the amount of received precipitation – areas with little infiltration (e.g. pavements) and high runoff (e.g. areas with steep gradients) have a coefficient close to 1, and permeable surfaces (such as vegetated soil) are closer to 0. The runoff coefficient (C) is expressed:

$$C = \frac{\text{outlet water volume / time}}{\text{total rain volume / time}}$$

C has accuracy limitations and omits factors that may affect the true runoff value. Examples of this could be effects from evapotranspiration (retention), detention (temporary storage), drainage lines, slopes (topology) and flow conditions, as well as meteorological data, groundwater and subsoil considerations.

Generally, the coefficient overestimates the water discharge, but its simplicity makes it a quick way to estimate runoff. Tables of surfaces with their characteristic C-values are accessible online. Typically, large, flat areas with permeable land and vegetation have the lowest C-values – and smaller impermeable areas, such as asphalt, dense clays and slopes, have the highest C-values assigned. When using innovative materials for water management, the corresponding reduction of C from their contribution must be considered. Therefore, C-values of Leca LWA have been measured and documented in controlled environments.

As the focus on water management has intensified, advanced modelling tools have become more widespread. Modelling software such as SWMM, MIKE Urban, MIKE 21 or StormTac can employ advanced calculations based on other variables in addition to the runoff coefficient.



Examples of development of runoff coefficients (C) for different surfaces with increasing rain intensity. The permeable surface, combined a Leca LWA subsurface layer, will resist increase in runoff, even at high rain intensities.

The more rain, the higher the runoff coefficient will be, as surfaces saturate with water during a rainfall. Leca LWA will act in synergy with surface components and reduce the runoff from the complete construction as a subsurface layer. The effect will increase with the thickness of the Leca-layer and the contribution from Leca LWA will increase the resilience of permeable and semi-permeable surface materials.

Area	Surface type, intense rain	Run-off coefficient, C
Impermeable areas	Flat roofs, concrete, dense urban areas, asphalts	0,9-1
Semi-permeable areas	Scattered buildings, gravel roads, compacted surfaces	0,3-0,9
Permeable areas	Parks, forest, permeable pavements, areas with high infiltration	0,2-0,3

The table lists various surfaces and their typical range of runoff coefficients (C) during intense rainfalls. Leca LWA as a substrate will reduce the C of such surfaces depending on fineness and/or thickness, as well as the rainfall intensity.

Rainwater detention by Leca® LWA – principles

The water runoff from and area can be reduced by local water management practices that temporary detains water.

Dimensioning calculation of runoff based on rainfall intensity (L/s), area and coefficient of discharge.

The following instructions show how to determine the amount and the intensity of water running off an area, and can be used when planning efficient local water management. Municipalities may have their own regulations and methods for drainage calculations.

Basic calculations

Calculations of runoff are commonly executed by using the rational method. The rational method, also called the rational formula, is in its simplest form expressed as:

$Q = C \cdot i \cdot A$.

Q = storm water runoff (L/s or m^3/s)

C = runoff coefficient

i = rainfall intensity (L/s or m^3/s)

A = area of catchment (m^2)

The rational method was originally developed as a simplified analysis of water runoff lines of equal travel time over a defined area. The basic formula above includes no temporary storage and assumes that the peak runoff ratio and rainfall intensity is equal to the ratio between volume of rainfall water and the volume of runoff. If needed, other variables may be introduced in the rational formula, e.g.:

$Q = C_S \cdot S_L \cdot i \cdot A \cdot K_f$

Q = storm water runoff (L/s or m^3/s)

C_S = slope, subsoil or surface adjusted runoff coefficient with Leca*

S_L = storage coefficient**

i = rainfall intensity (L/s or m^3/s)

A = area of catchment (m^2)

K_f = climatic factor (projection of future changes in rainfall due to climatic changes)

In constructions, the final C-value of a catchment is case specific. The needed volumes of Leca LWA can be estimated by calculating and comparing the expected pre- and post-development of runoff volumes in relation to the amount of water that must be detained. Note that in many cases calculations overestimate runoff and storage requirements.

**Leca LWA is not the surface material and can be considered contribute with the runoff coefficient CS, depending on intended use and the calculation.*

***For Leca LWA this is related to the unsaturated water absorption capacity and has a factor of 0.95 or less.*

Typical C_s-coefficients		Finely crushed Leca LWA		Coarsely crushed Leca LWA		Round Leca LWA	
Thickness of Leca-layer		200 mm	100 mm	200 mm	100 mm	200 mm	100 mm
Rainfall intensity (L/s) pr. hectare	200 L/s	0,15	0,2	0,2	0,3	0,3	0,4
	300 L/s	0,25	0,4	0,4	0,5	0,5	0,6
	400 L/s	0,4	0,5	0,5	0,6	0,7	0,8

The table shows estimated runoff coefficients (CS) of Leca-materials. The values are based on laboratory measurements on 100 mm and 200 mm layers of pre-wetted Leca LWA, with 2 % slope. The results have been scaled up to match an area in hectares (ha). Observe that the outflow is slower than the inflow to the system, and that the tests show the contribution from only Leca LWA, and there are no additional contributions from other materials.

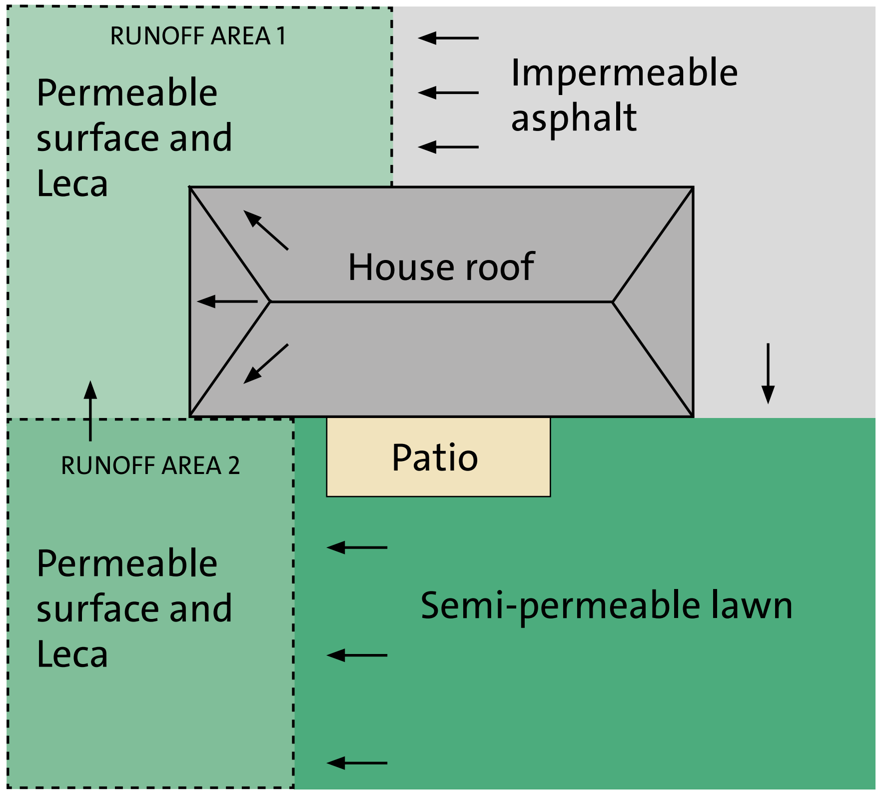
As an alternative to natural infiltration and surface effects, Leca LWA can be used to reduce local runoff coefficients. Capillary suction from pores and friction between water and grains enables the material to simulate mechanisms found in the natural environment, such as forests and grasslands.

The runoff coefficients (CS) for Leca LWA stated in this publication are solely for the Leca-materials. Surface layers, such as sedum, pavers and grass, and additional components, such as soil, textiles, sand, have their own runoff coefficients that contribute to the overall detention of water. This means that the contribution from a Leca-layer will act in addition to other detention media that have their own C-values.

The following example illustrates how to plan and build constructions using Leca LWA as sublayer. Leca LWA will detain, drain and promote infiltration to the ground, and simultaneously prevent waterlogging and ponding. The porous internal structure will absorb and store water, and after rainfalls water can be infiltrated or released into the drainage system. The reduction of runoff from a Leca LWA sublayer will act in synergy with the chosen surface layer and other natural detention mediums in place.

Leca LWA simulates mechanisms that exists in natural environments, and below permeable surfaces and swales Leca LWA will fuction as a high capacity detention medium.

By using Leca LWA under a permeable surface, the effects from natural surfaces such as grass, soil or sand increased. Natural surfaces obtain their runoff coefficients from infiltration, capillary suction and friction, and this is also the case with Leca LWA as the materials will act on the water below the top surface and continue to detain water.



Natural permeable surfaces may have initially low a runoff coefficient C. At intense rainfalls a sub-surface layer of Leca LWA will ensure detention and infiltration, and thus a continued low C-value. The solution will rapidly regenerate and be ready for consecutive downpours.

A catchment may consist of variable zones with different runoff coefficients (C) with 2% slope. The average runoff coefficient for connected zones can be calculated by measuring or estimating the runoff intensities for the individual areas:

$$C_{average} = \frac{C_1 \cdot A_1 + C_2 \cdot A_2 + \ldots + C_n \cdot A_n}{A_1 + A_2 \ldots + A_n}$$

To calculate the runoff, the dimensioning rain event for the area must be defined. In this case the area will need to manage incoming rain of 108 mm/h, that corresponds to the intensity; $i = 0.03$ L/s m^{-2}.

Suppose a contribution from two areas with Leca-based sublayers of 200 mm and 100 mm depths, and with C-values of respectively 0.25 and 0.40, in a 2 % slope. The areas are correspondingly 40 m^2 and 60 m^2 (see illustration). The incoming volume of water to the two areas, for a 108 mm/h rainfall, would amount to 10.8 m^3/hour (3.00 L/s) water during the period:

Area 1 (200 mm layer of Leca LWA):
$C_1 = 0.25$
$A_1 = 60\ m^2$

Area 2 (100 mm layer) of Leca LWA:
$C_2 = 0.40$
$A_2 = 40\ m^2$

$$C_{average} = \frac{0.25 \cdot 60\ m^2 + 0.40 \cdot 40\ m^2}{60\ m^2 + 40\ m^2} = 0.31$$

Using the rational formula, $Q = C \cdot i \cdot A$:

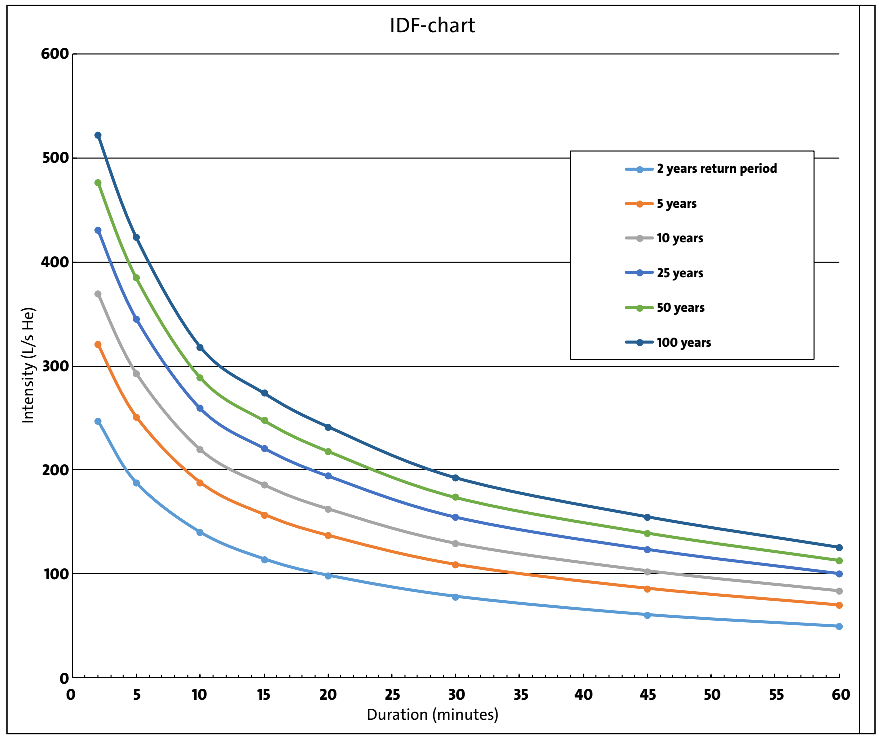
$Q = 0.31 \cdot 0{,}03$ L/s $m^{-2} \cdot (60\ m^2 + 40\ m2) = 0{,}93$ L/s $= 3.35\ m^3$/hour runoff water *for the 100 m^2 area.*

For area 1 and 2 combined, the total runoff intensity will be reduced from 10.8 m^3/hour to 3.35 m^3/hour. This assumes a dimensioning rain event of 108 mm/h, $C_1 = 0.25$, $C_2 = 0.40$, and that the C = 1 for the areas if no water management measures were in place.

Intensity-duration-frequency curves (IDF) are common tools for flood forecasting and for planning urban drainage designs. In order for a solution to cope with extreme rainfalls IDFs are used for dimensioning purposes.

IDFs relate rainfall intensity with durations and frequencies of occurrences. A dimensioning rain event are linked to a geographic area with a given duration and volume of incoming water. By using IDF intensities with the rational formula, expected runoffs can be estimated. Be aware of seasonal variations and varying definitions of flooding and extreme events.

Local regulations that govern the allowed runoff intensity may be in place regardless of rain projections. Use of IDFs with the conventional rational formula is best suited for calculating runoff from catchments up to 50 hectares. Advanced procedures or modelling software should be used for larger catchment areas.



This is an example of an intensity-duration-frequency curve (IDF) from a part of Oslo in Norway. IDFs indicate the requirements a solution must fulfil for a defined catchment area in order to be effective. The curves are created on the basis of local meteorological data and they are highly region specific.

Permeable constructions

The following examples illustrate how Leca LWA can be used in constructions as a subsurface detention medium.

A solution can be constructed as an open-ended system by using the inherent detention capability of Leca LWA. Alternatively, a detention solution can be constructed with a restricted outlet for water. If this is the case, the restrictor defines the C and discharge velocity, and when water is accumulated this way the Leca LWA mainly provides water storage space and promotes water retention. Combinations of such solutions should be considered. Assessments of components should be done independently and a suitable runoff coefficient (C) for the complete solution should be estimated.

Example construction 1
This illustration shows how rainbeds, swales, green roofs and other vegetated areas could be constructed with Leca LWA as a sub-surface. A minimum of 100 mm of Leca LWA is recommended, and a thicker layer will contribute accordingly. After complete submersion, Leca LWA will rapidly regenerate as it releases water. When the topsoil is saturated, the Leca LWA continues to detain and drain as long as water reach the layer. For all constructions, Leca LWA will prevent waterlogging, provide temporary storage and detain of water. Such constructions are often referred to as blue-green solutions.

Laboratory testing show that complete permeable constructions with Leca LWA has lower runoff coefficients (C) than an isolated permeable surface alone or a Leca LWA layer by itself. The layers in a build-up can act in synergy. In a scenario where Leca LWA and pavers by themselves are tested to have runoff coefficients of e.g. 0.4, the complete construction with permeable pavers on top of Leca LWA will be reduced, and together gain a runoff coefficient of e.g. 0.2.

Example construction 2
A permeable surface area with paving stones for pedestrian traffic is good use of available space. The finest fractions of Leca LWA are suited for setting of pavers and tiles, and in some cases a sand support layer can be omitted. Instead a plastic grid or a net can be used as stabilization for the top pavers. Such constructions are often referred to as blue-grey solutions. They are ideal for creating a variety of open areas, such as on flat rooftops, above underground parking garages and as patios in gardens with shallow bedrock. The sublayer is shown in the example, and if needed, an extra layer of thermal insulation could be added.

Example construction 3
Load bearing structures can be given water management functions. The illustration shows a construction for trafficked areas with added space for detention and infiltration. Leca LWA has been used as geotechnical, lightweight backfill materials for decades. Accordingly, the geotechnical principles of Leca LWA can be combined with water management applications as well. A base layer of appropriately sized sand and crushed rocks below the surface is necessary for stability, and a permeable geotextile should be used between gravel and Leca LWA.

Underground detention ponds and infiltration

Leca LWA can be used in underground spaces for collection of rainwater for infiltration and storage purposes. The high porosity and large available volume make Leca LWA an effective solution for construction of underground detention ponds with infiltration capacity. Leca LWA are installed quickly and cost efficient and can be blown in place with pressurized air.

As a sublayer the Leca LWA is an invisible component of water management solutions. Rapid infiltration and storage of water can be enabled by using Leca LWA under natural permable surfaces, such as grass, sand or dirt.

An example calculation of necessary depth (h) of Leca LWA, assuming 24-hours water absorption and 10 % compression with a coarse, round Leca-fraction (8-20 mm). The volume of Leca LWA needed for handling a dimensioning rainfall is calculated from the inherent fraction of voids (external pore volume).

To determine a volume of Leca LWA needed in a subsurface, storage/ infiltration pond, use equation:

$$h = \frac{V_{dim}/V_{porøsitet}}{A}$$

h = depth of Leca LWA filling (m)

A = infiltration/detention area (m^2)

V_{dim} = *maximum volume of water* (m^3)

$V_{porosity}$ = *factor of total porosity and voids available for water*

The following depth (h) of Leca LWA is needed to store 8 m^3 of water in a 10 m^2 area:

V_{dim} = 8 m^3 water

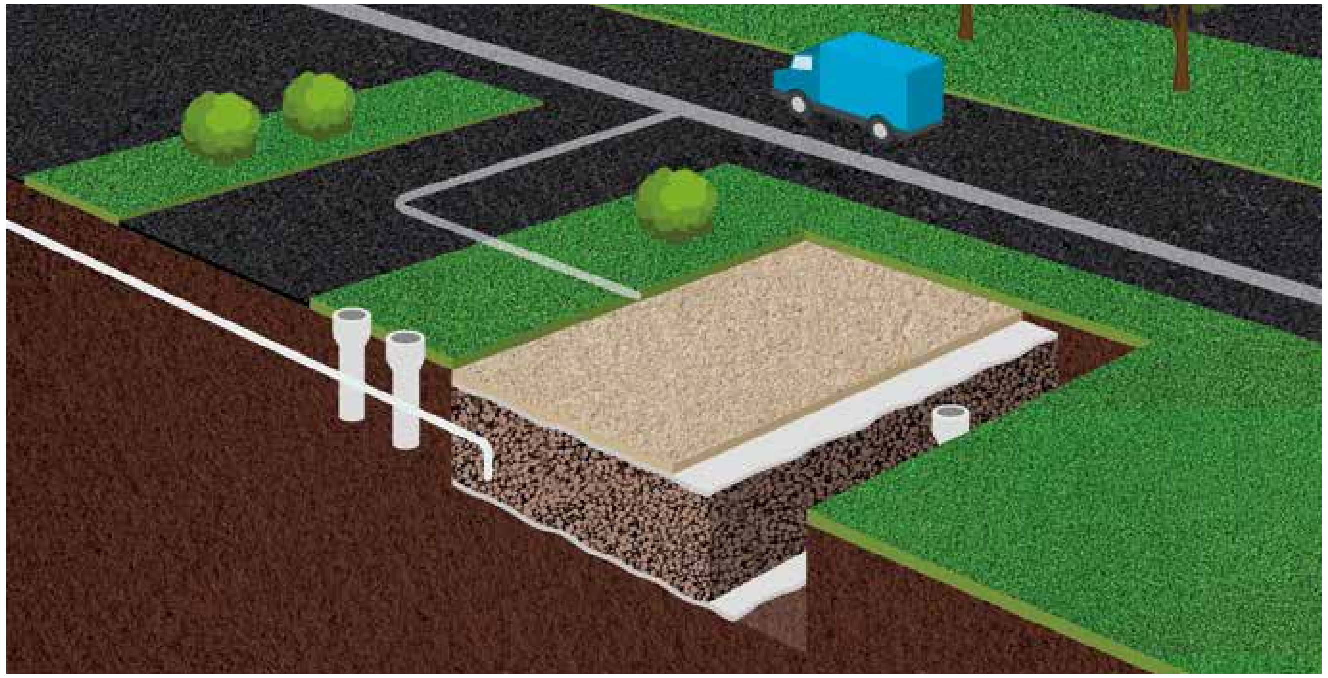
$V_{porosity}$ = 0.45 (45 %)

A = Infiltration/detention area = 10 m^2

$$h = \frac{8\ m^3/0.45}{10\ m^2} = 1.8 \text{ m depth"}$$

A 1.8-meter layer of Leca LWA covering an area of 10 m^2 will meet the water capacity requirement.

Understanding the ground conditions is very important when planning infiltration basins, as the subterranean properties can limit the total capacity for infiltration. Evaluate each application by using tabulated literature values or field measurements. For infiltration design, consider the following parameters.



The illustration shows a subterranean infiltration or detention basin. Leca LWA has high mechanical strength, it is lightweight and can easily be installed in large and inaccessible structures. Leca LWA is completely stable on uneven ground and can be pumped in place by pneumatic blowing.

Hydraulic permeability (m/day)
The velocity of the water movement through the underground. The grain size of the loose subsoil material and its corresponding liquefied strength affects the permeability.

Infiltration capacity (m^3/m^2 day^{-1})
The permeability of the subsoil and loose masses can restrict the rate of water that enter groundwater levels. Particle grain size distribution, permeability, and the volume (m^3) of incoming water defines the maximum capacity for stormwater to infiltrate or percolate into underdrains.

Hydraulic capacity (m^3/day)
The volume of water that can move through a sub-layer over time. The hydraulic capacity restricts the amount of water the subsoil layer can contain without saturation and increase of groundwater level.

Sediments and overflows
Suspended solids, sand and debris can be flushed from surroundings and into detention and infiltration ponds. Clogging is a hazard for all water management systems, and they should be protected by sedimentation basins and have emergency outlets. The volume of voids in Leca LWA is very large, and its pores provides high resistance to clogging by suspended solids and other particles. This property provides a lot of redundancy, reduces maintenance needs and increases the operational lifetime of the construction.

Permeability (m/s)

High	Moderate	Low	Very low
Rocks, gravel, uncrushed Leca LWA	Fine Leca, sand, silt and soils	Fine sand, lime-stone, silt, clays	Clays, shale, bedrock

> 10^{-1} 10^{-2} 10^{-3} 10^{-4} 10^{-5} 10^{-6} 10^{-7} <

Leca LWA has moderate to high saturated water permeability. The degree of crushing and grainsizes affect the hydraulic permeability. These properties can be specified, and consequently Leca LWA can be tailored for a wide variety of applications.

Leca LWA is well suited for subsurface infiltration- and detention-ponds. The porous structure provides temporary water absorption and abundant space for water. Leca LWA is easy to install and is a feasible alternative to construction of open basins, storage tanks or new drainage pipes. Leca LWA is geotechnically stable and can be used for load bearing purposes and as lightweight backfill in combination with water management.

Technical information and product data

Characteristic properties for three types of Leca LWA for water management.

Property	Unit	Note			
Product code			**2-4 cracked**	**4-10**	**10-20**
Particle shape			Cracked	Round/cracked	Round
Aggregate size	d/D mm		2/4	4/10	10/20
Loose bulk density, dry	kg/m³	± 15%	260	290	245
Voids	%	bulk porosity	55	45	45
Water absorption (EN 1097-10)	% volumen/% weight	5 min	10/39	8/26	6/23
		1 h	11/42	9/30	7/27
		24 h	14/55	10/36	8/33
	l/m³	1 h	110	90	70
Permeability, k	m/s	approx. value	0,05	0,10	0,36
Runoff coefficient, C (2 % slope)	From 27 mm/h rain (15 min duration)	100 mm layer	0,45	0,6	0,8
		200 mm layer	0,3	0,5	0,7
Bulk density *	kg/m³	wet	440	430	360
Thermal conductivity	W/(mK)	dry	0,14	0,095	0,095
		wet	0,17	0,12	0,114

*EN 1097-3, incl. 24 h water absorption and 10 % compaction

The table shows characteristic values for Leca LWA materials. Note that water absorption is an inherent property of Leca LWA. This is the amount of water stored by absorption by capillary suction into the internal pores of Leca-grains.

Leca LWA absorbs and detains water

Water absorption (by volume) is a common way to classify water holding capability. However, internal pore absorption capacity is not the primary mechanism behind detention and peak runoff reduction in Leca LWA. Internal absorption by volume of water constitutes to around 5-15 % of the Leca LWA volume, depending on type and exposure time. 24-hour water absorption is the recommended design value. Unless rewetted, absorbed water is gradually released through evapotranspiration.

Water absorption provides a degree of total runoff reduction, but the capacity for detention is far higher than the absorption capacity alone. This is due to the open porosity and high specific surface area. Water adsorption on the open, accessible surface happens regardless of its intrinsic absorption capacity and surrounding substrates. When the internal absorption capacity is saturated, Leca LWA will continue to detain water as previously shown. This property makes Leca LWA a resilient subsoil material that continuously regenerate its detention ability, even when subjected to consecutive or prolonged rainfalls.

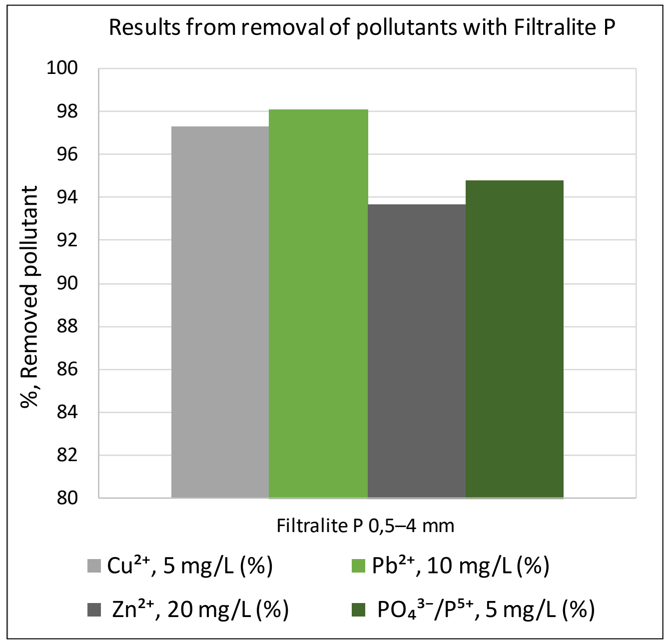
Filtration and pollution control

Leca-materials are known to have filtering properties that benefits water quality. By incorporating Leca LWA into biofilters or by using Leca-materials as dedicated filter strips, a wide range of pollutants and heavy metals can be removed from runoff from infrastructure. Leca-materials can be used in soil mixes or as a stand-alone sublayer, for example in bioswales, and will contribute by facilitating immobilisation or decomposition of contaminants.

Filtralite® P

Filtralite P is a highly specialized lightweight expanded clay aggregate (LECA) tailored for direct filtration of runoff water contaminated with heavy metals, phosphorous and other dissolved particles. At the start of a rain event, the first flush of water can be purified by an on-site strip made out of Filtralite P. The filter works by the precipitation followed by permanent capture of different chemicals.

Product type	Example grain size (mm)	Applications in stormwater management structures	Benefits in stormwater
Filtralite P	0,5-4 mm	Independent filter layer, part of drainage layer	Specialized filter medium for removal of solid and dissolved pollutants such as heavy metals, phosphates and suspended solids
Finely crushed Leca LWA	0-6 mm	Can be indipendent or part of soilmix for biofiltering	Small and crushed Leca aggregates, with high porosity and capacity for binding pollutants
Round Leca LWA	10-20 mm	Drainage layer. Detention ponds	High water conductivity. Voids can be used for temporary water storage. Good thermal insulation. High load-bearing capacity



A selection of results from a study on Leca LWA and Filtralite for removal of heavy metals from stormwater by filtration. Synthetic stormwater with high concentrations of dissolved heavy metals were tested in laboratory columns to simulate first flush scenarios.

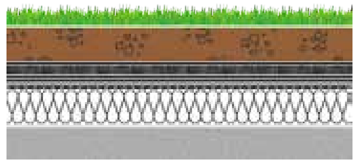
(STORMFILTER: Engineered Infiltration Systems for Urban Stormwater Quality and Quantity, 2015-2017)

GREEN ROOFS
CALCULATION REPORT

Green roof with intensive greenery

The layer system	Material	Layer thickness [cm]	Storage. Water [l]	Weight [kg/m²]	Weight with water [kg/m²]	Thermal resistance [m²·K/W]
Vegetable layer	**Lawn**	10	0	5.00	5.00	0.000
Substrates	**Substrate for intensive greening**	15	60	150.00	247.50	0.167
Filter layer	**Geotextile 100 g/m²**	0.1	0	0.13	0.14	0.001
Drainage layer	**Leca® 4/10**	4	3.48	12.80	17.40	0.250
Protective layer	**An absorbent-protective mat 300-1200 g/m²**	0.3	2.7	0.30	3.00	0.005
Layer against root	**0.36mm PE foil**	0.036	0	0.33	0.33	0.000
Separating layer	**Geotextile 300 g/m²**	0.1	0	0.28	0.28	0.001
Waterproofing	**Waterproof membrane**	0.2	0	2.40	2.40	0.011
Thermal insulation	**XPS**	15	0	5.25	5.25	4.286
Moisture barrier	**Vapour control membrane**	0.02	0	0.19	0.19	0.000
Construction	**Reinforced concrete slab**	15	0	360.00	375.00	0.088

CALCULATION RESULTS



Total thickness (without construction): **35** [cm]
Water storage: **66** [l/m²]
Weight in dry condition (without construction): **177** [kg/m²]
Weight in wet condition (without construction): **281** [kg/m²]
Estimated value of heat transfer coefficient U: **0.202** [m²·W/K]

** Disclaimer: The statements, technical information and recommendations contained herein are believed to be accurate as of the date hereof. Since the conditions and methods of use of Leca® lightweight aggregate and of the information referred to herein are beyond our control, Leca UK expressly disclaims any and all liability as to any results obtained or arising from any use of the product or reliance on such information. To discuss this further please contact enquiries@leca.co.uk or call 0844 335 1770.*

Visit our Leca® Green Roof Online Calculator

Leca UK has launched an online calculator for those who plan to functionalize areas for water management. The calculator provides details about how to construct green or blue-grey solutions with Leca LWA, and describes methodologies in accordance with local building customs. Simply enter the type of construction or roof, either green or paved, extensive or intensive, then choose basic parameters and the preferred construction materials. The online calculator can suggest an ideal combination and assembly of materials. A technical description, exportable in pdf-format, is available. In addition, performance indicators such as water retention properties, thermal insulation values and weight considerations will be calculated.

Use our Leca® Green Roof Calculator at:

https://www.leca.co.uk

Filtering and biofiltration

Because of the highly porous structure and large surface areas of the crushed grains, Leca LWA is perfectly suited for treatment of rainwater. Leca LWA can physically, biologically or chemically bind both dissolved and solid particles. Expanded clay has long been used for water treatment purposes and has long term resistance to clogging. The local environment can be protected by immobilization and removal of pollution that would otherwise end up somewhere else. Leca LWA as a filter solution has low estimated operating costs and a long life span.

Disclaimer
The information provided in this publication is based on our current knowledge and experience with Leca-products. Pictures, illustrations and representations of Leca LWA, and suggested usages, must be considered illustrative examples. Examples are not specifications for dimensioning and are not to be used directly for projecting purposes.

The provided runoff data are conservative values from laboratory tests, pilots and literature. Included diagrams and data are from independent, single sample tests from third party research, and the behaviour of the materials may differ in completed, full-scale installations. It is the user's own responsibility to use Leca LWA products as intended, and to execute performance controls on completed systems. The user is responsible for damage if the products not are used as intended or for improper applications. Leca International can provide documentation and advice for the use of Leca LWA products for water management purposes.

ONE SINGLE CLAY PELLET DOESN'T REPRESENT A LOT

Leca®

BUT MANY CLAY PELLETS CREATE A BETTER FUTURE

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SAINT-GOBAIN

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