



Stormwater management through Sustainable Urban Drainage Systems: a study in the climatic context of the Venetian Plain

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SUDS



Stormwater management systems that mimic natural drainage processes to reduce the effect of urbanization on the quality and quantity of stormwater runoff

| BENEFIT | WHAT IT COVERS |
|---------------------------|--|
| Flood risk management | Impact on people and property |
| Water quality management | Surface water quality improvements to aesthetics, health, biodiversity, etc |
| Groundwater recharge | Improved water availability or quality |
| Pumping wastewater | Reduced flow of wastewater to treatment works |
| Rainwater harvesting | Reduced flows in sewers, pollution or dependence on potable water |
| Treating wastewater | Reduced volume of wastewater to treat from combined drainage systems |
| Climate change adaptation | Improved ability to make incremental changes and adapt infrastructure (no regrets) |

SUDS can also deliver additional benefits

| BENEFIT | WHAT IT COVERS |
|------------------------------------|--|
| Biodiversity and ecology | Sites of ecological value |
| Amenity | Attractiveness and desirability of an area |
| Health and wellbeing | Physical, emotional, mental health benefits from recreation and aesthetics |
| Air quality | Impact on health from air pollution control |
| Carbon reduction and sequestration | Operational and embodied carbon reduction together with sequestration |
| Economic growth | Business, jobs and productivity |
| Tourism | Attractiveness of touristic sites |
| Education | Enhanced educational opportunities |



URBAN SPRAWL IN THE VENETO REGION

1983 – 2006

~350 km²
(1.8% of total surface)



SUDS solutions



Two Research projects funded by University of Padova

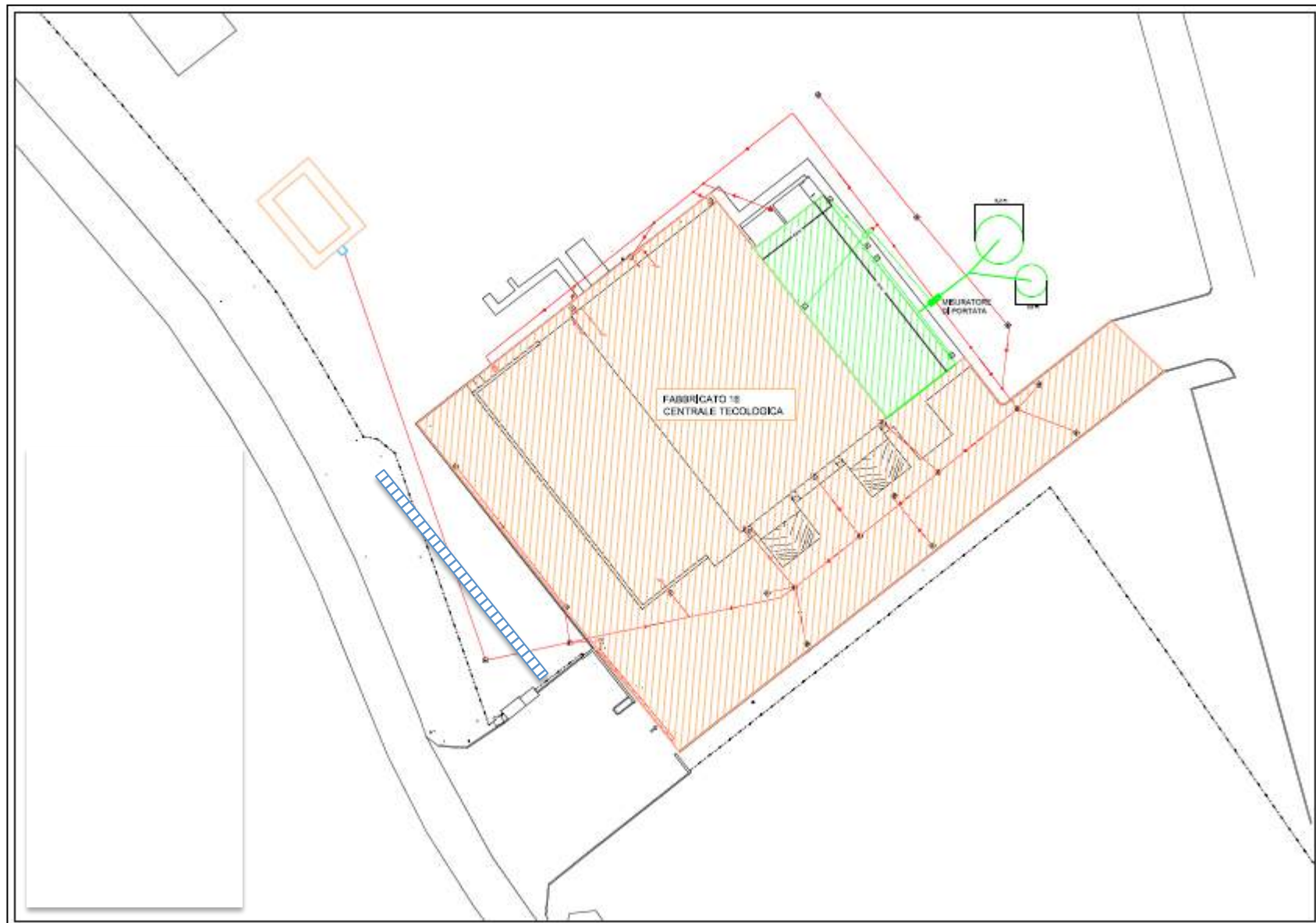
1. Green structures for runoff control in urban environments

2. In situ sustainable management of stormwater runoff by mean of green roofs: evaluation of systems suitable for Venetian Plain

MAIN PURPOSES

- i) study effect and performance of SUDS in stormwater management within the climatic context of the Venetian Plain,
- ii) evaluate the plant species adaptation to the particular conditions of SUDS
- iii) provide students and stakeholders of real and innovative examples of design solutions for stormwater management in urban areas,
- iv) establish a reference hotspot from which practitioners and public administrations can obtain information bringing to include these solutions in urban planning as well as in specific public/private designs

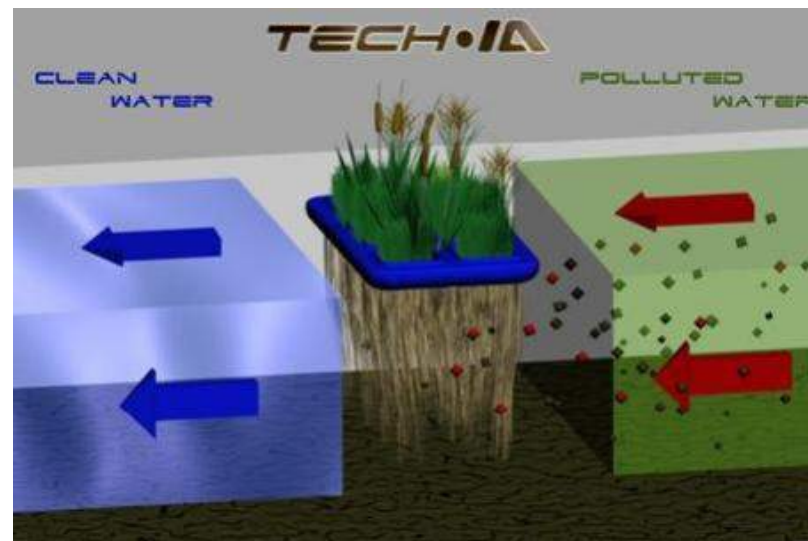




Bioretention pond



Bioretention pond - MATERIAL AND METHODS



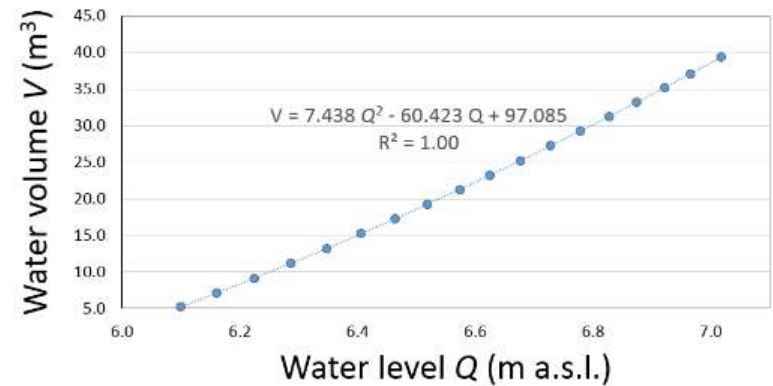
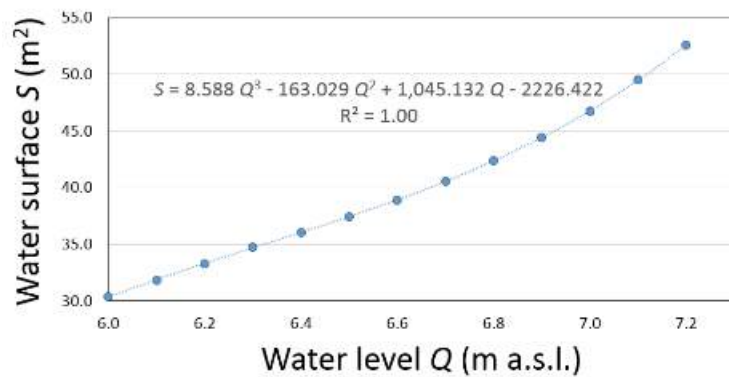
- *Alisma parviflora* (12)
- *Bacopa caroliniana* (24)
- *Caltha palustris* (24)
- *Iris* “Black Gamecock” (20)
- *Lysimachia punctata* (24)
- *Lythrum salicaria* (24)
- *Mentha aquatica* (24)
- *Oenanthe javanica* “Flamingo” (24)
- *Phalaris arundinacea* “Picta” (24)
- *Typha laxmannii* (24)



Bioretention pond - MATERIAL AND METHODS



Bioretention pond - MATERIAL AND METHODS



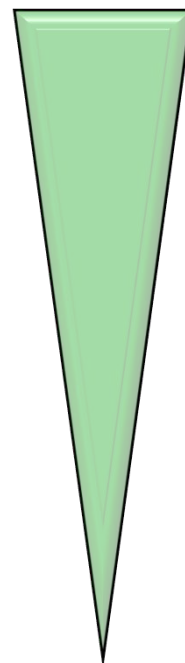
Bioretention pond - RESULTS



- *Typha laxmannii*
- *Bacopa caroliniana*
- *Phalaris arundinacea* “Picta”
- *Mentha aquatica**
- *Caltha palustris*
- *Lysimachia punctata*
- *Oenanthe javanica* “Flamingo”
- *Lythrum salicaria*
- *Alisma parviflora*
- *Iris* “Black Gamecock”

* = invasive

EXCELLENT



INSUFFICIENT

Bioretention pond

Sept 2016



Rain Garden



Rain garden – MATERIAL AND METHODS



Rain garden – MATERIAL AND METHODS



Echinacea viola - *Echinacea purpurea* 'The king'



Giaggiolo d'acqua - *Iris pseudacorus*

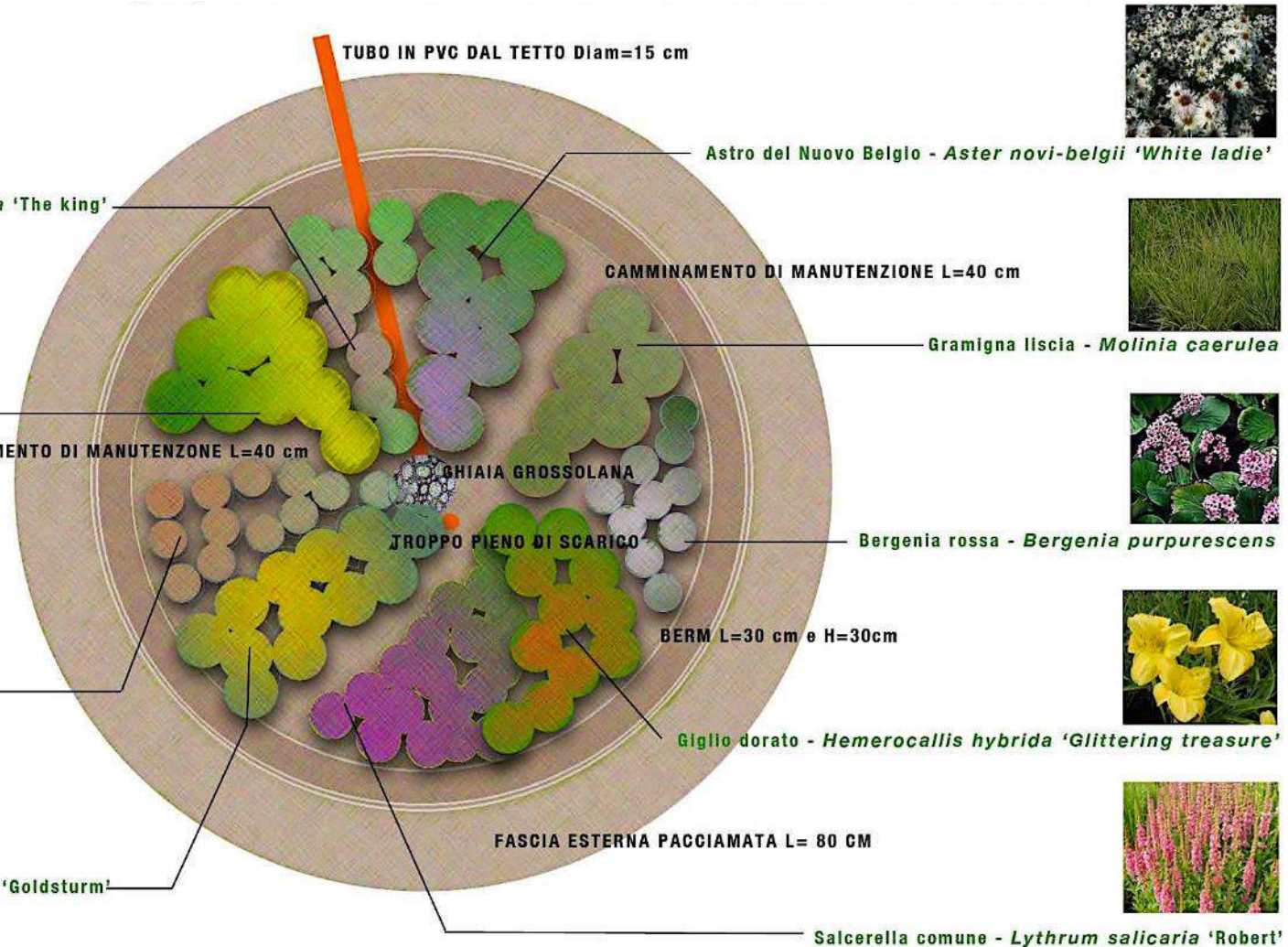


Carice del cuolo - *Carex buchananii*



Rudbeckia gialla - *Rudbeckia fulgida* 'Goldsturm'

Scala 1:50



Astro del Nuovo Belgio - *Aster novi-belgii* 'White ladie'



Gramigna liscia - *Molinia caerulea*



Bergenia rossa - *Bergenia purpurescens*

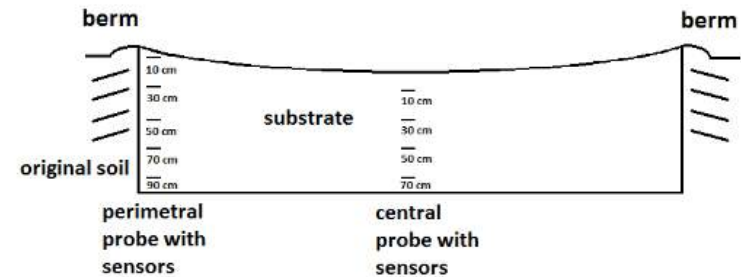
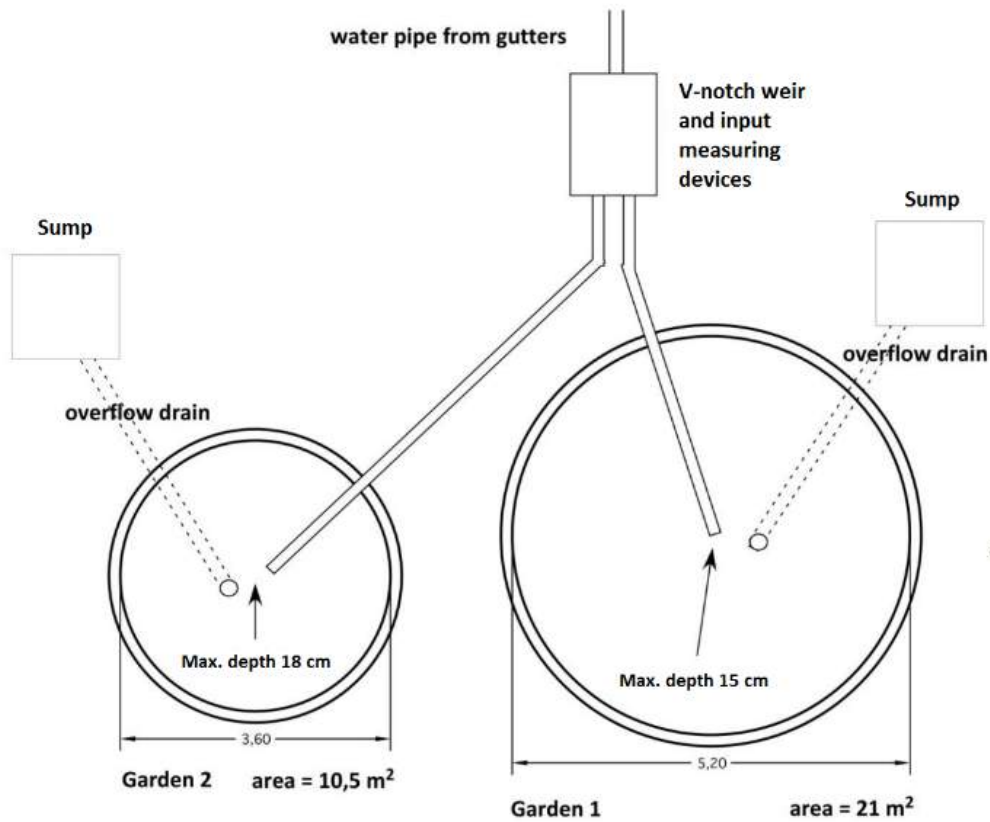


Giglio dorato - *Hemerocallis hybrida* 'Glittering treasure'



Salcerella comune - *Lythrum salicaria* 'Robert'

Rain garden – MATERIAL AND METHODS



Rain garden – MATERIAL AND METHODS

$$\text{INFILTRATION} = (\text{RUNOFF} + \text{RAIN}) - (\text{ET} + \text{OVERFLOW})$$

Input volumes

Output volumes

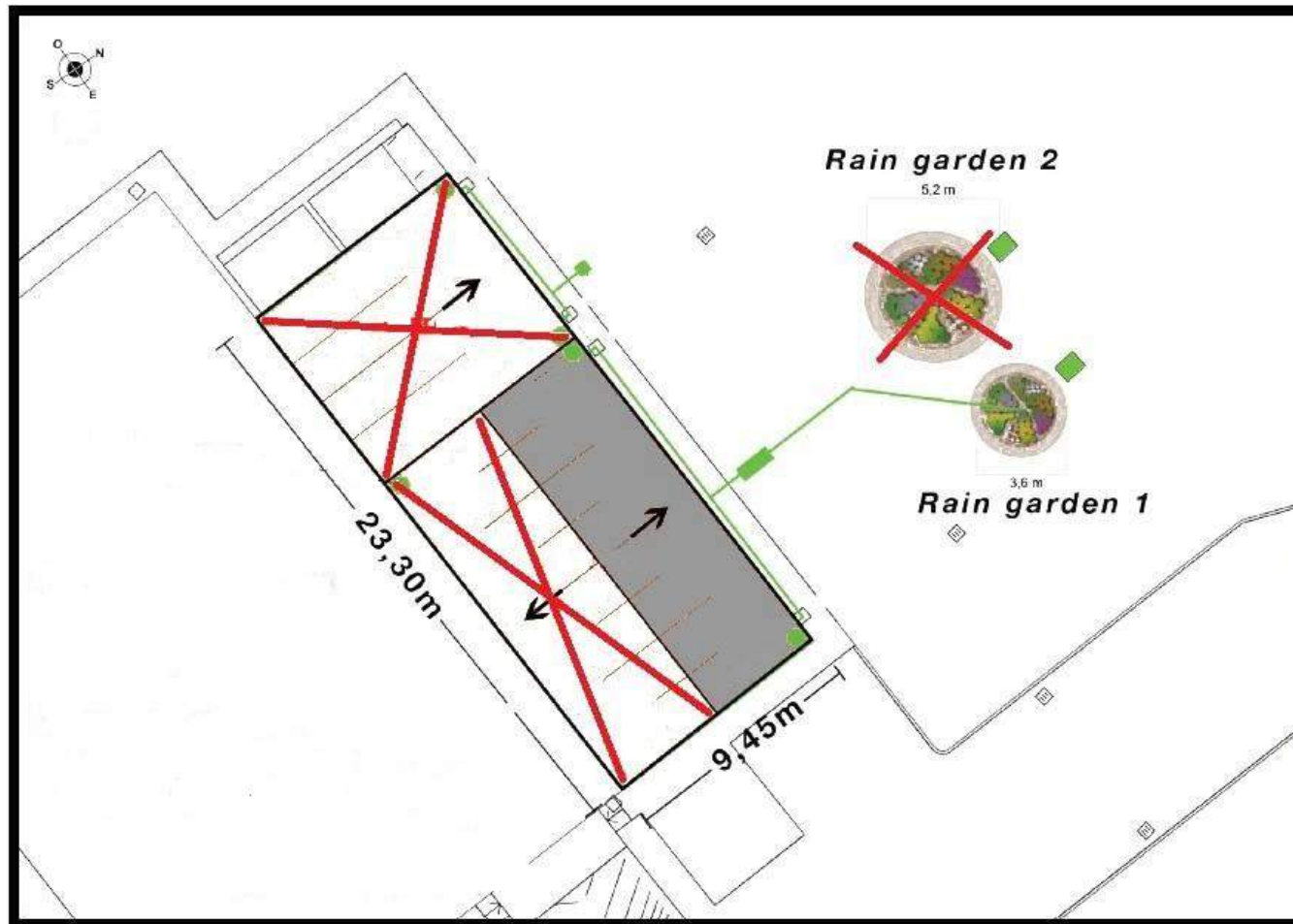
ET → **estimated** using WUCOLS method
(Costello et al., 2000)

$$\text{ET} = \text{ET}_0 * K_L$$

$K_L = K_S * K_D * K_{MC}$ **landscape coefficient**



Rain garden – MATERIAL AND METHODS



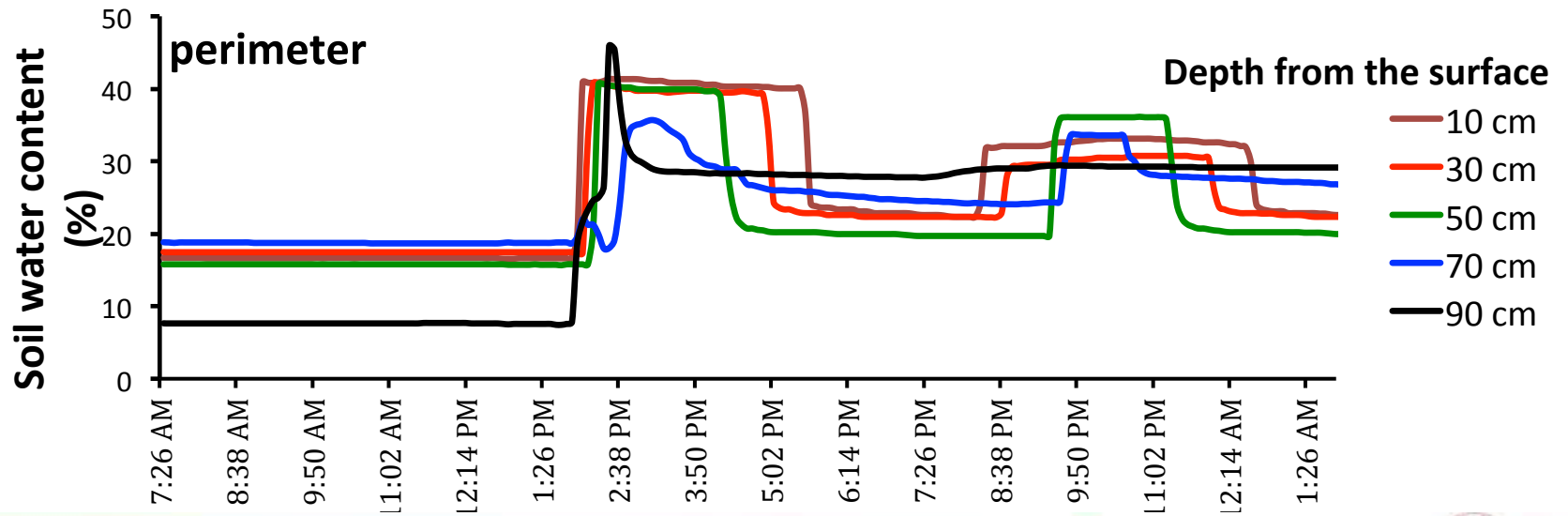
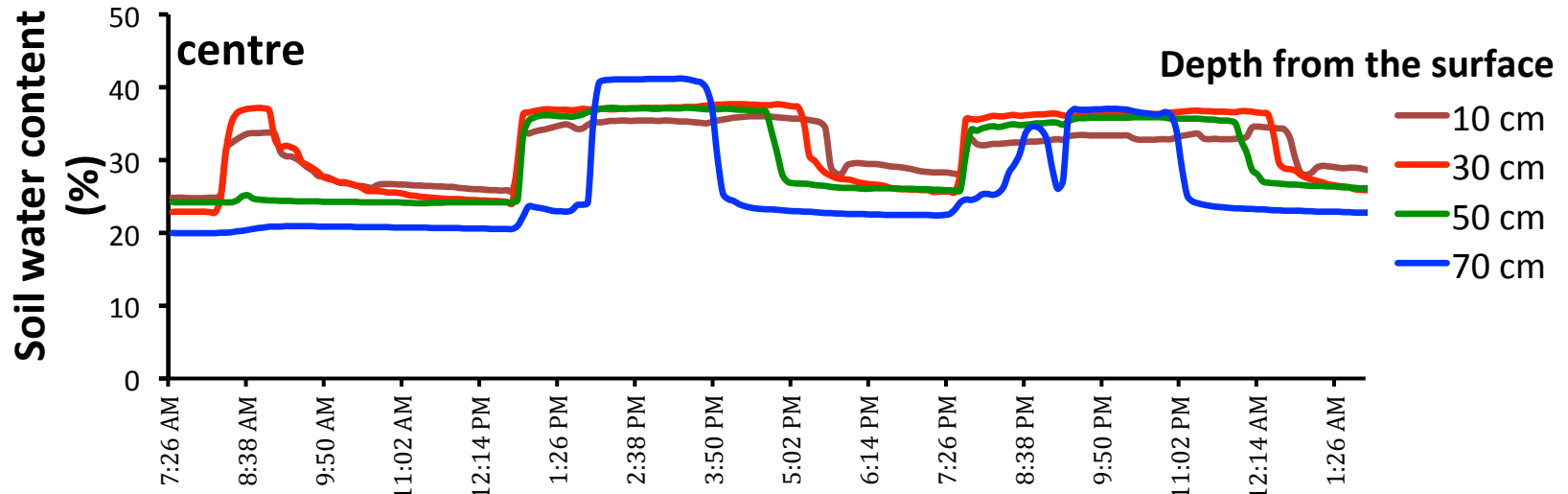
Rain garden - RESULTS

$$\text{INFILTRATION} = (\text{RUNOFF} + \text{RAIN}) - (\text{ET} + \text{OVERFLOW})$$

| % roof drainage area | Roof runoff (L) | Direct rain (L) | Overflow volumes (L) (% of total input) | Evapo-transpiration (% of total input) | Infiltrated volumes (% roof runoff) |
|----------------------|-----------------|-----------------|---|--|-------------------------------------|
| 10 | 42070 | 8030 | 950 (2%) | 7540 (8%) | 41 315 (98%) |
| 15 | 99770 | 16380 | 5780 (0.5%) | 9200 (8%) | 101 170 (101%) |
| 20 | 42070 | 4015 | 70 (-) | 3770 (15%) | 42 560 (101%) |

High ability to manage stormwater runoff!

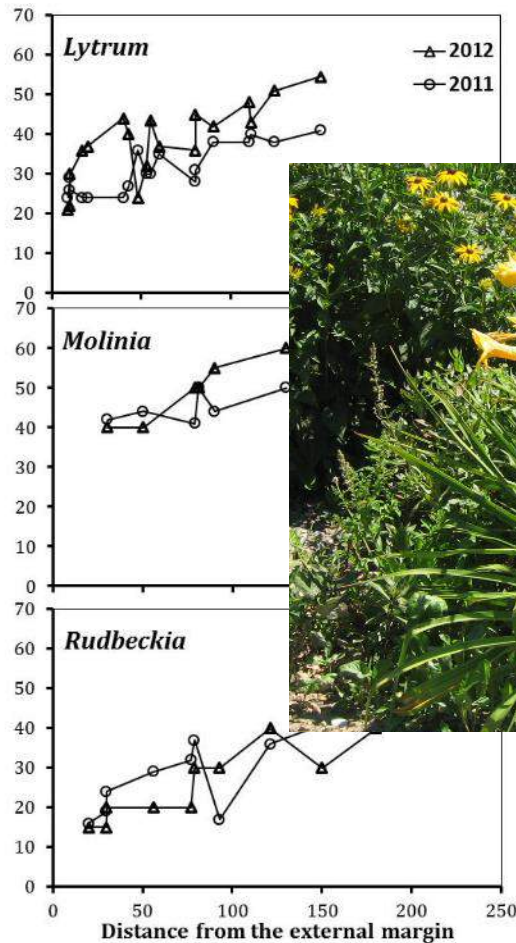
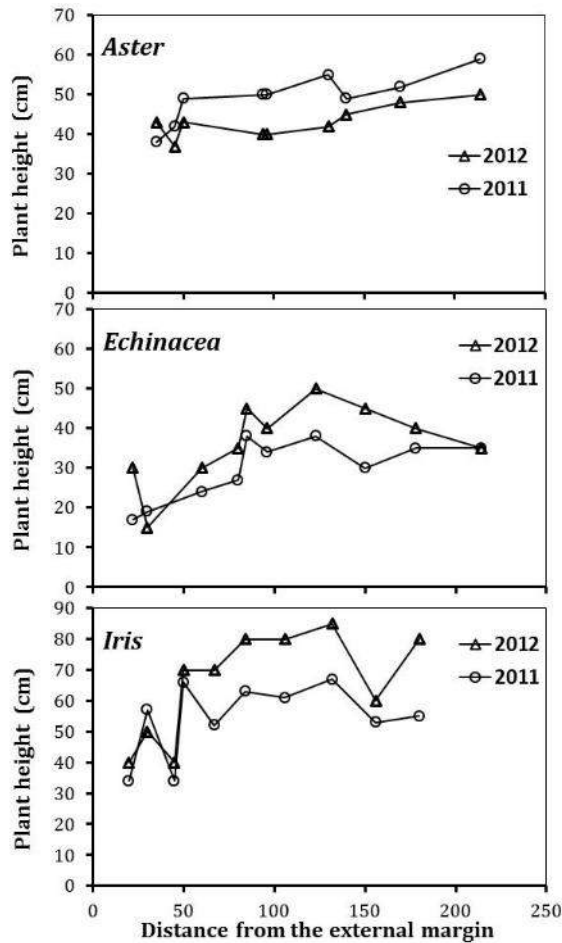
Rain garden - RESULTS



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Rain garden - RESULTS



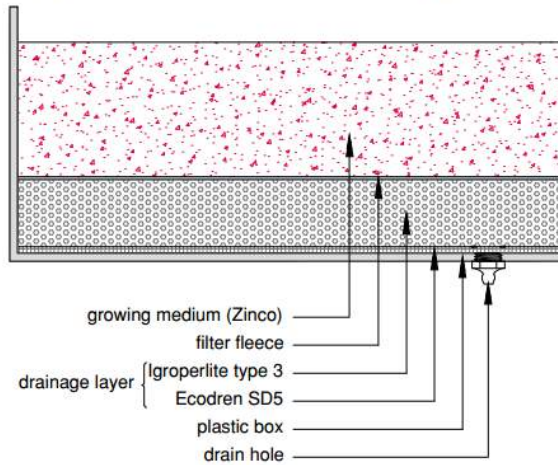


Green roof

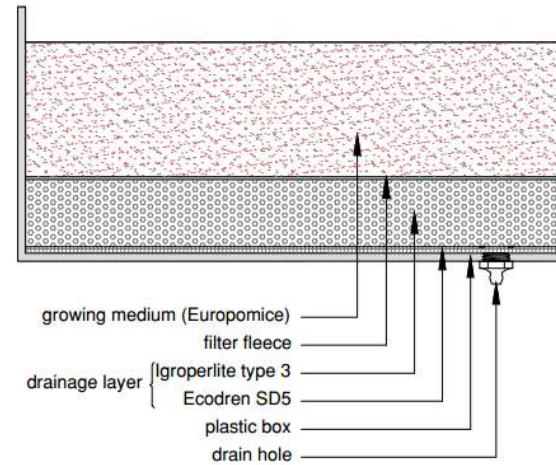


Green roofs – MATERIAL AND METHODS

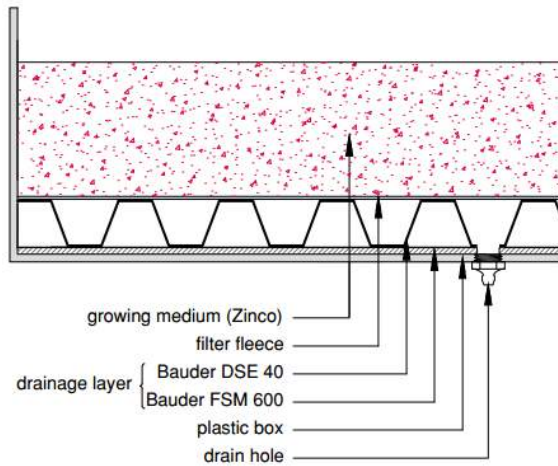
Recycled medium (Zinco) + Mineral layer (Perlite)



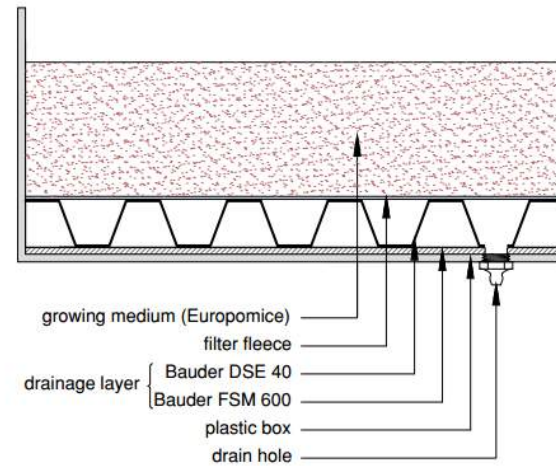
Volcanic medium (Vulcaflor) + Mineral layer (Perlite)



Recycled medium (Zinco) + Preformed layer (Bauder)



Volcanic medium (Vulcaflor) + Preformed layer (Bauder)



Green roofs – MATERIAL AND METHODS

A) Mix *Sedum*



- *Sedum acre*
- *Sedum reflexum*
- *Sedum sexangulare*
- *Sedum album*

B) Mix Herbaceous perennial



- *Euphorbia cyparissias*
- *Melica ciliata*
- *Potentilla pusilla*
- *Campanula spicata*
- *Bromus erectus*

C) Mix Suffruticose plants

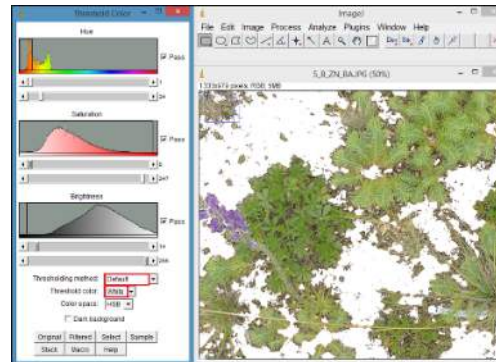


- *Dianthus sylvestris*
- *Dianthus carthusianorum*
- *Dianthus hyssopifolius*
- *Clinopodium nepeta*
- *Thymus serpyllum*
- *Anthemis tinctoria*
- *Artemisia alba*

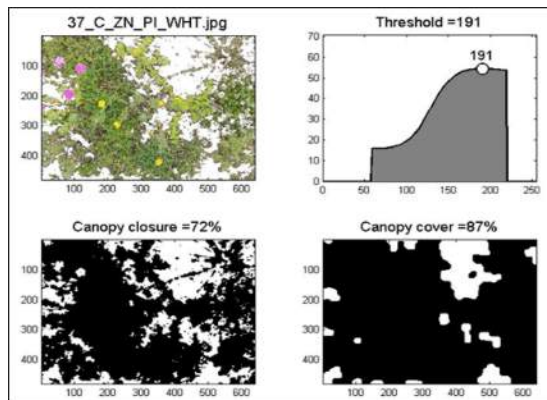
Green roofs – MATERIAL AND METHODS



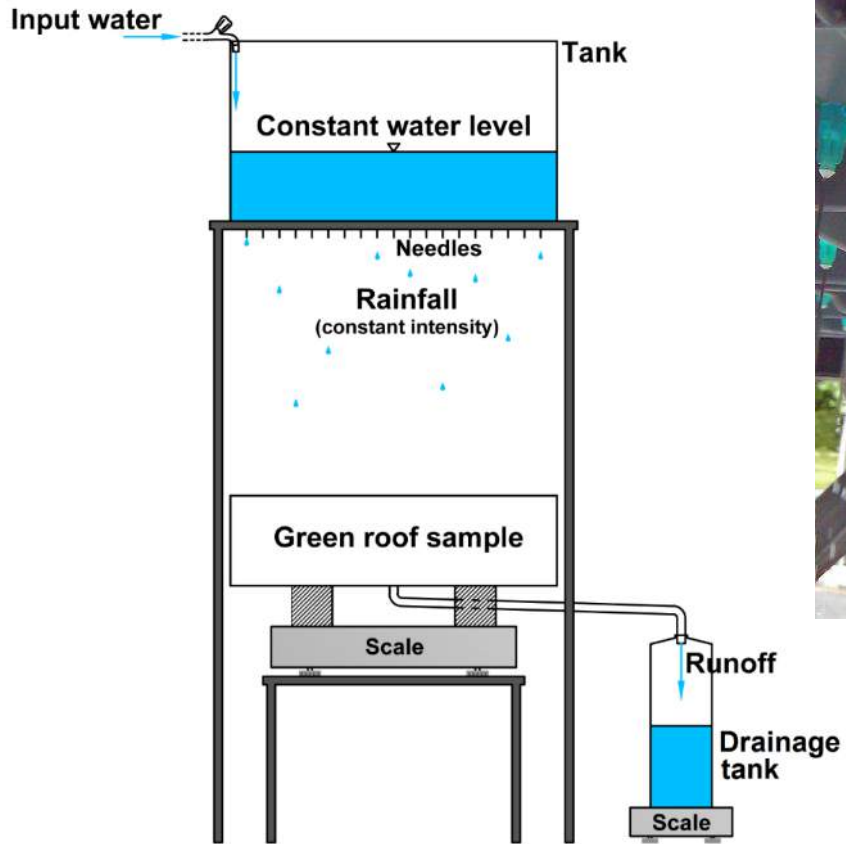
Software Image J



Software MatLab



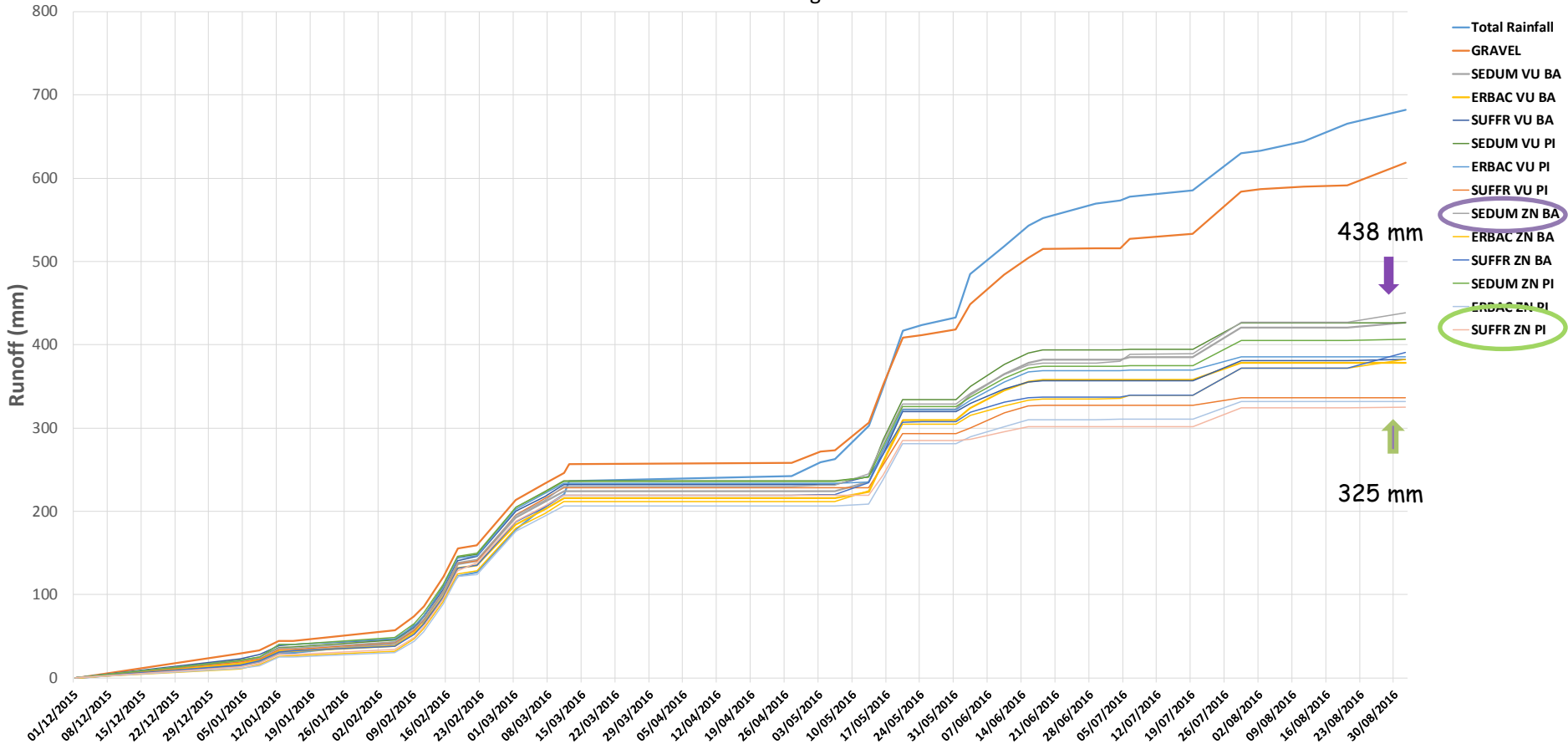
Green roofs - Laboratory tests



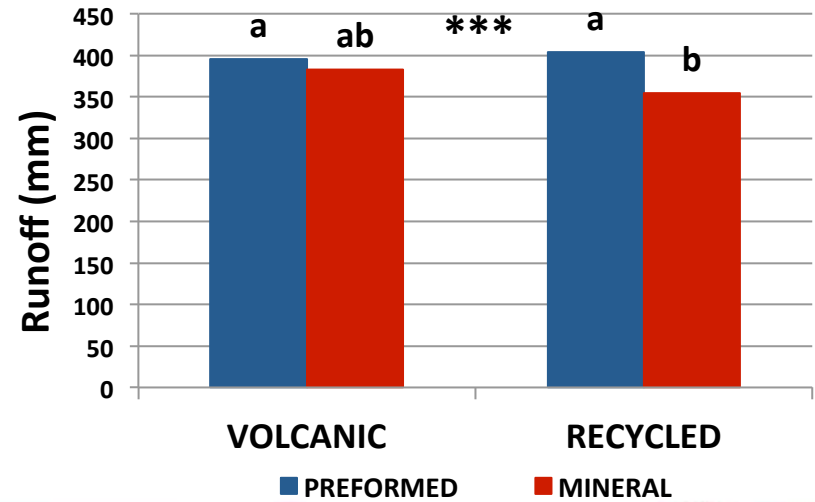
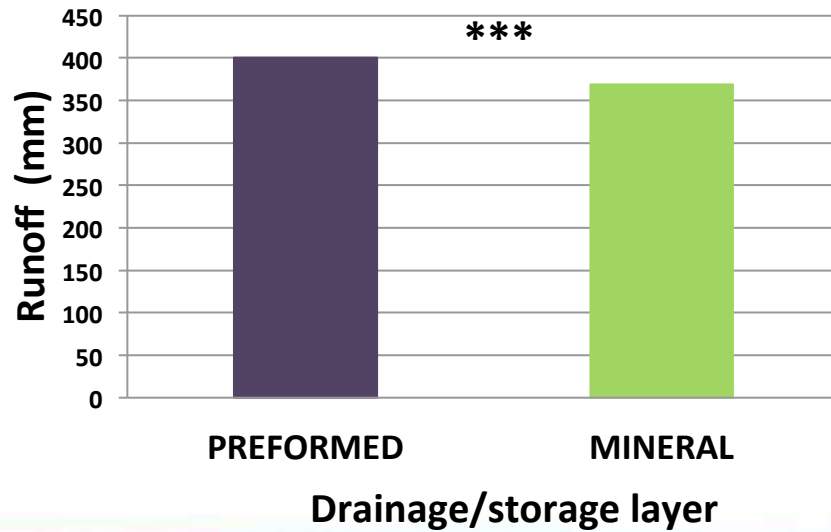
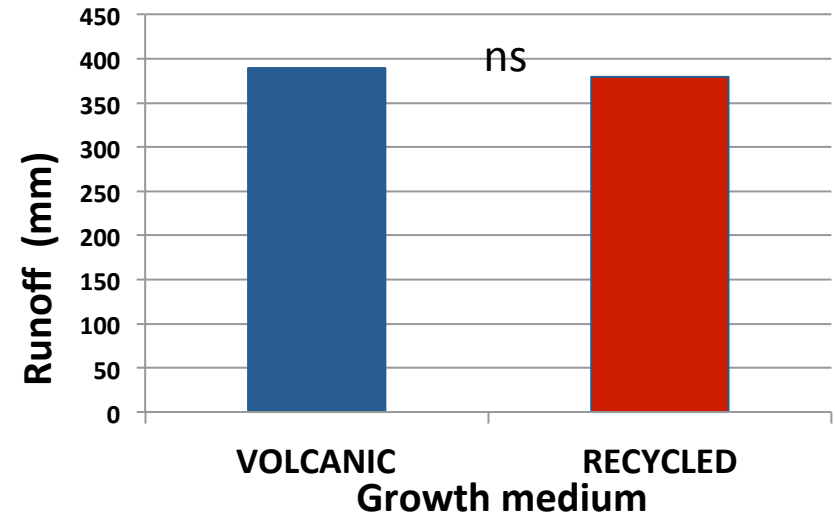
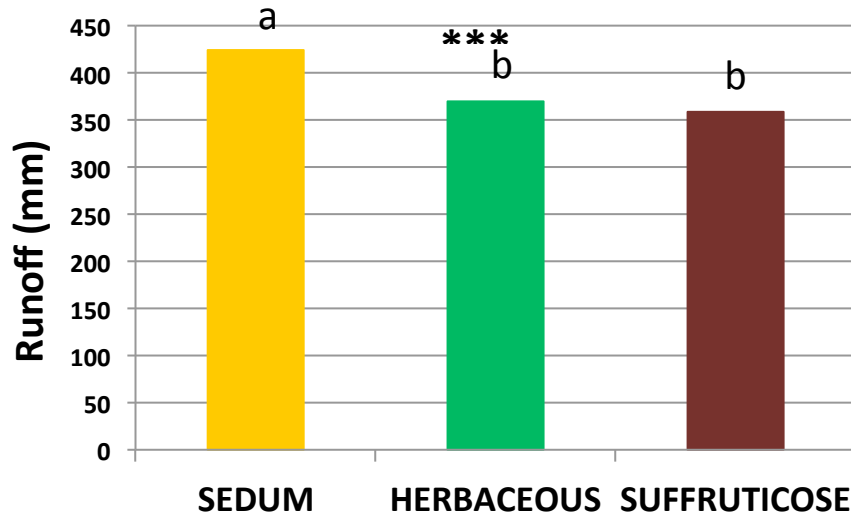
Green roofs - RESULTS

Cumulated runoff

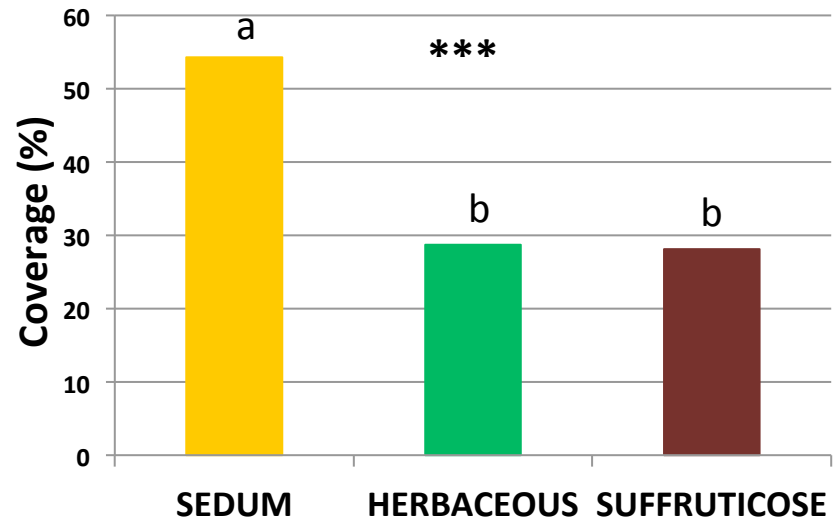
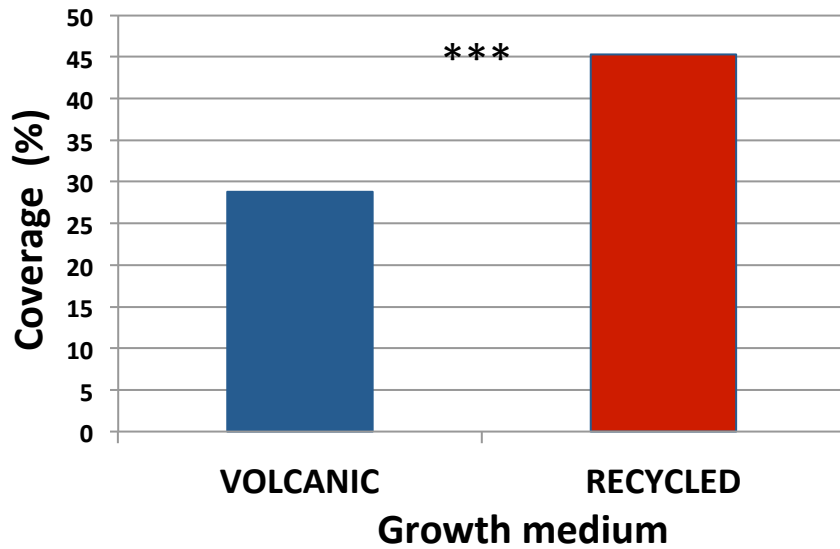
Dec 2015 - Ago 2016



Green roofs - RESULTS



Green roofs - RESULTS



CONCLUSIONS

All the three systems have shown to be interesting solutions for the sustainable management of urban stormwater runoff

Now we hope to have overcome the main problems related to the correct measurements of the data

Our research will continue!



THANK YOU FOR YOUR ATTENTION

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