
Regione Emilia-Romagna
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FREEING THE SOIL
GUIDELINES FOR IMPROVING RESILIENCE
TO CLIMATE CHANGE
IN URBAN REGENERATION PROCESSES

RegioneEmilia-Romagna

DEPARTMENT OF TRANSPORT, MATERIAL AND INTANGIBLE INFRASTRUCTURE NETWORKS, TERRITORIAL PLANNING AND DIGITAL AGENDA

GENERAL DIRECTORATE CARE OF THE TERRITORY AND ENVIRONMENT

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URBAN REGENERATION GUIDE LINES

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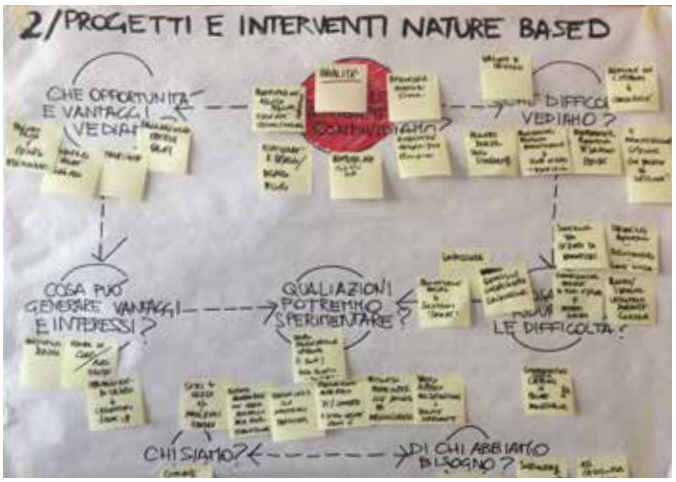
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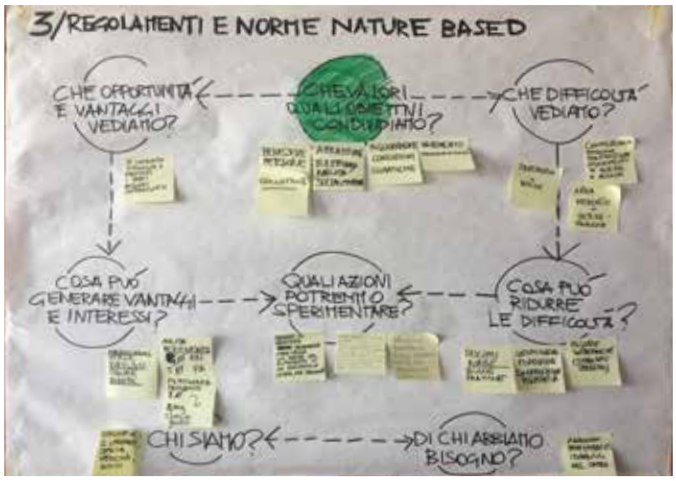
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INTRODUCTION

Cover: flowery lawn inside the Rotonda 1st May in Milano Marittima on the Riviera Romagnola. (Photo by Francesca Poli)

The summary of the work of the 2° meeting for the definition of the guidelines of the SOS4Life Project where the participants worked on the aspects of replicability of good practices with particular reference to design and regulatory issues.

The FREEING THE SOIL guidelines are a steering document for urban regeneration processes, with specific emphasis on resilience to climate change.

The guidelines are made up of two volumes:
FREEING THE SOIL 1
Guidelines for resilience in urban regeneration
FREEING THE SOIL 2
Urban resilience case studies: adaptation projects and processes for urban regeneration

Volume 1 addresses the topic of resilience on the scale of cities and regulations and on the scale of individual projects, , with a specific focus on nature-based solutions that can be implemented in the built environment in order to free land and carry out adaption measures through green and blue infrastructures and the use of vegetation in hostile settings.
This volume is organized into 5 chapters:

0- INTRODUCTION TO THE GUIDELINES
1 - URBAN AREAS TO REGENERATE AND CLIMATE
2- CRITERIA FOR URBAN, ECOLOGICAL AND ENVIRONMENTAL QUALITY
3- NATURE-BASED PROJECTS AND SOLUTIONS
4- VEGETATION AND TREES IN HOSTILE URBAN SETTINGS
5 - GLOSSARY AND BIBLIOGRAPHY

The fact sheets show various solutions using images, technical drawings and texts, and include information on the actions, maintenance and cost. The volume ends with a reference glossary on the topics of climate, heat, vegetation, and water.

Volume 2 shows various case studies of adaptation projects and processes that were carried out on various scales in redevelopment and regeneration contexts in Italy and abroad.
The case studies are classified into six categories:

A - LARGE DISMISSED AREAS FOR TRANSFORMATION AND ECO-DISTRICTS
B - LARGE DISMISSED AREAS FOR TRANSFORMATION AND URBAN PARKS
C - URBAN SQUARES, PUBLIC SPACES, PUBLIC GARDENS, AND PARKING LOTS
D - TEMPORARY GARDENS
E – BOTTOM-UP ADAPTATION EXPERIENCES
F - URBAN-PLANNING TOOLS AND DETAILED PLANS

The project fact sheets show the case studies in a general text - with a focus on green and blue infrastructures and reference standards - and a series of images and drawings to show elements that are innovative and can be replicated elsewhere

TARGET AUDIENCE: WHY THE GUIDELINES SHOULD BE USED BY MUNICIPALITIES

The guidelines are intended for individuals in the public sector — officials involved in town planning, urban regeneration, public works, and greenery — and professionals at design offices and companies who work in town planning, architecture, landscaping, and engineering.
The guidelines are a steering document and, as such, are not directly binding, though they do discuss potential ways to implement physical measures capable of achieving general- and sectoral-planning objectives of urban-planning and environmental regulations that are in force.
The challenges of climate change and urban regeneration are extremely complex, and there is no widespread experience to refer to in these fields. We need to experiment with new urban models and adaptation criteria that

are appropriate for dealing with the vulnerability of today's cities.
The quality of what the market and the professional world offer changes when demand changes. In this sense, this challenge first comes into play in the public sector rather than in the professional world and in companies.
The advice we give to municipal governments and public officials is to implement the FREEING THE SOIL guidelines and try them out with gradual adaptations in order to learn — together with the design and business world supply chain — a new way of making the city public.
The previous REBUS project experience — of which these guidelines are in a way the natural continuation — has in Emilia-Romagna led to an important urban resiliency to climate change training cycle and to the first experiments in some municipalities, which are making a foray into projects and processes involving urban regeneration and general urban-planning plans. But it is necessary to have experience in all the supply chain phases in order to create a new way of imagining the regeneration of an existing city and to construct public works based on quality, sustainability, and resiliency criteria.
Our hope is that this document can therefore be used as a work basis for new public work tenders or for regulations for implementation plans, supporting officials and technicians who work in municipalities, in professional offices and in construction, landscaping, and building companies.

WHY THERE IS A NEED FOR AN INTERDISCIPLINARY APPROACH

Dealing with the topics of urban regeneration and resilience requires a number of actors and skills and a large capability for finding effective, feasible, and sustainable solutions.
These guidelines are in fact the outcome of research that is the result of a trans-disciplinary collaboration in town planning, landscaping, agricultural and hydraulic engineering, and architecture. This way of working was chosen with the intention of generating a new knowledge space, one which enriches the individual disciplines and which is considered essential for effectively dealing with the public-space project. This collaboration has also pursued the need to further investigate natural and low-cost solutions, even when using technology, to amplify their effectiveness.

The professional who is working on a public space project, or the administrator who is committed to assessing its effectiveness, implements a series of knowledge, techniques and technologies, that give rise to an appreciation, a sense of belonging to the place and in general, feelings of well-being and safety in the urban space user. The same project must also know how to provide an efficient solution to the menace that climate change represents, and this double challenge can be dealt with in many ways. The approach proposed here is based on the awareness that it is increasingly necessary to build a bridge between the various disciplines, as is evident from the multidisciplinary composition of the authors.
For these reasons, throughout the entire research development and study case in-depth analysis phase, several structured discussion opportunities were organized with the SOS4Life project partners, to share the work plan and structure and analyse its aspects and needs.

Several workshops were organized between December 2018 and June 2019 to establish the contents of the guidelines, addressing four aspects:

- the most significant threats in the projects designed to counter land use and favour urban regeneration;
- the replicability aspects of best practices with specific reference to design and regulation topics;
- the ease of use and application of the guidelines;
- the strategic aspects aimed at the application of Emilia Romagna Regional Law no. 24/2017 in urban planning, with specific reference to the definition of support contents to the Urban and Environmental Quality Strategy of the PUG (General Urban Plan) on the scale of the urban and building project.

All the meetings were managed and facilitated with thematic work groups, using various discussion methods: the focus group, to focus on common problems and obstacles; the value proposition canvas, to develop solutions to the threats; the cart and technical inspections for developing project solutions.
The technicians and consultants of the Municipalities of Forli, Lazzaro di Savena (BO), Carpi (MO), ANCE Emilia-Romagna, Legambiente Emilia-Romagna and ARPAE, participated in the work and expert group of Emilia-Romagna Region . Officials from the Municipalities of Rimini, Cervia (RA), Medicina (BO), Montechiarugolo (PR) and the Bonifica Renana, who have experiments on urban resilience in progress, all collaborated.

PROPOSED NATURE-BASED SOLUTIONS - COSTS AND BENEFITS

The costs of a public work, although highly dependent on the context and the characteristics of the intervention itself and the local conditions, are relatively easy to identify, while in general the benefits are hard to establish.
Identifying the two aspects of a public work, costs and benefits, as completely as possible, is essential but complex, and it is even harder to determine them for all the works conceived with nature-based criteria. In fact, these works are capable of providing important ecosystem services, serving the urban environment and the well-being of the people. However, these services are almost never considered as rewarding evaluation criteria or as avoided costs.
Evaluating the costs and benefits of the Nature-based Solutions is very important for the Public Administration, but also for the possible involvement of public and private stakeholders who can be partners in the implementation and financing of the intervention, and can especially bring advantages and benefits from the implementation of the work. In fact, more often than not, it is not about spending more with the Nature-based Solutions, but about designing the public space in a different way, investing more in solutions that can reduce costs and maintenance time, and also considering in the cost-benefit evaluation the avoided costs thanks to the risk reduction or the generated context values, which can increase the real estate value of private interventions that lie in the area of influence of the renewed public spaces.

Interest in the measurability of the environmental and economic benefits of green urban infrastructures is increasing and - thanks to evaluation software and systems - can now be quantified by assigning them a value, both in terms of avoided costs and of created value. It is indeed possible to 'measure' the project quality, assessing its effectiveness under a microclimate or distributed ecosystem service point of view, using elements to define the urban quality and environmental strategy of a plan or project. Among the tools for climate and heat, for instance, we can use Envi-met, for green infrastructures we can use the USDA Forest Service iTree suite tools, which return the saved costs in terms of absorbed dust, stored gas, run-off reduction, and aesthetic benefits.

COSTS INDICATED IN THE PROJECT DATASHEETS

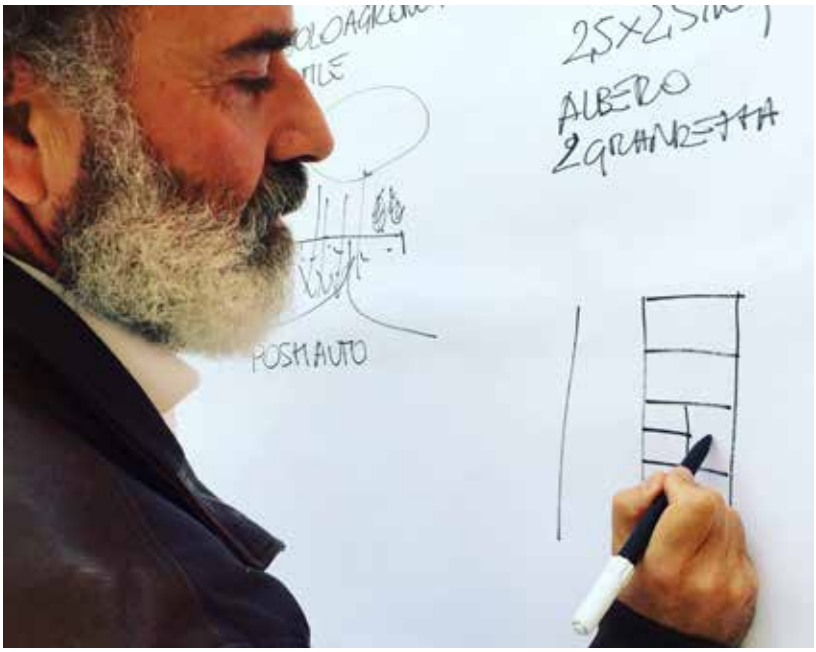
For a cost-benefit analysis, the full cost of the life of the work shall be taken into account, from its design (feasibility analysis, preliminary, final, executive project, specialized analysis and on-site surveys, etc.), to construction, the various maintenance phases (initial maintenance, regular, occasional maintenance), and its dismantling.
Regarding the works costing, this guide reports the indicative estimates of costs for carrying out Nature-based Solutions. To this end, where possible, the Emilia Romagna Region Price List was adopted as reference (Regional List of prices for public works for land protection of the Region of Emilia-Romagna - year 2018, approved by deliberation of the Regional Council no. 512 of 9 April 2018), while for the quantification of material costs and more specialised works not on the regional price list, reference was made to prices from market surveys and/or prices used in urban redevelopment public works or similar.
The costs indicated in these guidelines represent a parametric estimation of costs, or an estimate of unit costs with respect to characteristic parameters of the intervention such as, for instance, the spatial size (cost per sq. m) or the number of planned safeguards and mitigation elements (for instance cost per single drainage well, etc.).
It is clear that these costs may vary depending on the specific context, the choice of different materials, the scope and dimensions of the intervention, of specific choices.
An estimate of the subsequent maintenance costs of the works was provided, wherever it was possible to quantify within a defined range.

ECOSYSTEM BENEFITS INDICATED IN THE PROJECT DATASHEETS

Regarding the ecosystem benefits generated by the proposed nature-based solutions- indicated in the project datasheets - the CICES (Common International Classification of Ecosystem Services) - classification, developed by the European Environment Agency (AEA), were used as a reference - making a qualitative evaluation of the ecosystem services generated by the proposed Nature-based Solutions.
The CICES classification identifies over 70 services provided by green infrastructures. Considering the framework of the proposed Nature-based Solutions, the evaluation field were reduced to services provided specifically in urban areas, leading to the determination of 9, thus classified:

- provisioning
  - food and biomass production
- regulating
  - regulation of dust for air quality
  - noise reduction
  - run-off and flooding-risk reduction

The 3° workshop in Bologna.
(Photo by E.Farnè)



The study visit in Milano Marittima and Rimini. (Photo byE.Farnè)

- boosting of pollination and biodiversity
- heat regulation and increase in urban and microclimate comfort

⇢ cultural services

- usability and attractiveness of the public space
- identity and sense of belonging
- beauty of nature

For each service provided by the green and blue infrastructures and the proposed Nature-based Solutions, a score was assigned from 0 to 3, where 0 is the absence of service, 1 is a low score, 2 average, 3 high. This indicative evaluation allowed us to highlight the benefits provided by the various proposed Nature-based Solutions. It is interesting to note how this classification includes all the specific environmental benefits in the regulation services, namely those connected to climate, pollution, urban rainwater management, effects on public health and the well-being of people. Green infrastructure capacity of producing food and biomass for the urban population are part of the production services. Social benefits that make a place usable, attractive, and capable of generating a sense of belonging in the people, are part of the cultural ecosystem services.

It is in fact the mixture of the different ecosystem services provided by the green infrastructures that generate resilience and liveability in the city, and it is these services that - together - determine that context value which also affects the economic value of an intervention.

THE VISUAL IMAGE OF THE GUIDELINES

In parallel with the technical activity and together with the partners, some manuals and guides concerning regeneration operations carried out with Sustainable Urban Drainage Systems and Nature-based Solutions, which are extremely widespread in the Anglo-Saxon world and in Northern Europe, have been studied from a point of view of communications and of representation. Among others, the following were studied in depth: *Trees in Hard Landscapes. A Guide for Delivery* (U.K., London), *Strengthening Blue-green Infrastructure in Our Cities. Enhancing Blue-green Infrastructure & Social Performance in High Density Urban Environments* (U.S.A.), *The Guide to Depaving. A Parking Lots to Paradise Production* (Canada), *Planting Beds in the City* (Stockholm, Sweden), *Ondate di calore in città. Basi per uno sviluppo degli insediamenti per l'adattamento ai cambiamenti climatici* (Swiss Confederation); *Aménagement des eaux pluviales* (Lyon, France) and *Rigenerare la città con la natura* (Italy, Emilia-Romagna).
These manuals are particularly interesting in both the richness of the visual elements and technical information, and for the contents developed through research groups related to various disciplinary fields.
The manuals have been very useful in various European countries for developing a different public space project culture, starting from the criteria of sustainability and resilience. Also, one of the most stringent requests of the SOS4life project partners was to have a work tool capable of standardising different needs and competences and good practices.

urban areas to regenerate and climate

1. THE CENTRAL ROLE OF URBAN AREAS
planning climate adaptation policies in urban regeneration processes

2. INTERVENING AT EACH SCALE
urban regeneration from the sidewalk to the neighbourhood, to the city

3. OASIS CITY
creating shade and evapotranspiration in the urban fabric

4. SPONGE CITY
recreating space and time for the water return water to the aquifers

5. GREEN CITY- BLU CITY
integrate water management, heat regulation, infrastructure and mobility

6 UNDERGROUNG CITY
rethinking the design of public spaces above and below the ground

7 PUBLIC CITY,
CITY FOR PEOPLE
rethinking urban spaces for attractiveness, health and social inclusion

1

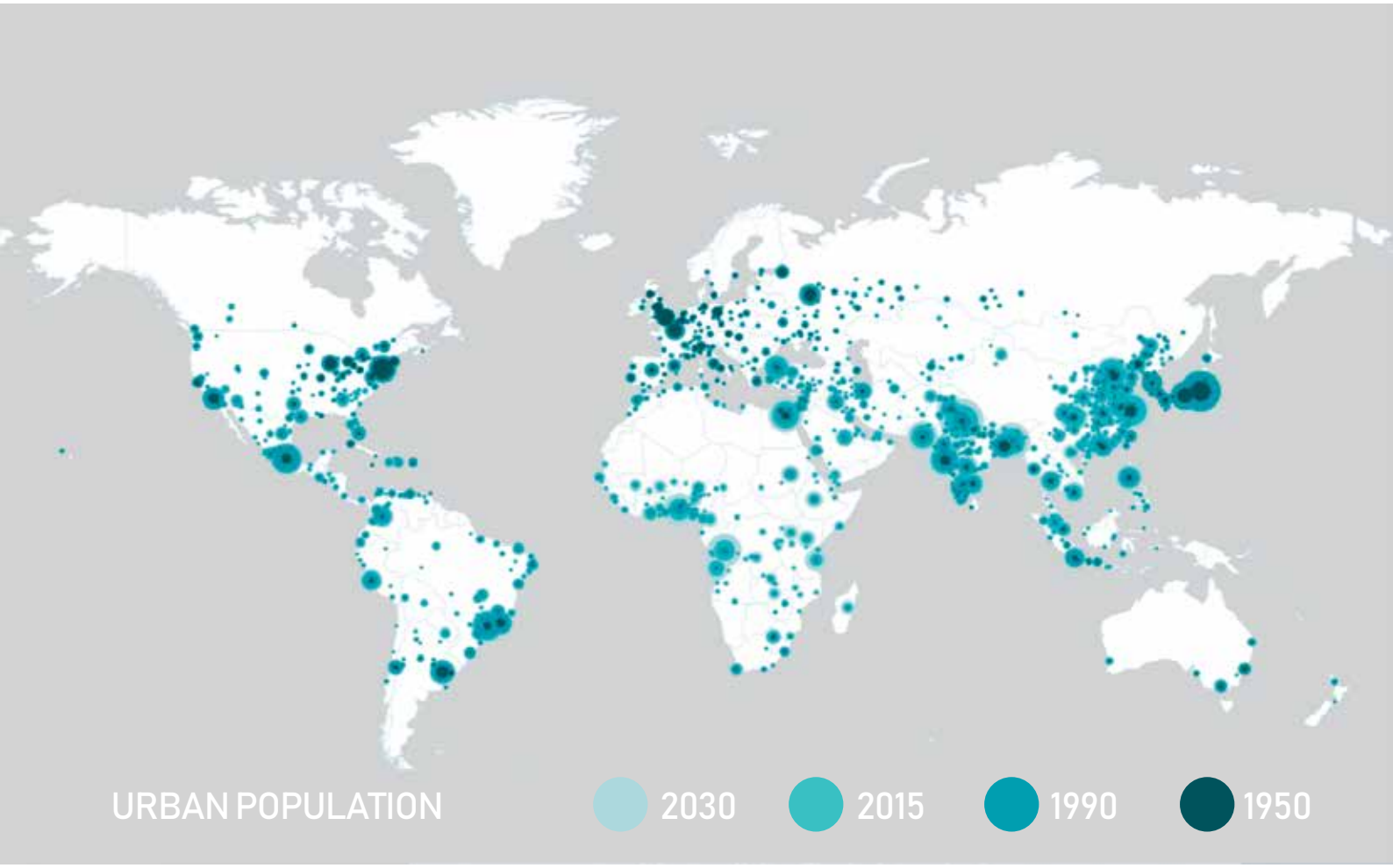
THE CENTRAL ROLE OF URBAN AREAS
planning climate adaptation policies in urban regeneration processes

Global warming - and consequent changes in rain and temperature regimes - is considered the most important aspect of today's environmental crisis, and is responsible for the worsening of many of the critical issues already present in the more urbanized areas of our country and the planet in general.
Some data can help us understand the central position of urban areas in the fight against climate change, the relevance of processes - demographic, environmental, and climate - in place today, and why it is so important to intervene urgently in urban contexts.
At a global level, urban areas make up just 3% of the planet's surface, but host 54% of all human beings and consume 70% of the energy and 80% of the food. Between now and 2050, the world population should increase from 7.6 to 10 billion people, reaching 70% of the total. In Europe and Italy, more than 70% of people live in cities nowadays, and this percentage is going to increase even further.

Cities are the main culprits responsible for greenhouse gases and polluting emission, attributed to them as 75% of the total. As we know, these emissions come from human activities, including:

- transport (mobility of persons and goods);
- households (energy consumptions for cooling and heating of buildings);
- industry (industrial combustion and energy production).

the other hand, the high concentration of population, goods, and activities, and extreme urban system artificiality further increase their vulnerability to environmental impacts and, specifically, to extreme weather events.
We must not think that these issues concern only large urban spaces: even if vulnerability can vary greatly from city to city and even inside one particular city, all urban areas, whether big or small, are nowadays exposed to the effects of climate change.
Nor should we make the mistake of thinking that the current lack of urban system adequacy in guaranteeing an acceptable level of safety and environmental well-being for people is only due to the climate emergency. This, in most cases, has done nothing but exacerbate the criticalities already present due to a growth that has sealed increasing amounts of land and has not known how to keep the balance between sealed and green areas, which has hardened the water network and linearized river beds, sealed streams in urban areas, compromised the natural cooling capability of vegetation and blocked natural ventilation in central areas. Floods, overflows, extremely high summer temperatures, concentrations of pollutants and greenhouse gases in the air: all phenomena that are a far-from-negligible threat to the well-being, safety, and health of people.
Of the various environmental crises, the climate one is perhaps the most complex that we will have to face in the next decades, and cities will have a central role in the adaptation processes. Urban planning policies shall be primarily aimed at regenerating existing cities and urban regeneration cannot miss the opportunity of integrating the mitigation and adaptation to climate changes objectives into its implementation.
We know that the pursuit of these objectives includes an approach based on the reintroduction of nature into the city, which contributes at the same time to improving the environmental and social quality and the livability of public spaces and, ultimately, the beauty of our urban areas. Moreover, we must remember that the quality and availability of public spaces in our cities can also play a fundamental role in economic value creation, because the quality of the buildings together with the quality of public space develop 'contextual' values that increase the value of the buildings, as proven by the growing relevance given to the contextual factor in city dwellers' purchase and leasing choices.



At a global level, urban areas make up just 3% of the planet's surface, but host 54% of all human beings, consume 70% of the energy, 80% of the food, and emit 75% of pollutants and greenhouse gases.

75%

2

INTERVENING AT EACH SCALE
urban regeneration from the side walk to the neighbourhood, from mobility system to the city

Pursuing climate protection objectives and combatting the effects of climate change passes through actions that can affect different scales of intervention and place themselves in both public and private spaces.

Cities can act on various scales at the same time, implementing actions ranging from adaptation plans to the insertion of environmental and climate sustainability criteria in the urban transformation and regeneration processes, to retrofitting actions with widespread adaptation interventions in existing urban fabric or mobility and car-free model actions. This, of course, is going from urban fabrics and more exposed contexts (due to morphology, hydraulic criticalities, building energy characteristics, demography, etc.) to the impacts of extreme weather events,

At municipal level the climate strategy acts mainly on the public city on physical spaces wherein the hard measures that take place will have to find a place. These could be grey measures - technological and engineering solutions - and green measures – ecosystem-based approaches - such as Nature-based Solutions.
The urban design scale is perhaps the most interesting one, because of the innovative approaches that it implements in the transformation of the existing city.
Through urban-scale projects, local administrations have the possibility of intervening by means of small and large urban spaces, squares, parking lots, degraded neighbourhoods, barracks, abandoned production spaces, transport (rail yards, airports, etc.) and roads (roads and parking lots) infrastructures, transforming them into public gardens, tree-covered parking lots, small and large urban parks - elements of a true network that connects these urban spaces together and with others at a territorial level.
In any case following two fundamental strategies:

- maintain and/or restore urban soil permeability;
- introduce green and blue infrastructures as nature-based solutions to manage heat stress and rainwater in a sustainable manner.

At the building microscale, actions can for instance include interventions such as green roofs (with advantages both for the building, which will have lower energy costs thanks to improved insulation, and to control run-off), de-paving of appurtenant areas, and tree-planting. Other initiatives, which are bottom-up can also take place under the initiative of single city dwellers or associations that promote and collaborate in the de-sealing as actions to create usable green areas, improve thermal comfort, lower the temperature and improve the water cycle management. One instrument for the implementation of these actions can be the signing of agreements between citizens and Public Administrations that have sustainable common asset management and care as their objective.
These actions can be on public or private public-use spaces, such as pavements, open sealed spaces of schools or church areas that can become small gardens and green areas dedicated to rest and play.

The large neighbourhood of Østerbro has been the object of a climate adaptation project conceived from the city's climate plan and from a Europan contest based on car-free urban models. The project has planned for a reduction of 20% of space dedicated to vehicles to return it to citizens and develop adaptation interventions.
(Project and images by Tredje Natur)

Since 2014, in just 5 years, it has gone from the plans to the project to the works. The project has involved all the roads, parks, and gardens of the neighbourhood
(Photo by Luisa Ravanello, 2019)

270.000 sqm

The street today.
The space is dedicated to vehicle traffic, the street is occupied by the cars, it is almost impervious and there are no spaces for rest.

existing vehicle road space

50.000 sqm

Obtained by subtracting standard green areas and regulation public spaces from the vehicle spaces.

public space subtracted from cars
for climate adaptation actions
and the creation of green areas for residents

Freedom!

The space is returned to the residents. New green areas and new public spaces are conceived for the people and the climate adaptation measures.

20% reduction in the car road surface

3

OASIS CITY
creating shade and evapotranspiration in the urban fabric

Starting with shade, we try to translate the three main strategies for refreshing urban areas into measures: shade, wind, and evapotranspiration. Let's think of the physiological comfort effect that shade can generate in people and that of overall microclimatic regulation produced by green spaces, even small ones, but with continuous trees that are possibly connected to each other This is the case of the so called 'villas' of the Apulian cities: real oases of coolness among the stones of the old city, a place for cooling down and of intense urban socialization.

Creating widespread shade situations in the city means eliminating large surfaces from direct solar radiation, thus preventing the 'hot materials' that buildings, houses, streets, squares are made of, from absorbing it and turning it into heat. Heat that, by day, contributes significantly to worsening our thermal comfort, involving both the confined spaces in which we live and work, and the open spaces where we normally walk, stand, play, practice sports. Urban temperatures decrease only in correspondence with green spaces and water bodies.

The enormous amount of heat accumulated by the city's materials during the day is released through the night, creating a phenomenon defined as urban heat island, which stands for a surface and air temperature difference that can vary, depending on the cases, between 2 and 8 degrees, with night temperatures that decrease very little with respect to day ones, compromising our physiological comfort for days, decidedly having a negative effect on our sleep (and our work) and the health of the most vulnerable individuals.

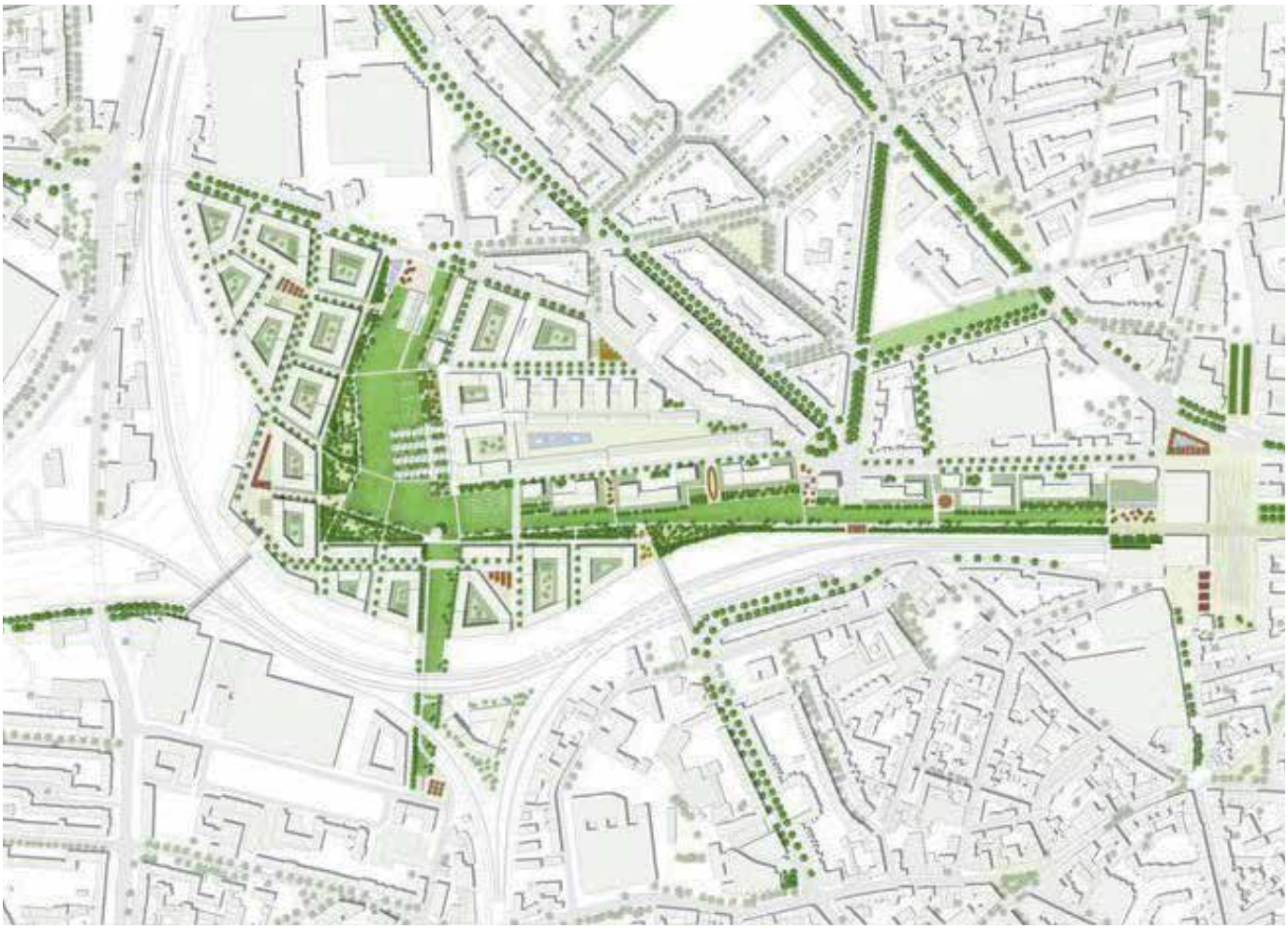
In other words, the morphology of the city (geometry of the urban structure and building density first and foremost), the characteristics of the mineral materials of the buildings and land, the scarcity of vegetation and water bodies, result in heat accumulation during the day that cannot be dissipated during the night. During the summer months this causes physiological discomfort conditions in the population.

Shade in the city can be created both with artificial structures and with the insertion of trees. Whenever possible, it is always preferable to choose plants because they perform better and more simultaneous thermoregulatory functions of the urban microclimate, together with many others.
The trees - based on their crown form, size and density - can contribute to shade urban paving of squares, streets, slow mobility paths, cycling-pedestrian, as well as the building walls and roofs (reducing the accumulation of heat, energy demand for cooling, and discharged heat on open spaces).

Shade generated by green infrastructures, in order to be truly effective in lowering temperatures, must be conceived so as to guarantee an adequate level of continuity of the shades generated by single trees. This effect is associated with that of evapotranspiration, which must ensure a certain continuity: in fact, the refreshing effectiveness of a plant mass is generated by the sum of the evapotranspiration and shade effects, and is proportional to the continuity of the former and the proximity of the latter.

But plants, besides giving us shade and keeping the city's mineral surfaces cooler, play another fundamental and irreplaceable function: evapotranspiration. Through it, plants introduce water vapor into the air that, in combination with the shade, contributes to ultimately lower air temperatures.

To the right, some images of the villa comunale and of the tree-lined avenues in Trani, Puglia.
The villa comunale is an urban garden or park that is typical of the cities in the South, which have always lived with the heat and have found in the villa an effective adaptation measure.
The villa is often connected with lines of trees and shaded streets that innervate in the city centre, so as to reverberate the comfort effect.
In the villa comunale, shade is compact and the land is treated as an integrated system of dirt paths that alternate with lawns and gardens. Temperatures can be 7-8 ° C lower than the surrounding context
(Photo by Luisa Ravanello)




FRESH
Torino
La mappa delle aree fresche di Torino
The map of cool spots in Torino
N
Torino
Urban
Lab

Top left, regeneration project of an urban area using open spaces. The project is financed through the urban planning tool of Landes Garten Schau. In Germany, there are international landscaping exhibitions that have been established since the war (IGA, Buga, and Laga) that finance urban regeneration from the landscape (Landscapedesign.)

Bottom left, Fresh Torino, urban map of shade and of cool places distributed to citizens and tourists in the summer of 2018.
The map, developed in English and Italian and distributed in various points of the city, was conceived as an information and support tool for the summer's scorching heat (UrbanLab Torino)

In questa pagina, in alto. Villa urbana a Trani. Collocata in posizione spettacolare in prossimità del centro storico, la Villa occupa un terrazzamento sul mare; è interamente pianeggiante e si estende su parte delle antiche mura. Nel giardino della Villa, di proprietà pubblica, vi sono palme, lecci, querce e pini marini. All'interno è presente anche un piccolo giardino delle spezie provenienti dall'Europa e dal bacino del Mediterraneo. (Foto di Luisa Ravanello)

Right, Piazza Fontanesi in Reggio Emilia, in the historic centre.
The square was born from the demolition of the block, in 1783, on which houses, the Santa Maria Maddalena convent and church rose. Remaining a market square and with ruins for almost a century, Piazza Fontanesi was configured at the end of the 19th century with the planting of linden trees.
In the square, from spring and during the summer, temperatures are lower than the ones in the centre by 6-7 ° C. This comfort condition makes it particularly attractive for other social functions, such as the market, and recreational functions, such as afternoon and evening nightlife (Photo by Luisa Ravanello).

In questa pagina, in basso, a destra. Plaza of the Human Rights a Monaco in Germania. La piazza si trova nei pressi di un centro commerciale molto frequentato ed occupa una superficie grande il doppio rispetto alla centrale Marienplatz. Obiettivo del progetto è creare uno spazio intimo e accogliente per residenti del quartiere, fresco ed ombreggiato durante tutto l'arco della giornata. L'impianto vegetale è costituito da filari irregolari di conifere messe a dimora su una superficie continua di sabbia stabilizzata. I percorsi principali sono in cls drenante, mentre gli arredi e le sedute in materiali naturali come il legno. (Progetto paesaggistico e foto di Valentien + Valentien)

4

SPONGE CITY
recreating space for the water

Some of the 'metabolic functions' historically developed by public spaces of the cities have been lost in time or transferred to grey infrastructures.
One of these is water cycle management. During their development, urban systems have not adequately taken into account hydraulic invariance and hydrology principles. Cities have progressively sealed the land and given up on managing rainwater, and urban hydraulic systems are now proving their inadequacy for dealing on their own with previous criticalities and new ones triggered by the effects of climate change.

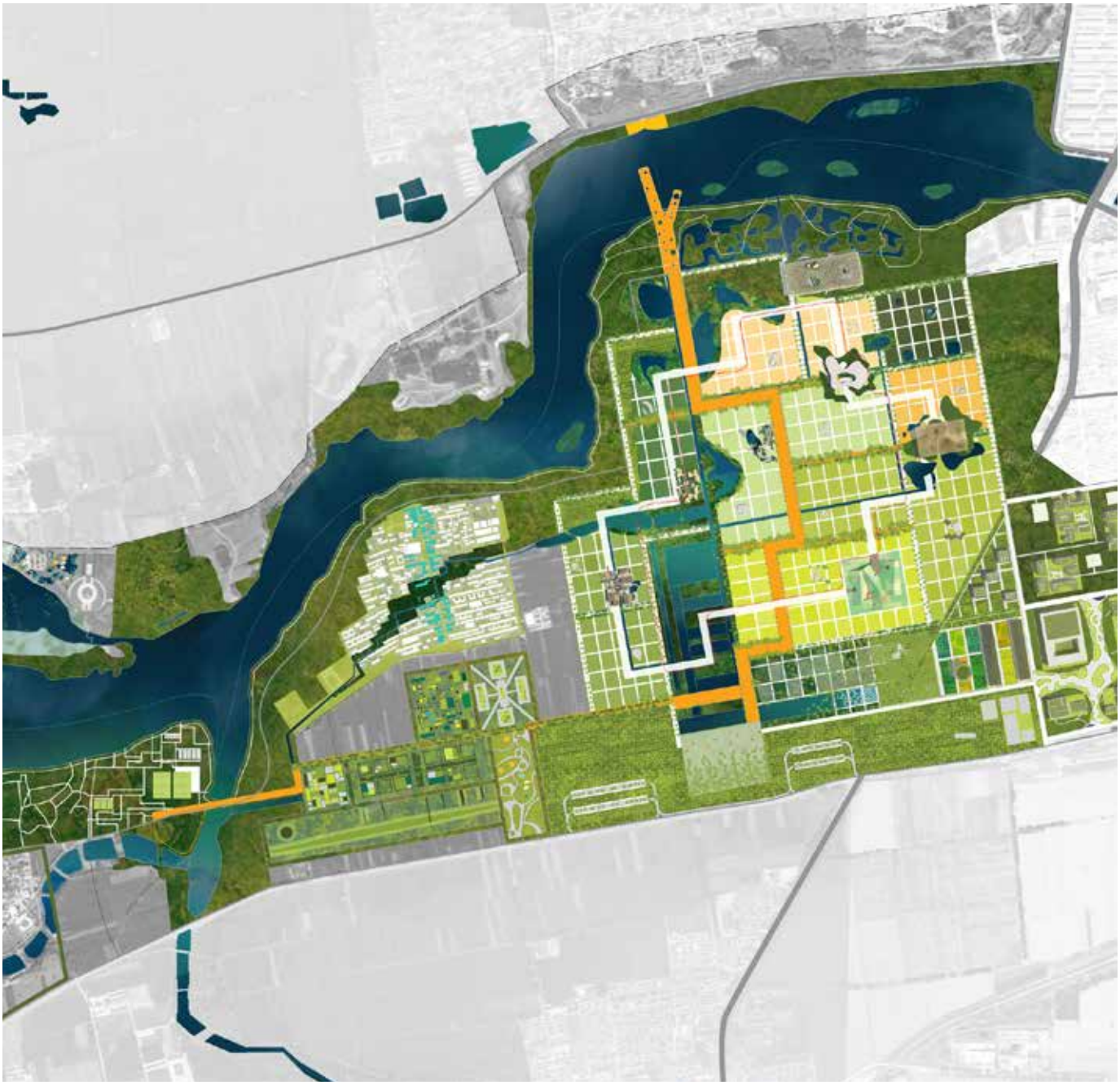
In order to face the new challenges imposed by climate change, these natural functions must be recovered by reconsidering the intrinsic potentialities in the land and plants of open spaces. Anyone who observes the built environment can notice the clear prevalence of waterproof surfaces, to the detriment of permeable land, areas covered with herbaceous, shrub, and tree vegetation: public spaces - such as squares, parks, pavements - are almost always covered with asphalt or non-draining paving, unfortunately almost always regardless of an actual functional need. The same can be said for the appurtenant spaces of buildings, whether public or private.

Also due to the worsening of extreme atmospheric phenomena, this urban soil characteristic is now making the management of surface rain runoff particularly problematic: in the case of intense and prolonged rains, the hydraulic networks quickly enter a crisis stage, resulting in flooding, putting people's safety at risk and causing extensive damage to infrastructures and environmental and economic losses.

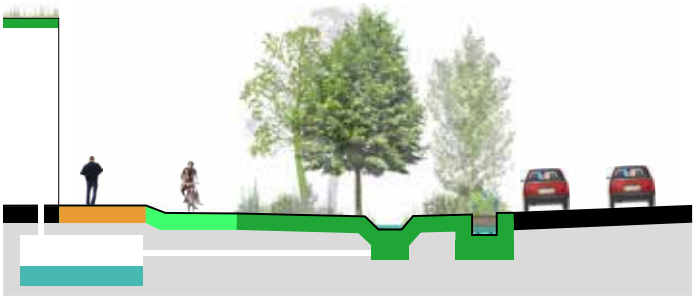
This happens because the urban settlement growth has almost always been incapable of guaranteeing adequate quotas of permeable surfaces, eliminating the 'sponge' function that the ground and plants can carry out and that consists basically:

- in slowing down the superficial flow of water (so-called runoff);
- in favouring lamination and infiltration, through the ground, towards the surface and deep aquifer;
- in their temporary retention in depressions and specifically-designed volumes;
- in allowing the evaporation of the ground and evapotranspiration through plant leaves;
- in the retention and storing of water for a later use (maintenance of green areas, street cleaning, etc..).

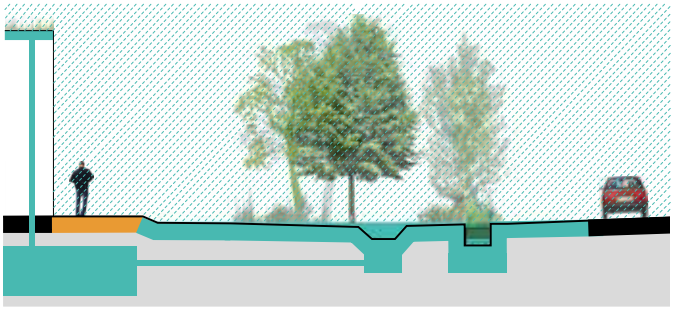
Given the increasing critical nature of grey infrastructures, which are now absolutely inadequate for managing the growing amount of rainwater that is concentrated in a smaller number of extreme events throughout the year, restoring this natural regulatory function of the soil is more appropriate than ever, by favouring the design of green-blue infrastructures that allow for the landscaping management of the hydraulic and hydrologic invariance volumes and the simultaneous creation of multi-functional public spaces.



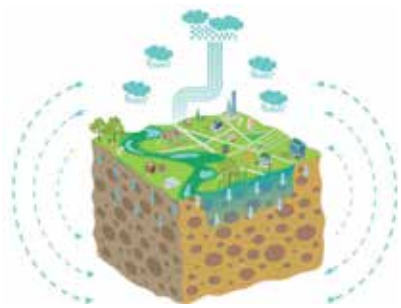
area urbana inondabile in condizioni normali



area urbana inondabile dopo un intenso acquazzone



SPONGE CITY



during intense rains, fast refilling of the aquifer

in the rainy season, water infiltration into the ground

in the temperate season, purification of surface water

in the dry season, collection of water

5

GREEN CITY, BLU CITY
integrate infrastructures for water management, heat and mobility network

If the two fundamental alterations that urban systems nowadays find from a climate point of view can be essentially referred to the superficial energy balance (temperatures) and the rainfall regime, and if the best performing and multifunctional solutions are nature-based, then it goes without saying that the allocation of green areas in the city can no longer be considered a merely ornamental or quantitative topic but one of performance.

We know how the scarcity of green areas has a drastic effect on water management and on urban system thermoregulation capability, on air and water quality and on city liveability.

Among the actions that can be implemented to regulate the surface run-off management and improve the microclimate, we can find soft or hard measures - physical, engineering interventions (grey infrastructures) - or green measures, the so-called Nature-based Solutions: green and blue infrastructures[1]
The latter are to be preferred because - especially if conceived holistically - they perform much better in many ways, as they carry out more functions simultaneously, such as: absorption of pollutants, storage of greenhouse gases, reduction of summer temperatures, rainwater interception, support to grey networks of mobility and slow mobility, to social, sport, and recreational activities, etc..
A vast European and international literature strongly recommends its adoption, replacing or integrating grey infrastructures.
These are environmental services that, if properly designed, can provide the urban environment and populations with multiple services and benefits including ecosystem services that concern both land and vegetation cover, biodiversity, etc..

The ecosystem services of the land, vegetation, and, in general, of natural and semi-natural environments, can be identified, quantified, and monetized and are generally classified according to four main functions:[2]

- the function of regulating the climate and microclimate, natural risks, water cycle and purification, waste recycling, etc.;
- the life support function, which includes soil formation, photosynthesis, and the nutrition cycle based on growth and production, habitat creation and biodiversity conservation;
- the supply function of real goods, such as oxygen, food, water, timber and fibre, etc.;
- the cultural function, relating to aesthetic and recreational values, that contribute to our spiritual and psychological well-being.

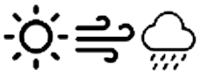
1- Green and blue infrastructures are defined as an ecosystem network that offers less expensive and more effective alternatives to the traditional 'grey' infrastructures and that offers many other advantages both for the citizens of the EU and for biodiversity. The green infrastructure is a strategically planned network of natural and semi-natural areas with specific environmental characteristics designed and managed to provide a wide range of ecosystem services, such as water purification, air quality, space for recreation and mitigation and adaptation to the climate. This network of green (permeable land and vegetation) and blue (water) spaces can improve the environmental conditions and therefore the health and life quality of the citizens. It also supports a green economy, creates job opportunities, and improves biodiversity. The planning of these infrastructures can provide environmental, economic, and social benefits and contribute to reducing dependence on grey infrastructures, more expensive to build and maintain *(https://ec.europa.eu/research/environment/index.cfm?pg=nbs)*.

2- Common International Classification of Ecosystem Services (CICES - Haines-Young and Potschin, 2013)

Drawings of the Boulogne-Buillancourt eco-neighbourhood, where the interaction between the built fabric project and that of the public spaces for green and blue infrastructures is evident. Public spaces, mostly permeable and vegetated, are created before the buildings as they are conceived from the ecosystem services that supply the built environment with heat and water management. (*Cities for People* exhibition, REBUS 2018)

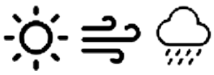
TESSUTO EDIFICATO

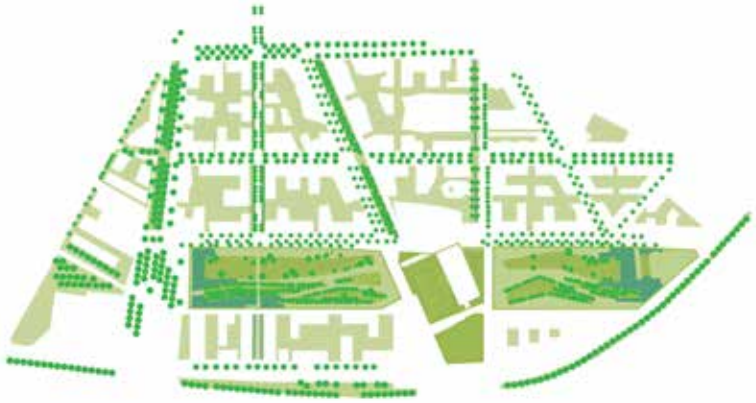
CONCEPITO PER ISOLATI PERMEABILI ALLA RADIAZIONE SOLARE
ALLE CORRENTI DEI VENTI E CON AMPI SPAZI PUBBLICI

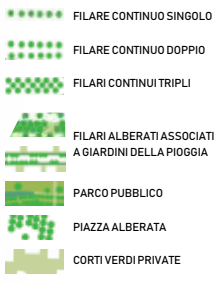


INFRASTRUTTURA VERDE

CONNESSIONE DEL VERDE PUBLICO E PRIVATO
MASSE VEGETALI E FILARI ALBERATI
CON CHIOME CONTINUE E CONTIGUE
E SUOLI PERMEABILI VEGETATI

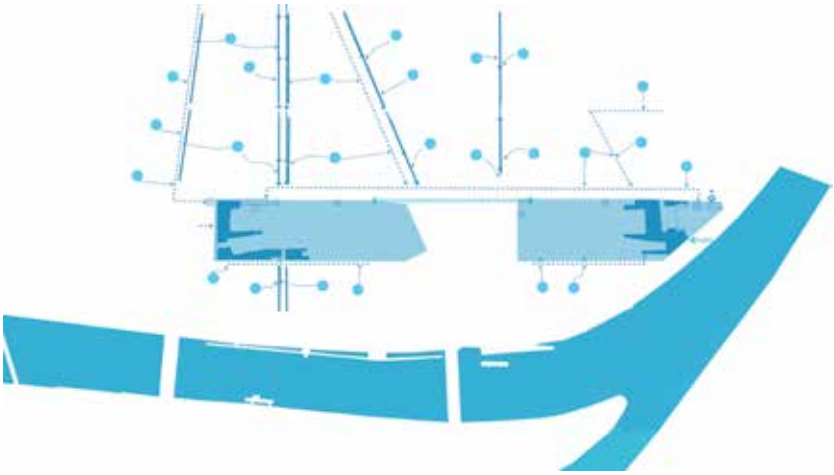


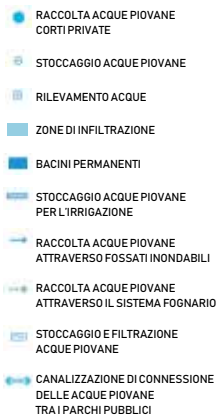




INFRASTRUTTURA BLU

SISTEMI INTEGRATI DI RACCOLTA DELLE ACQUE
SOLUZIONI TECNOLOGICHE INTEGRATE
A SOLUZIONI BASATE SULLA NATURA





6

UNDERGROUNG CITY
rethinking the design of public spaces above and below the ground

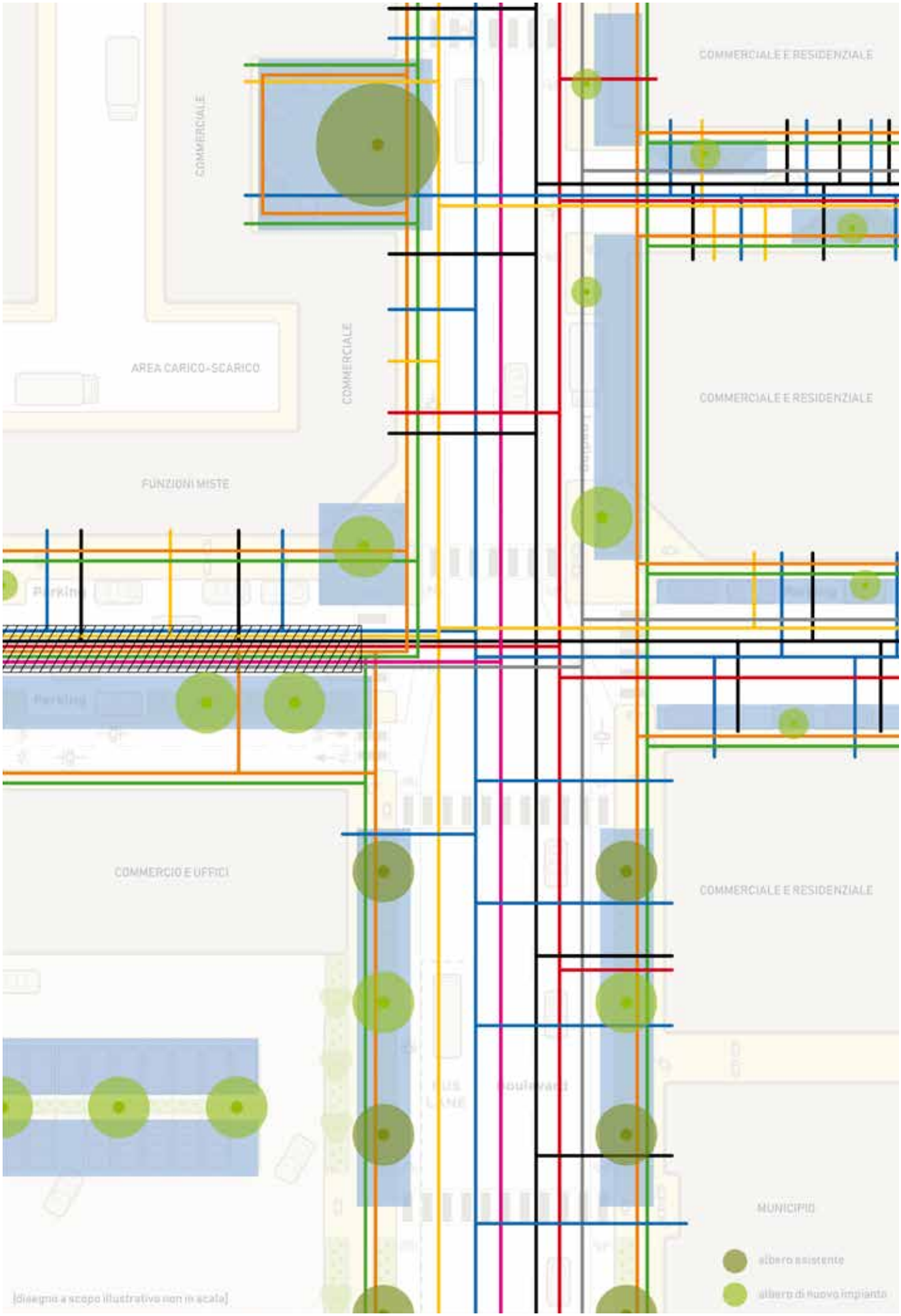
We often forget that in the bowels of the city run network infrastructure that collects meteoric water, wastewater and other technological networks (gas, lighting, electricity, heating, fiber optic, ...) and that together with these networks insist the natural infrastructure formed by the roots of trees and plants, with a mirror volume to the aerial canopies. Technological networks, often built without an overview of the city, are a highly limiting factor in the green regeneration of the public spaces above and for the life of green infrastructure, so valuable for the production of eco-systemic services necessary for urban life and people's well-being. And therefore, public space must also be conceived above and below the ground, integrating the needs of the different engineering and natural networks.

The failure to govern these intricate networks of sub-services – whose hidden geography has often not engaged local governments and managers to a concerted design and rational implementation of them – today, when reviewing existing urban fabrics, places an important constraint on the integration of new public space projects in urban areas. The construction, modification and expansion of the various underground infrastructures can, over time, conflict heavily with the health and survival of trees and green infrastructures or even preclude their construction due to and the physical impacts that threaten the radical apparatuses of plants.

These issues are sometimes overcome, other times there is a question of the economic sustainability of interventions. For this reason, we need to start paying more attention both in intervening in the networks of existing sub-services (advice and accompaniment of competent figures, such as agronomists-forestry, in the construction phase) and by redesigning the networks in a smart way, taking into account the future needs of the landscape project of the above space and a more efficient, economical and fast maintenance of underground networks.

In the city, the trees, the streets, the sidewalks and sub-services they often struggle to living with each other inconveniences and inconveniences: asphyxiation and coercion to the detriment of the correct development of the apparatus radical trees and plants, lifts flooring and flooring cords, possible damage and damage Interference underground lines.

In the design of streets and sidewalks is fundamental take consider both the necessary spaces for operation and maintenance sub-services, both the size that allow for adequate tree accretion urban greenery, so that there is no interference in the coexistence of the different Systems.
(Source: Trees in hard landscapes - A guide for delivery, TDAG - http://www.tdag.org.uk/)


COMMERCIALE E RESIDENZIALE
COMMERCIALE
AREA CARICO-SCARICO
COMMERCIALE
COMMERCIALE E RESIDENZIALE
FUNZIONI MISTE
Parking
Parking
COMMERCIO E UFFICI
COMMERCIALE E RESIDENZIALE
MUNICIPIO
albero esistente
albero di nuovo impianto
[disegno a scopo illustrativo non in scala]

7

PUBLIC CITY, CITY FOR PEOPLE
rethinking urban spaces for attractiveness, health and social inclusion

People are fine in a public space if they feel safe, if they feel comfortable and their well-being - physical and psychological - is attended to and if they have the possibility of living, socializing and experiencing moments that stimulate them and renew a sense of belonging.
Being well in the public space is a requirement that can therefore be satisfied and designed and that depends on the perceived environmental quality, in terms of livability and vitality.

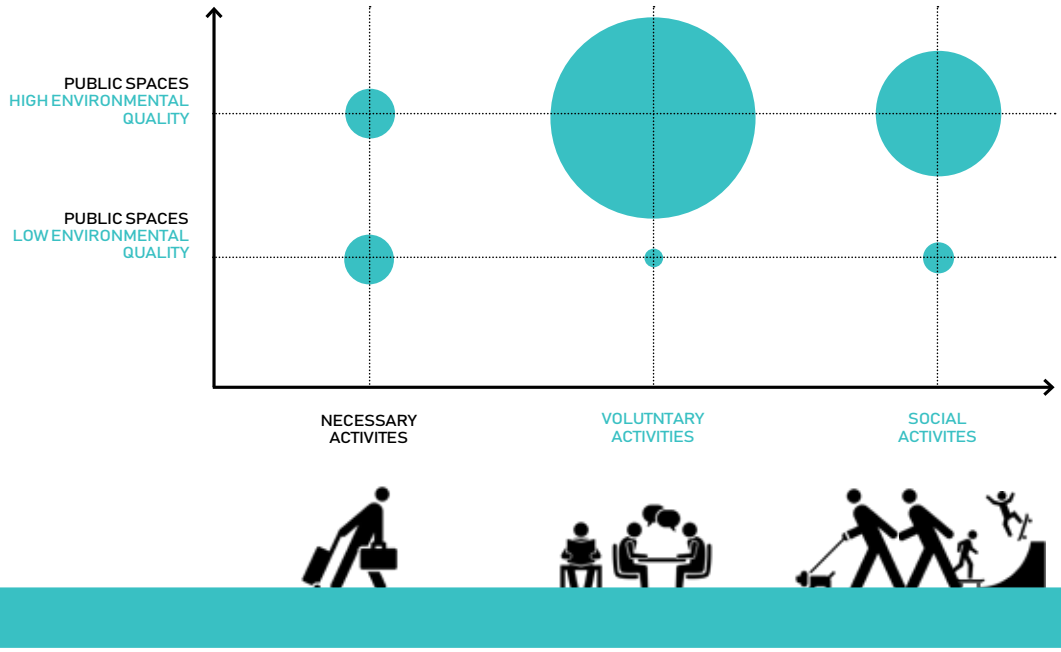
The activities that people carry out in a place - as Jan Gehl reminds us in his studies on the human-scale city [4] - can be subdivided into three different types.

- ESSENTIAL ACTIVITIES. These are activities that people are required to do and that they do every day, such as going to school or work, or shopping, taking the bus or train. In these cases, people tend to choose the shortest path and the environmental quality of the chosen route has little influence on the choice.
- VOLUNTARY ACTIVITIES. These are activities that people do when they want or have the time, such as sitting down to read a book or lying in a park in their free time, or going for a walk in the downtown streets. These activities take place in spaces that people choose, giving priority to the environmental quality and livability of places. The environmental conditions entice people to take breaks in the spaces and carry out actions even for prolonged periods.
- SOCIAL ACTIVITIES. These are activities that depend on the presence of more people in the same place, such as children's games or group sports among kids or getting together to talk with a friend, a girlfriend, a person we care about. The livability of public spaces, seating availability, the lack of excessive noise, the presence of shade and cool areas, entice people to being together in public spaces.

In order to obtain habitable spaces, the most correct approach to public space design must take into account the social activity- and safety-related variables, along with environmental and climate ones. Among the most important elements for outdoor comfort, the morphology of the space, plant and mineral materials, the presence of water, trees, seating spaces, must be taken into consideration.

A careful look at the human dimension of the city must therefore consider some key aspects such as livability, safety, environmental sustainability, and people's health. These objectives are all the more attainable as we increase the attention towards citizens and the way they live and move in the city, to carry out the social and voluntary activities in their free time.

4 - J. Gehl, 2017, *CIties for People*, Italian translation, Maggioli Editore


PUBLIC SPACES
HIGH ENVIRONMENTAL
QUALITY
PUBLIC SPACES
LOW ENVIRONMENTAL
QUALITY
NECESSARY
ACTIVITES
VOLUTNTARY
ACTIVITIES
SOCIAL
ACTIVITES

criteria for urban, ecological and environmental quality

1. MANAGING THE URBAN HEAT ISLAND AND HEAT WAVES WITH GREEN INFRASTRUCTURE
2. MANAGING URBAN RAINWATER AND HEAVY RAINS WITH BLUE INFRASTRUCTURE
3. INFILTRATING WATER INTO THE SOIL
4. MANAGING EXCAVATED SOILS AND ROCKS
5. INCREASING THE ENVIRONMENTAL AND PERFORMANCE REQUIREMENTS OF PUBLIC WORKS

1

MANAGING URBAN HEAT ISLAND AND HEAT WAVES WITH GREEN INFRASTRUCTURE

In summer, the heat can become very intense and unbearable in cities and urban agglomerations. This is the result of many factors that depend on urban morphology:

- ⇢ limited air circulation due to high-density urbanisation,
- ⇢ numerous waterproof or built-up surfaces that absorb solar radiation,
- ⇢ scarcity of green and permeable areas,
- ⇢ inadequate orientation of buildings,
- ⇢ excessive use of low-albedo mineral materials on the ground that overheat the surrounding environment.

These elements, taken as a whole, generate a heat island effect within the urban fabric; it is a phenomenon endogenous to the urban system that causes very high daytime temperatures, reaching their peak in the second half of the day and decreasing at night. When a heat island is associated with the exogenous phenomenon of a heat wave, consisting in torrid temperatures by day and high levels of humidity by night that last for a few days in a row, the difference in temperature between day and night within the urban fabric is reduced, making the conditions of discomfort unbearable for people. Temperatures remain high at night and night-time cooling has no significant effect. This results in an increased risk to the health of the urban population and the risk of death rises significantly.

STRATEGIC APPROACH

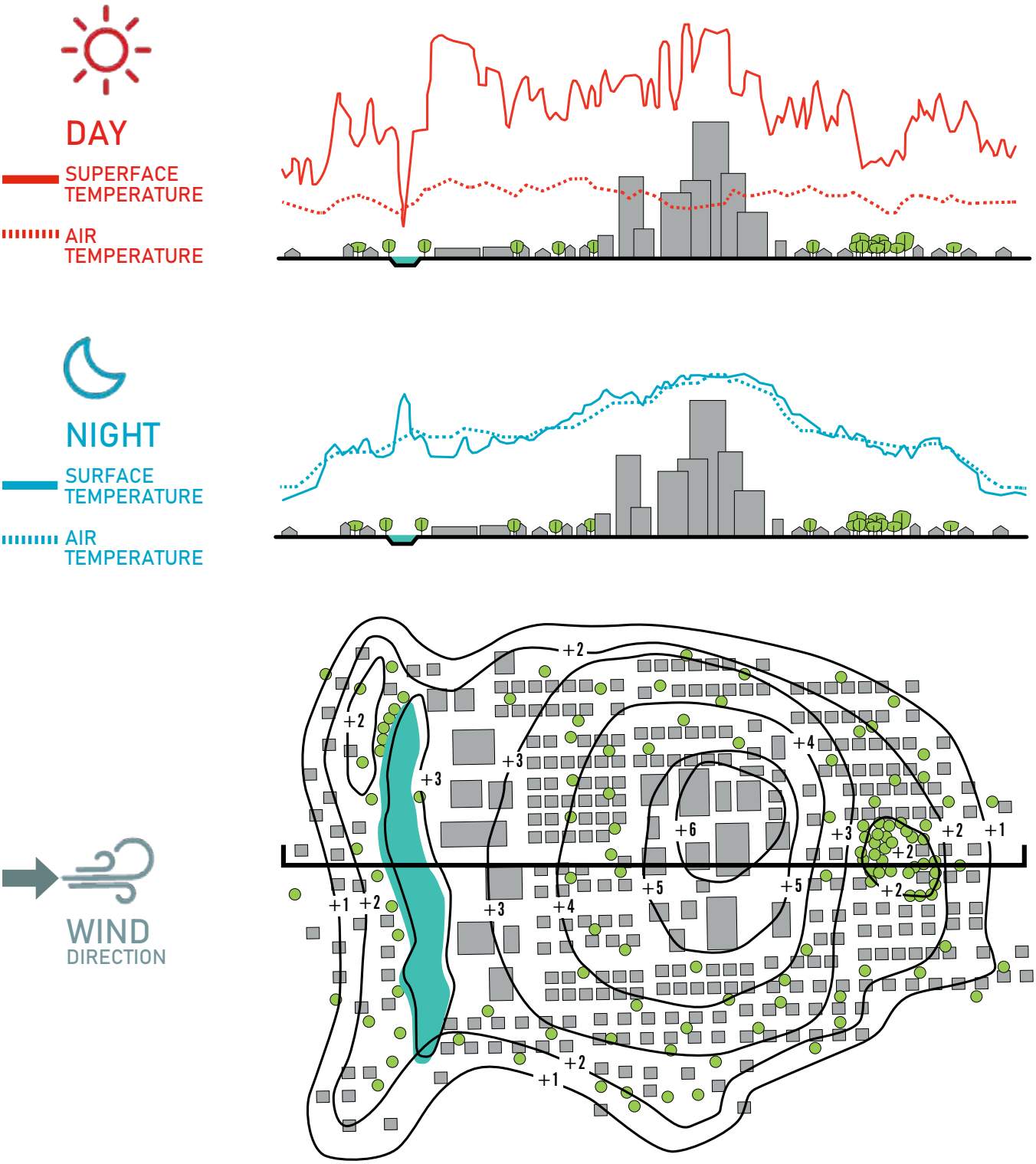
In order to counter the impact of excessive heat in urban areas, structural interventions on the urban morphology of a city are needed and a system of interconnected green infrastructures should be adopted to significantly reduce temperatures, improve air circulation, provide for sustainable water management and support slow mobility systems.

Creating such urban green infrastructure requires—as part of the stages and areas to develop the planning instrument, ranging from the cognitive framework, through the environmental and territorial sustainability assessment, to the development of the urban ecological and environmental quality strategy—that certain priorities be set and followed.

⇢ EVALUATE THE EXISTING ECOLOGICAL ENDOWMENT AND URBAN GREEN HERITAGE IN QUANTITATIVE AND QUALITATIVE TERMS. The benefits to the urban environment of eco-system services, in particular those with a regulatory effect, should be taken into account and areas of greatest fragility and risk should be identified.

⇢ MAP THE PUBLIC AND PRIVATE AREAS THAT ARE AVAILABLE AND/OR CAN CONTRIBUTE TO THE CREATION OF AN URBAN GREEN INFRASTRUCTURE. Mapping can help to identify areas that can contribute to creating green infrastructure and enhancing services for regulating heat, dust, water, noise and pollination.

Urban areas often have dark surfaces and scarce vegetation, so they tend to absorb a great deal of solar radiation, transforming it into heat, much more than neighbouring peri-urban and agricultural areas. The generated heat is released into the air by the wind. However, in the most densely built-up areas and/or where wind is modest or absent, heat is slow to dissipate and, as it builds up, it leads to an increase in surface and air temperatures, generating discomfort and making life unbearable throughout the day and night. The urban heat island phenomenon means that - at the same air temperature, as we move from rural and peripheral areas to the urban centre - there is a temperature difference of more than 5 or 6 °C. The only points of discontinuity and coolness in an urban heat island are urban parks, streams and waterbodies, where present. There may be a difference of at least 2 or 3 °C between these and the urban centre. That is why city parks and riverside or lakefront promenades are important areas for the well-being of people living in the city.
(Urban heat island patterns and variation of surface and air temperatures between day and night / Source: Voogt, 2003)



⇢ PROVIDE FOR DESEALING AND WIDESPREAD VEGETATION COVER IN THE SEALED AREAS AS PART OF URBAN REGENERATION AND IN PUBLIC AREAS OF TRANSFORMATION IN ORDER TO CREATE OASES OF COOLNESS. Desealed green areas should be as widespread as possible and interconnected with existing green areas. In these areas, nature-based solutions - such as rain gardens, green trench drains, vegetated draining ditches, rustic green areas, shaded and tree-lined areas and rows of trees - capable of enhancing the eco-system services for regulating heat, dust, and water and enhancing biodiversity within the narrower urban fabric should be favoured.

⇢ SELECTIVELY DEMOLISH DENSER OBSOLESCENT FABRICS STARTING FROM THE CLIMATE ANALYSIS, TO DEVELOP A SETTLEMENT STRUCTURE WITH INTERCONNECTED FREE SPACES THAT CAN GENERATE AREAS OF COOLNESS AND AIR CIRCULATION. Selective demolition is essential for denser urban fabrics, such as those dedicated to handicrafts and those of a mixed nature dating from the postwar period, which were built without providing adequate services and significant open areas. Demolition should aim to clear areas according to the direction of the prevailing summer breezes, to favour air circulation, and to create adequate infrastructure to lower temperatures in the urban context.
It is also useful to consider enhancing the value of the context to make the most of the interventions also in economic terms, by conceiving liveable public spaces with a high degree of usability as part of the green infrastructure. In these cases, preference should go to solutions providing for the creation of parks and compact vegetated masses, including linear ones, that comprise smaller-scale yet systemic nature-based solutions, such as ditches and floodable parks—connected to water infiltration and sustainable management—, as well as green areas equipped for sports, cultural and social activities, capable of attracting people, rustic lawns and shrubby masses with the aim of enhancing biodiversity.

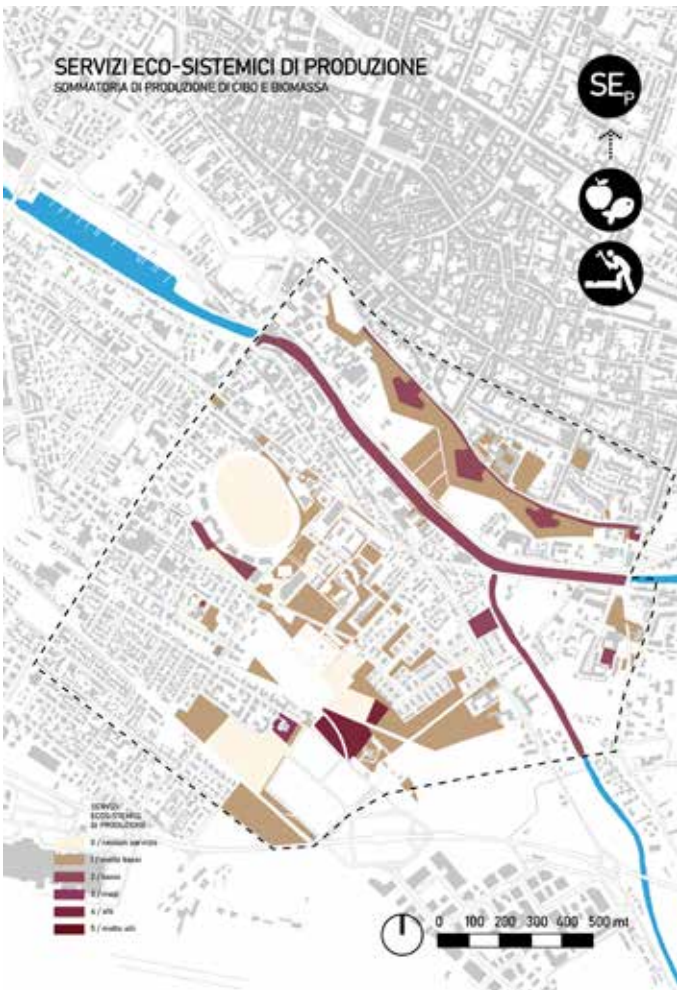
⇢ PLAN AND ENHANCE THE TREE CANOPY AND SHADE IN URBAN SPACES TO BUILD A NETWORK OF GREEN INFRASTRUCTURE, CAPABLE OF GENERATING COOLNESS AND URBAN COMFORT FOR PEOPLE'S HEALTH AND WELL-BEING. Green infrastructure should aim to generate a web of continuous shade along the network of major and minor urban roads, wherever conditions allow for it, especially if associated with areas of desealing on the ground and water collection that can expand and connecting with a broader system of green and tree-lined areas and private green areas pertaining to buildings.
We are referring here to parks and gardens, which can also perform ecological functions, as well as parking lots and squares that can be planted with trees and provide for small-scale nature-based solutions, courts, courtyards, parking lots and squares of residential, commercial, or production buildings and workshops.

⇢ PLAN AND FINANCE THE IMPLEMENTATION OF GREEN INFRASTRUCTURE AS AN URBAN ADAPTATION EFFORT, USING THE PLANNING TOOLS FOR IMPLEMENTATION OF URBAN REGENERATION ACTIONS. Urban green infrastructure is a fundamental piece of the Urban, Ecological and Environmental Quality Strategy of the General Urban Plan and constitutes, when drawing up operational agreements, public initiative implementation plans and building permits, a necessary and binding reference when determining the territorial, infrastructure and public services endowment on which the implementation of urban reuse and regeneration and new urban development measures hinges, in accordance with Regional Law 24/2017. For the creation of green infrastructure, the Urban, Ecological and Environmental Quality Strategy can identify the relevant actions to be implemented through the use of public resources and negotiations with private parties in operational agreements.

Urban Green Infrastructure Action Plan of the City of Ferrara - Perfect project. The maps show some analysis carried out in one of the seven analysis districts, between Via Bologna, the river and the areas south of the city. From left to right clockwise, maps of eco-systemic services provided by green infrastructures and analysed with the CICES classification: summation of regulatory services, cultural services, production services. Bottom right map of urban morphology analysis related to the prevailing direction of summer breezes.
The Neighbourhood Urban and Ecological Quality Strategy was developed from the analysis of eco-systemic services related to demographic, urban, morphological and climate data.
(Project and map processing, arch. Elena Farnè and Dr. Graziano Caramori with the Office of Plan of the Municipality of Ferrara)


SERVIZI ECO-SISTEMICI DI REGOLAZIONE
SOMMATORIA DI ASSORBIMENTO ACQUA PIOVANA E RIDUZIONE RUN-OFF, CONTRASTO ALL'ISOLA DI CALORE E MICROCLIMA, QUALITÀ DELL'ARIA E RIDUZIONE POLVERI, IMPOLLINAZIONE, ASSORBIMENTO DEL RUMORE
SE R
0 100 200 300 400 500 mt


SERVIZI ECO-SISTEMICI CULTURALI
SOMMATORIA DI ATTIVITÀ RICREATIVE, ESTETICA E BELLEZZA DELLA NATURA, IDENTITÀ E SENSO DI APPARTENENZA E SPIRITUALITÀ
SE C
0 100 200 300 400 500 mt


SERVIZI ECO-SISTEMICI DI PRODUZIONE
SOMMATORIA DI PRODUZIONE DI CIBO E BIOMASSA
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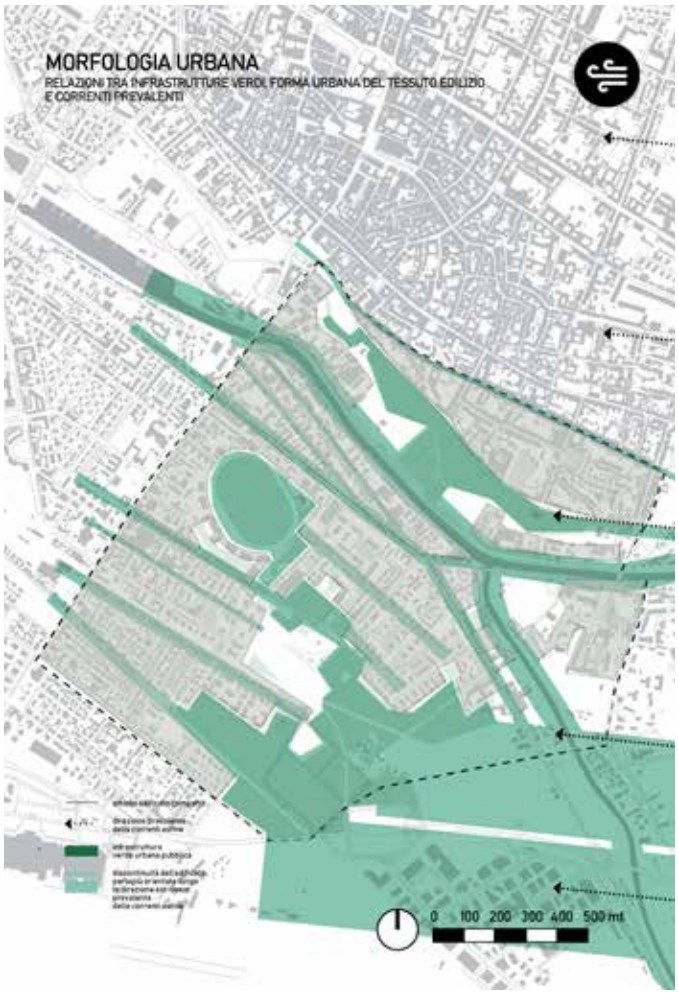
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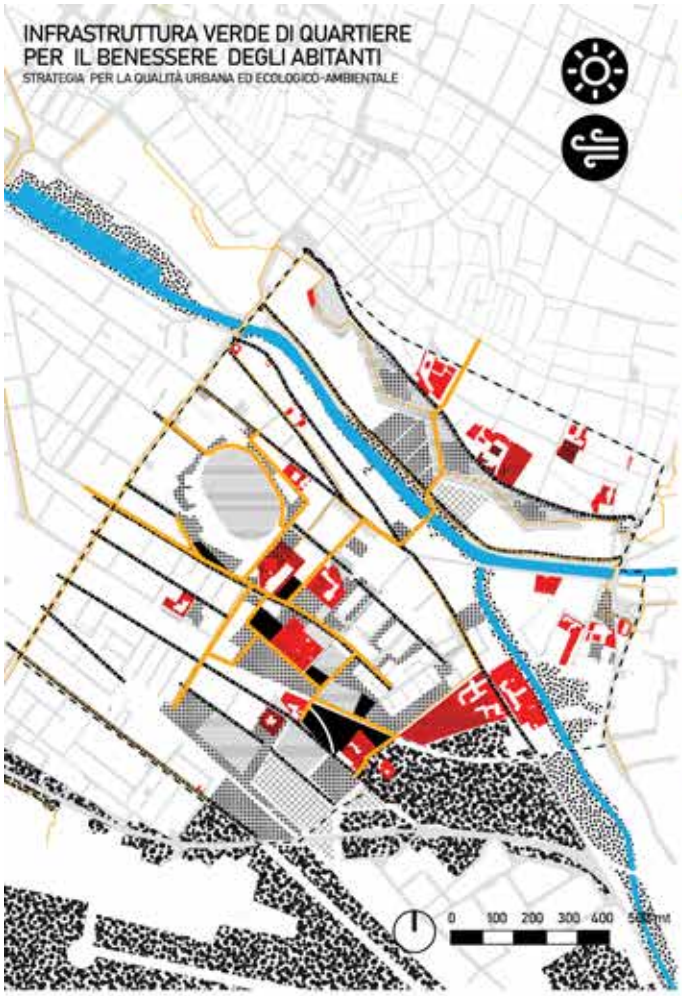
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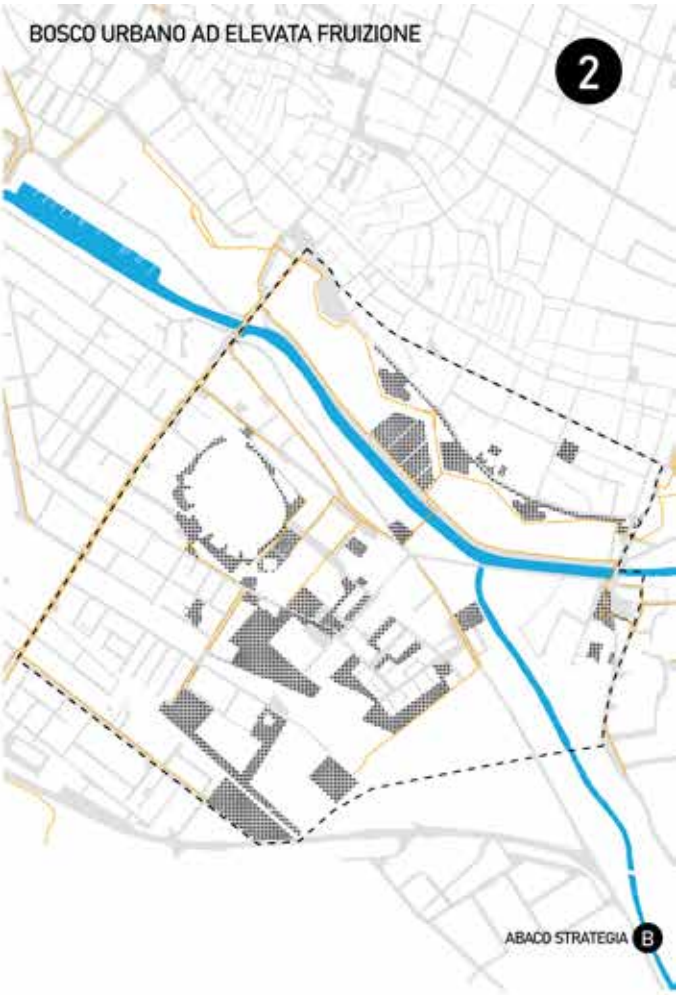
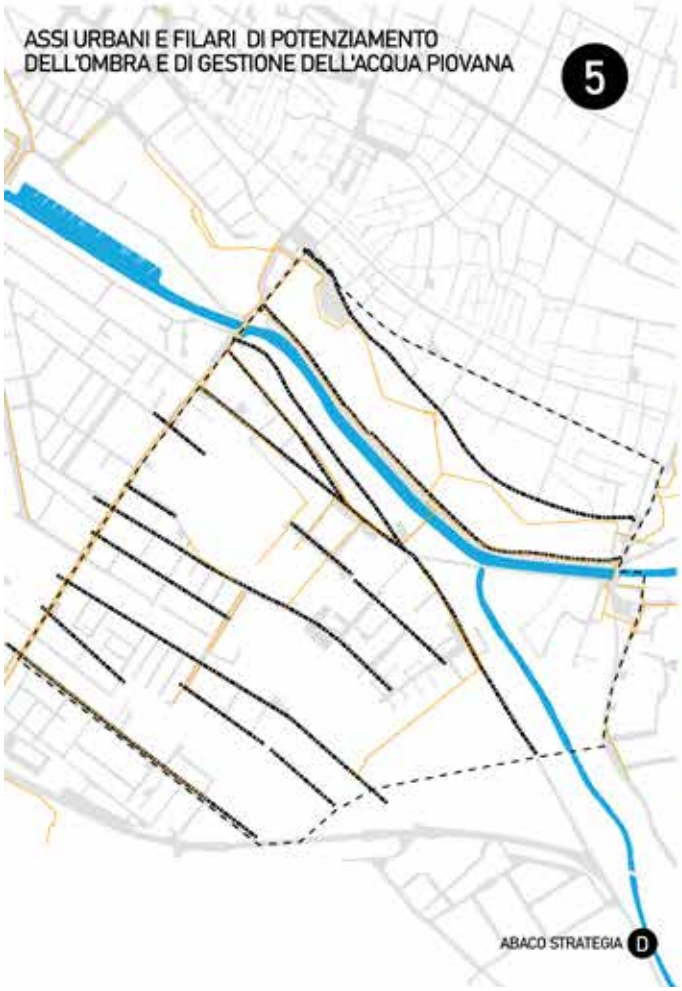

BOSCO URBANO AD ELEVATA FRUIZIONE
2
ABACO STRATEGIA B


ASSI URBANI E FILARI DI POTENZIAMENTO
DELL'OMBRA E DI GESTIONE DELL'ACQUA PIOVANA
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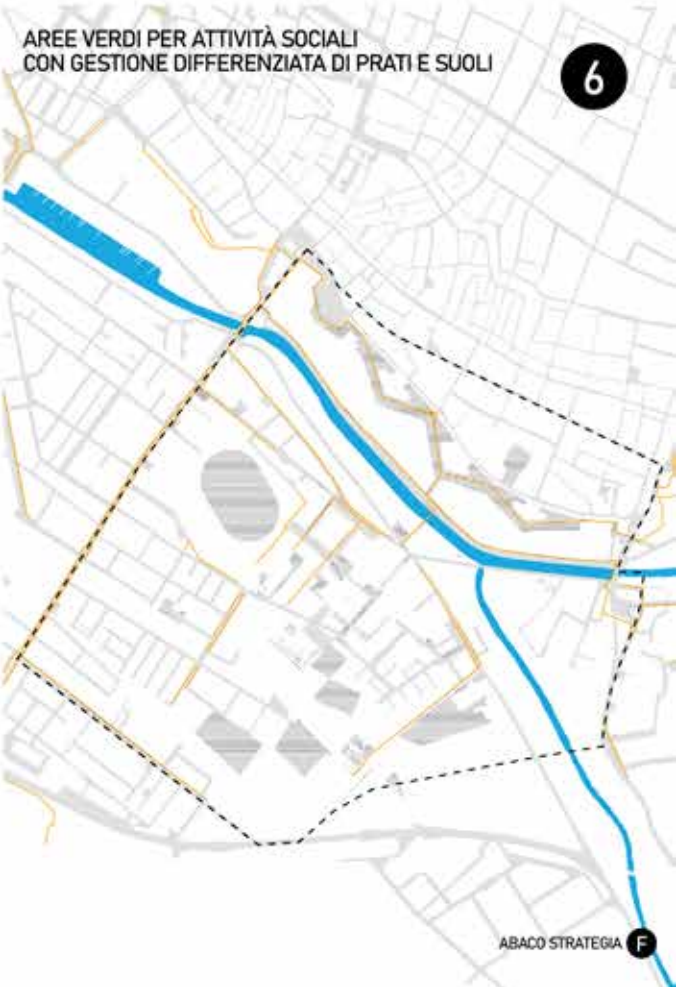
ABACO STRATEGIA D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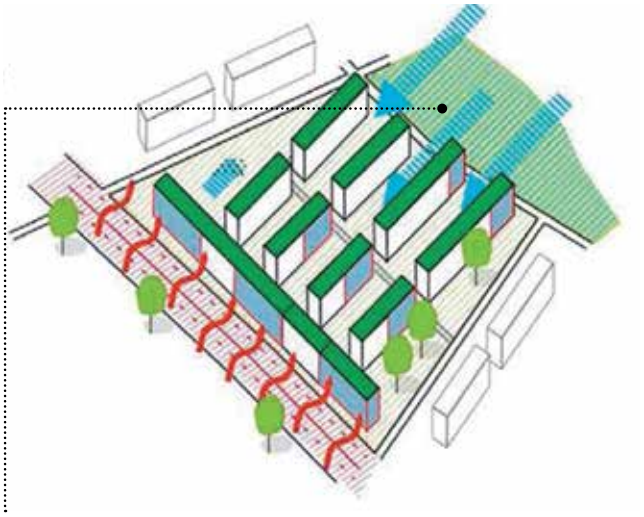
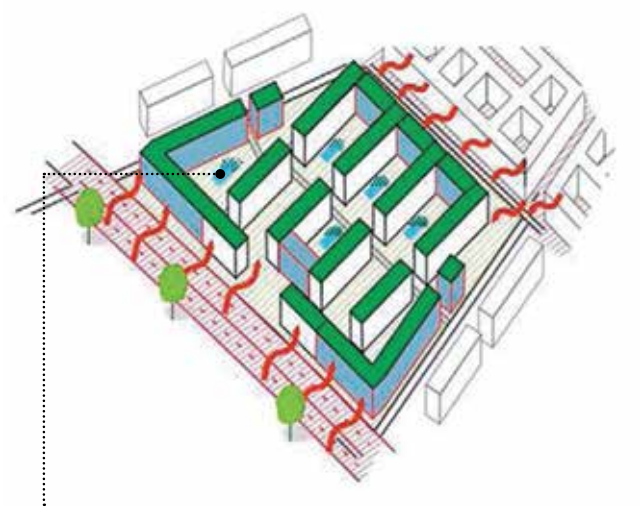
6
ABACO STRATEGIA F



surrounding environment exposed to climate impact with mitigation/ cooling spaces with cold air exchange areas



surrounding environment strongly exposed to the climate impact/ cooling within the neighbourhood with tree-lined points that create coolness

Right. Urban Green Infrastructure Action Plan of the City of Ferrara - Perfect project.
The maps show the summary map of the Strategy for Urban and Ecological-Environmental Quality for the districts that develop between the Park of the Walls, the rivers Volano and Primaro, Via Bologna and rivana and some levels of the founding elements.
The strategy is to create a widespread green infrastructure of shaded areas to serve the population, to be equipped and cultivated for the sociality of the neighborhood. This system of areas is tasked with enhancing the continuity of the shade through the masses of trees, in order to create paths and comfort areas for the heat island and cool oasis for residents. The green infrastructure also acts as a water regulation action and for the enhancement of ecosystem services for food and biomass production, pollination services and cultural ecosystem services for the use and sociality of public spaces. (Project and map processing, arch. Elena Farnè and Dr. Graziano Caramori with the Office of Plan of the Municipality of Ferrara)

Urban morphology and heat adaptation measures. In the first example (top), the built-up area is open and air exchange between cool peripheral areas and the built-up area with hotter air is favoured. In the second example (bottom) in conditions with a compact built-up curtain, cooling is given by courtyards and garden that create cool areas. (StEP Klima, Berlin)

2

MANAGING URBAN RAINWATER AND INTENSE RAINS WITH BLUE INFRASTRUCTURE

If not properly treated, the management of run-off rainwater in urban areas often poses serious problems for the community in terms of human safety, environmental protection and economic damage.

This is due to many factors depending on the city's urban morphology and the water management systems:

- numerous waterproof or built-up surfaces that do not absorb water,
- scarce presence of green areas and permeable soils,
- inadequate sizing of the drainage system with regard to heavy rainfall due to climate change and failure to separate rainwater and sewage collection systems.

In recent decades, there has been a rapid and intensive process of waterproofing the urban fabric, thus altering the natural cycle of water, which is not able to penetrate into groundwater, and which can contain pollutants that put groundwater at risk. In addition, significant changes are underway in the distribution of average rainfall, with an increase in the frequency of events characterised by extreme intensity of rainfall - due to a very high amount of rain that falls in a very limited period of time - that severely challenge traditional urban drainage systems and often entire blocks and neighbourhoods.

STRATEGIC APPROACH

In general, and in the light of the above, the approach to be followed is clear and basically consists in Sustainable Urban Drainage Systems (SuDS), which make it possible to pursue both the objectives of hydraulic safety (quantity), and those of environmental protection (quality).

FAVOURING NATURAL INFILTRATION OF WATER INTO THE SUBSOIL FOR HYDRAULIC SAFETY BY IMPLEMENTING THE PRINCIPLES OF HYDRAULIC AND HYDROLOGICAL INVARIANCE (QUANTITY).

The aim of the SuDS is to maintain or re-establish the natural water cycle, favouring as much as possible the infiltration of rainwater directly into the subsoil, discharging the least possible downstream, with a view to respecting the principle of hydraulic and hydrological invariance. In fact, it should be borne in mind that water is a precious resource that, when properly managed, must not be a danger or constitute a critical factor.

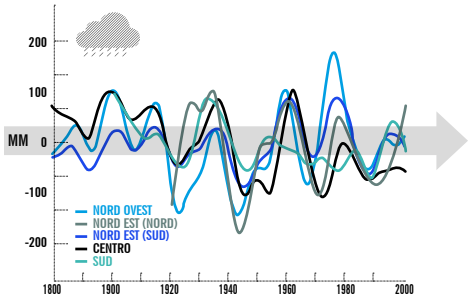
Urban regeneration actions must therefore promote compliance with this principle, through the following main strategies:

- preserving or restoring permeable areas (de-sealing);
- containing surface runoff (implementing the principle of hydraulic invariance, as well as that of hydrological invariance);
- restoring, as far as possible, natural infiltration into the subsoil in order to reduce water pollution and favour the refilling of aquifers (hydrological invariance).

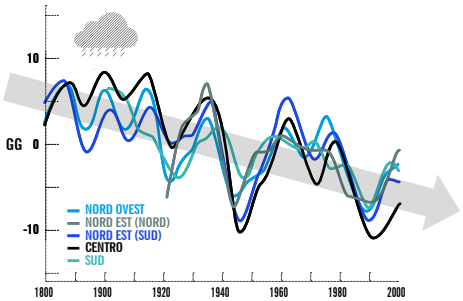
As the graphs below show, there is also an increase in the intensity of rainfall in Italy: the whole of Italy is characterised by a sharp decrease in the number of days with little rainfall, while the frequency of those with heavy rainfall is increasing, especially in some regions of northern Italy. These data tell us several things: the overall amount of rain is almost unchanged; the number of rainy days is decreasing while the number of dry days is increasing; the intensity and length of rainfall events is increasing. This means that individual rainfall events discharge more water in a shorter time, putting the urban environment at risk. (Trends of the daily intensity of precipitation in Italy and teleconnections, 2006, edited by M. Brunetti, M.Maugeri and T. Nanni / REBUS illustrations, exhition "*City for the people*")

Run-off is the portion of rainwater (up to 90%) that flows on the impermeable surfaces of cities (roofs, roads, parking lots, etc.) and quickly reaches the drainage networks without being filtered and retained (REBUS illustrations, exhibition "*City for the people*")

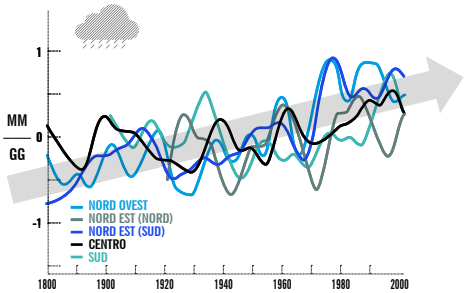
RAINFALL IN MM
PER YEAR



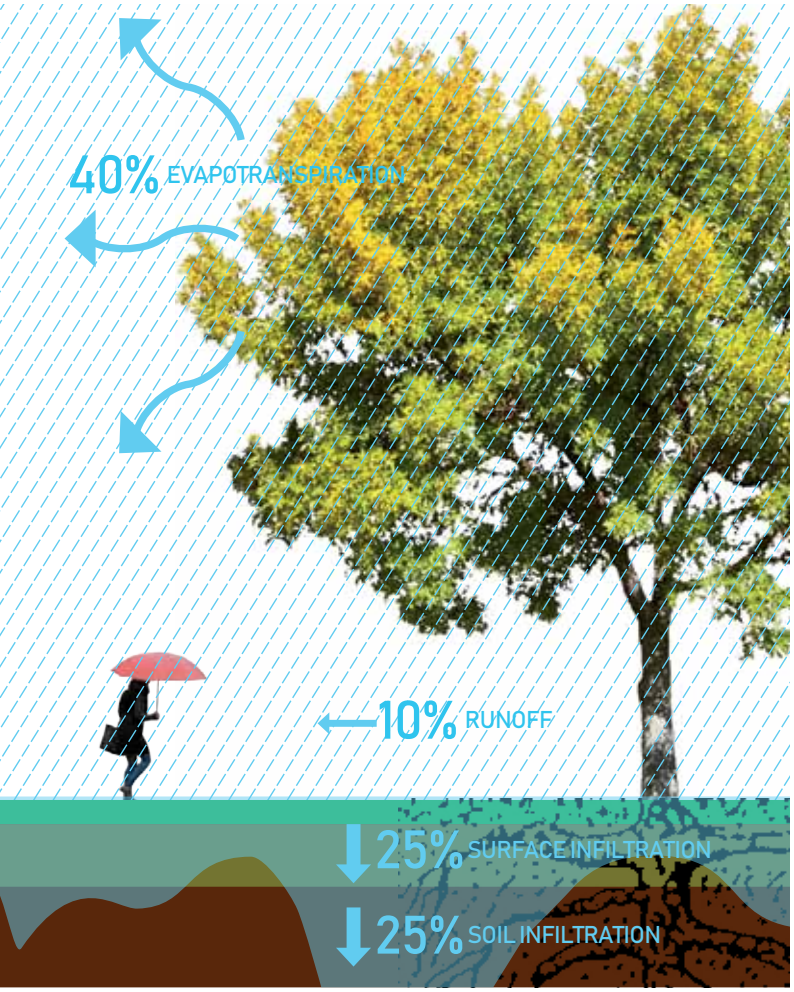
RAINY DAYS
PER YEAR



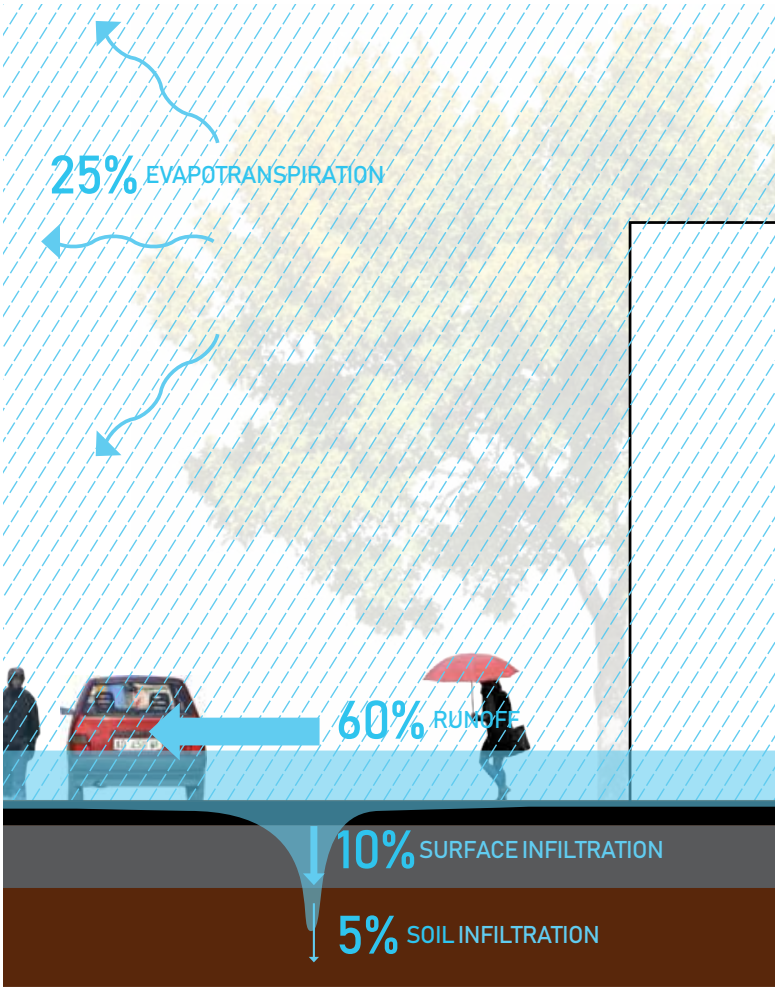
HEAVY RAIN IN ITALY
MM/DAYS OF RAIN PER YEAR



URBAN RUNOFF IN PERVIOUS AREAS



URBAN RUNOFF IN IMPERVIOUS AREAS

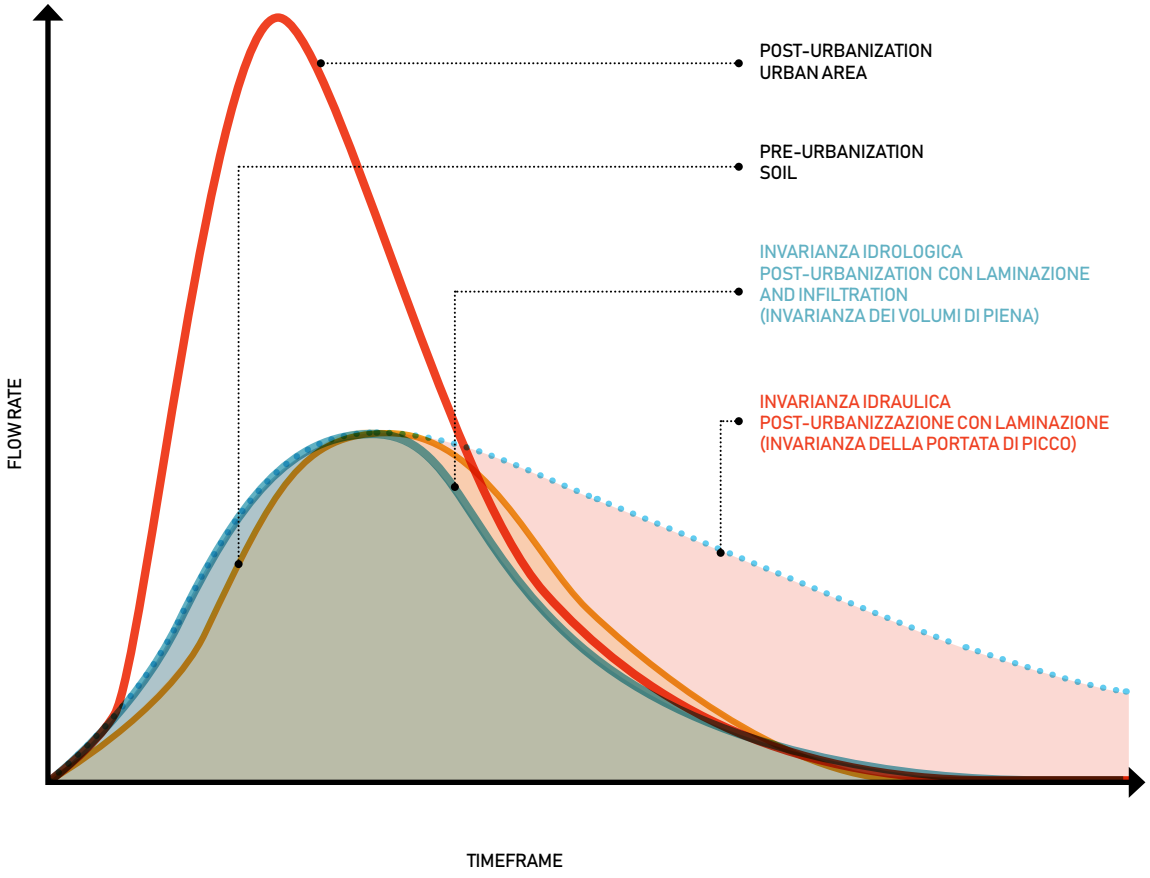


The graph shows the flow rate trends as the weather changes during a rainfall event (flood hydrographs) downstream of a lot, related to the pre-urbanisation and post-urbanisation situation in the absence of hydraulic mitigation and hydraulic and hydrological invariance measures. The blue and green fields, which represent the total volume of water discharged in the case of pre-urbanisation and post-urbanisation with hydrological and hydraulic invariance, are substantially equivalent, while the light pink field area related to the volume of water discharged with hydraulic invariance alone is greater than the area for pre-urbanisation.

As regards the methods for disposing of the volumes collected on site, a sustainable rainwater management system must provide for the following in descending order of priority:

- reuse of collected volumes, according to quality constraints and actual possible uses, such as watering gardens, washing road surfaces, industrial water and other private uses;
- infiltration into the soil or surface layers of the subsoil, where this is compatible with the soil and hydrogeological characteristics of the subsoil;
- discharge into a natural or artificial body of surface water;
- discharge into the sewer system, if necessary.

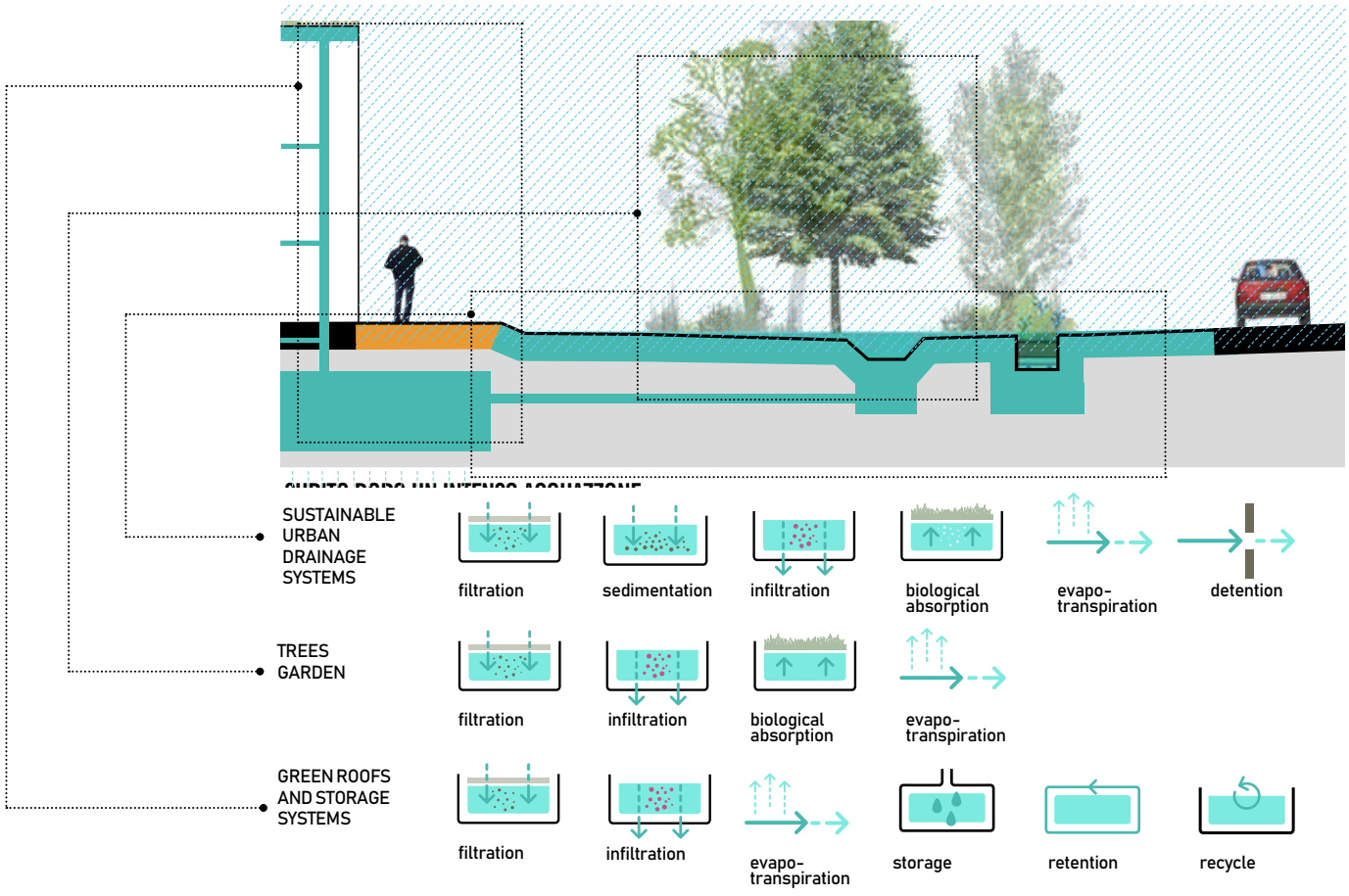
Obviously, the possibility of implementing these principles is to be assessed according to the limits present (hydrogeological characteristics of the soil, nature and quality of runoff water, vulnerability of the aquifer, etc.).
For the pedological and hydrogeological characteristics of the soils, please refer to the section on soils.



Effective urban drainage management is achieved by acting on rainwater as follows:
- SUSTAINABLE URBAN DRAINAGE SYSTEMS: they allow collecting, filtering, sedimenting, infiltrating, absorbing, evapo-transpiring, retaining and discharging the excess part.
- TREES AND GARDENS: they allow collecting, filtering, infiltrating, absorbing, and evapo-transpiring
- GREEN ROOFS AND STORAGE SYSTEMS: they allow collecting, filtering, infiltrating, evapo-transpiring, storing, retaining and recovering water for other uses (REBUS illustrations, exhibition *"Cities for people"*)

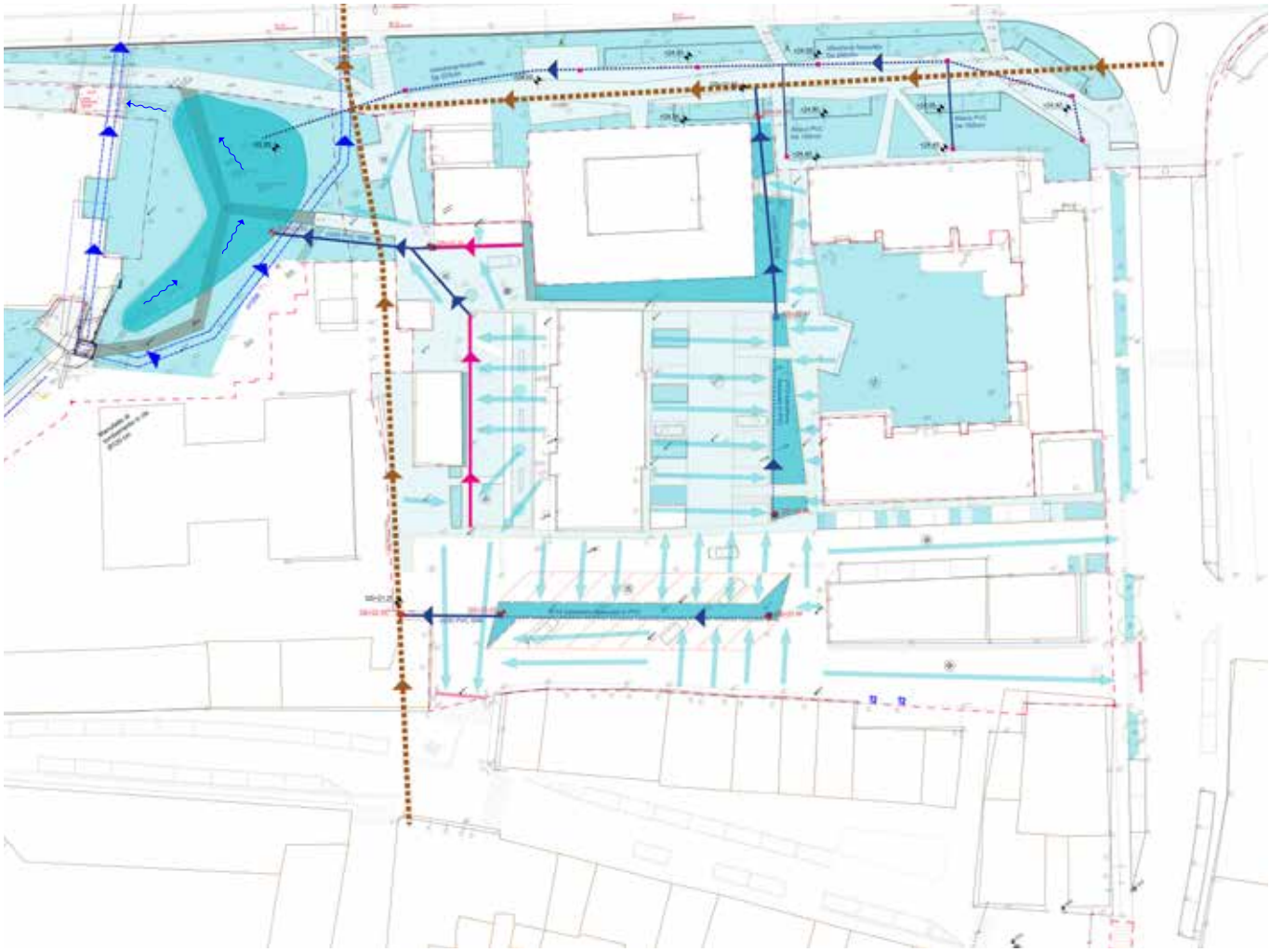
USING SUSTAINABLE URBAN DRAINAGE SYSTEMS TO IMPROVE THE QUALITY OF WATER TO BE INFILTRATED INTO GROUNDWATER. Some good practices for the design of SuDS systems in reducing pollution are the following:

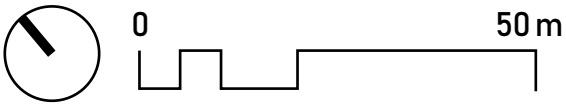
- treating the run-off of potentially polluted waters as close as possible to the source of pollution, as it is easier to isolate potentially polluted areas and manage treatment points;
- treating run-off waters with open-air systems, to exploit exposure to UV rays, and photolysis and volatilization phenomena, promoting sediment removal operations, using phytodepuration, easily identifying failures in the system and taking prompt action to restore its effectiveness, etc.;
- taking into account all possible contaminants and, if necessary, providing for a combination of treatment systems;
- to minimising the risk of remobilising sediments and other contaminants: for example, in the case of a phytodepuration effect by filtering vegetated areas, the filtering layer must be renewed periodically (at least once every 10 years) in order to minimise the risk that the retained pollutants are remobilised and then released into the aquifer;
- also considering the dangers of accidental spills.



Along the Medicine Canal. Urban Regeneration Intervention, Social Environment promoted by the Municipality of Medicine (BO) to the regional call of Urban Regeneration 2018. The project involves the restoration of the urban section of the remediation canal, the redesign of the public spaces of the village north of the historic center with a Nature-based approach and the involvement of the local community for the shared management of open spaces and some properties intended for public functions. An integrated system of green-blue-grey infrastructure for heat regulation and rain management has been designed on the public spaces of the village. Thanks to the slopes of the road plans the rain is made to flow in the rain gardens and there, thanks to the vegetation, the meteoric waters undergo a treatment of phytopurification before being returned to the canal. The events include the construction of a wet garden of retention for the phyto-purification of all the gravitational storm waters in the village, the introduction of rain gardens in the parking lots for water management, a continuous/ contiguous system for shade with the planting of new trees, the creation of a small pedestrian square, the creation of new sidewalks and bike paths and the

construction of small and shared seats.
The meteoric waters are gradually channeled to the wet garden by drained-cracked pipes and exploiting former drainage channels as vectors.
In the wet garden you will convey the meteoric waters of part of the neighborhood and you will derive from the medicine canal a share of flow in rain event, improving the quality of the effluent coming out of the wet garden itself (phyto-remedy).
The drainage of the tourist waters of the village is thus rethought in a NbS perspective: the influx into the net will be slowed thanks to capillary interventions of deseary of squares and parking areas, infiltrating, as far as possible, with draining trenches connected to the drainage network and creating volumes of retention up to the damp garden of the former mill. The drainage trim is completed by the low-cut green bands that receive, retain and infiltrate the rains of the public spaces that are desealinged.
(Project: arch. Elena Farnè, ing. Raffaella Lombardi, arch. Sebastiano Sarti, agr. Paul Gueltrini, ing. Francesco Pinosa)





The type of pollutant is a determining factor in choosing the treatment system: for example, organic and some inorganic compounds are degraded as they pass through the subsoil, unlike metals. The thicker the layers the pollutants have to pass through, the greater the effect of reducing their concentrations, where the degradation processes take place.

URBAN REGENERATION CONTEXTS

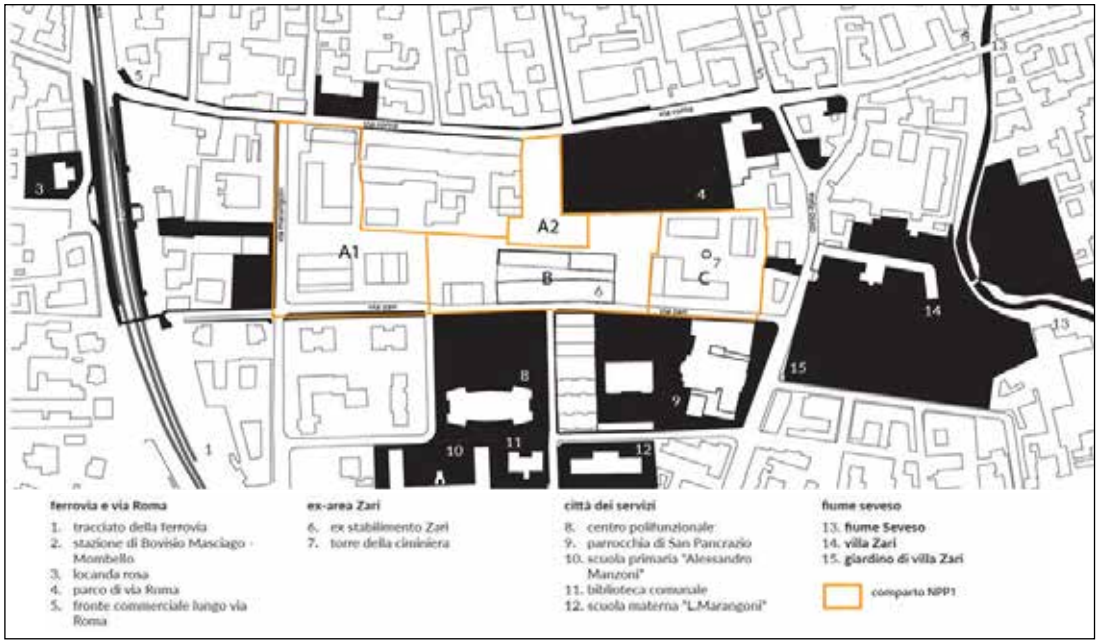
Urban regeneration can occur near watercourses or the coastline, regardless of whether it is a residential or productive context. In this case, and after assessing the flood risk due to static (tie-rods) and dynamic phenomena (e.g., embankment breach) or to heavy seas (levels indicated by the appropriate planning instruments, to be assessed together with other phenomena of subsidence and rising sea levels due to climate change), preference should go to territorial solutions with flooding areas with a naturalistic and landscape connotation (detention basins) and waterfront measures that ensure the achievement of appropriate hydraulic safety conditions in a "natural" way (e.g., dunes, elevated routes, etc.).

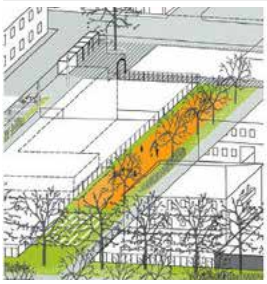
Transformation plans for the former Zari factories in Bovisio Masciago. NPP1 sector context analysis- Former Zari factories. In sector A2, which is public property, the design of the room - car park with rain garden and floodable square system has been further developed.

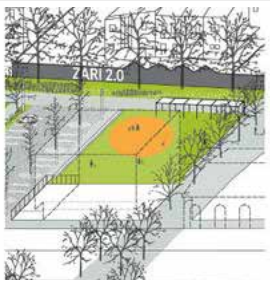
The process involves an area of about 31,000 square metres in the historic centre of Bovisio Masciago, a town of about 17,000 inhabitants located along the river Seveso in central Brianza.

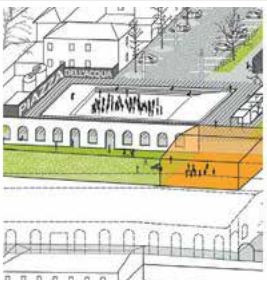
Hydraulic diagram as system structure of new public areas. The diagrams reflects hydraulic and hydrological invariance. Guidelines for the coordinated design of the public area system. Final scenario proposed for the design of the ZARI public areas.

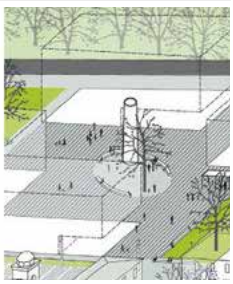
The Implementation Plan provided for the start of the design of a public area within the sector as a driver for other disused private areas. (Design by architects Alessadro Alì, Chiara Nifosi and Luca Tognù)











3 INFILTRATING WATER INTO THE SOIL

Over the decades, huge urban transformations have increasingly neglected the natural hydrological cycle and the management of runoff rainwater, reducing the share of evapotranspiration by vegetation and soil, increasing runoff and in particular reducing the flow into groundwater.

This has had two fundamental negative effects:
- the increase in run-off, which in the event of critical events may give rise to problems or danger,
- the reduction in refilling of the aquifer, which over time can cause undesirable effects such as drought, thus causing vegetation to suffer, and changes in the mechanical behaviour of soil with possible cases of subsidence or instability.

STRATEGIC APPROACH

Sustainable drainage systems (SuDS) aim to maintain or re-establish the natural water cycle, thus favouring as much as possible the infiltration of rainwater directly into the subsoil.
A fundamental aspect of the effectiveness of a SuDS is the type of soils and subsoils involved and in particular their infiltration capacity.
The effectiveness of the SuDS systems chosen depends on a large number of factors (the choice of the most suitable mitigation systems and the correct evaluation of expected performance, the correct execution of works, maintenance over time, etc.), and in particular on the intrinsic characteristics of the soil and subsoil of the intervention site.
The soil and subsoil where drainage systems are located that provide for infiltration into the aquifer, must therefore be able to receive water from the overlying layers, which can be made with "natural" materials (e.g., in the case of infiltration basins, trench drains, etc.) or artificial materials (draining/filtering surfaces, etc.), and facilitate the flow of water into the aquifer.

In order for the soil to be able to infiltrate the runoff flows associated with the events considered, it must have the following characteristics:

⇢ SUFFICIENT PERMEABILITY (soil type)
⇢ NOT BE SATURATED.

In addition to the above characteristics, there are a number of potential limitations to be considered for the implementation of an infiltration system:

- maximum groundwater level at the intervention site
- risk of soil instability or subsidence due to infiltration
- risk of slope instability due to infiltration movements
- risk of pollution from runoff waters containing contaminants
- risk of pollution due to mobilisation of existing contaminants at the site

Preliminary information on the suitability of a particular infiltration site can be obtained from:

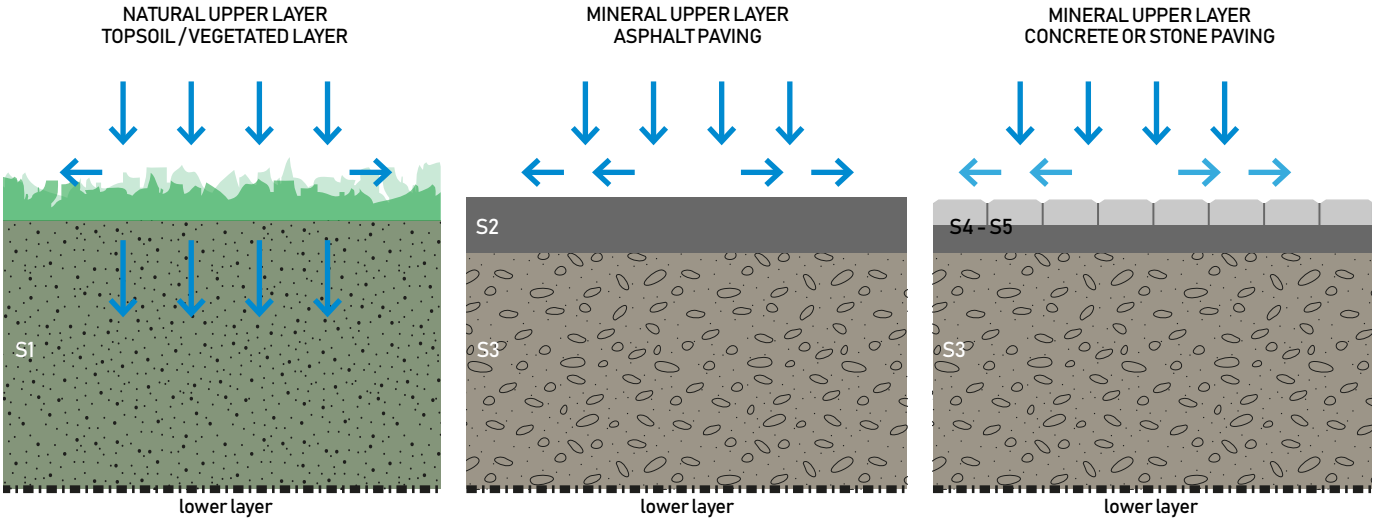
- existing maps and studies on geological and hydrogeological typing;
- geological risk maps;
- measurements and surveys of potential soil contamination at or near the intervention site;
- observations and tests using boreholes and piezometers.

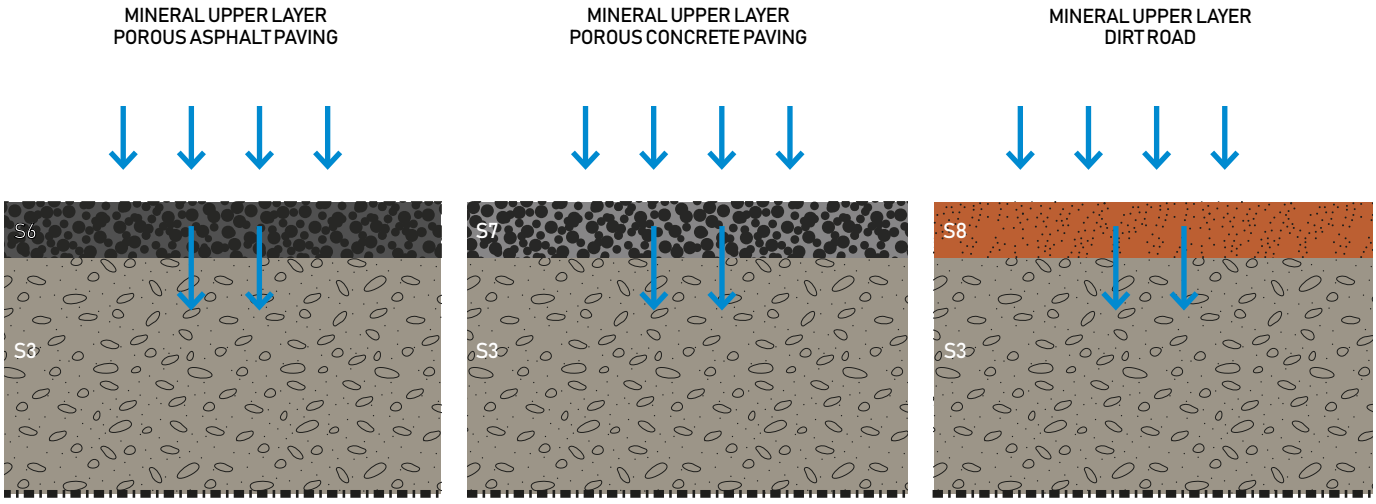
The top layer S can be natural (S1 plant soil, topsoil) or mineral (S2 asphalt -S3 stabilized - S4 concrete - S5 stone - S6 draining asphalt - S7 draining concrete - S8 limes).

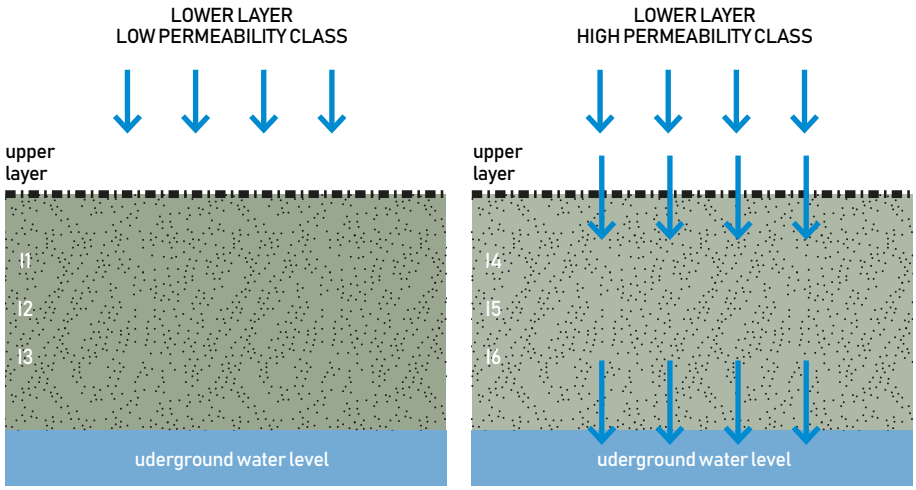
Infiltration to the underlying layer is possible in the presence of the layers S1 plant soil, S6 draining asphalt - S7 draining concrete - S8 lime.

The lower layer I may have low permeability classes (I1 clay - I2 limosa clay, sileck - I3 sile, sandy sine, sand and clay) or high (I4 sandy simeness, fine sand - I5 fine sand -I6 clean sand, sand and gravel).
Infiltration through the lower layer is possible in the presence of soils I4 sandy sine, fine sand - I5 fine sand -I6 clean sand, sand and gravel.

The effective combination of flooring -top layer S and soils- lower layer I - offers the possibility of infiltrating the aquifer, also restoring the natural water cycle in cities.



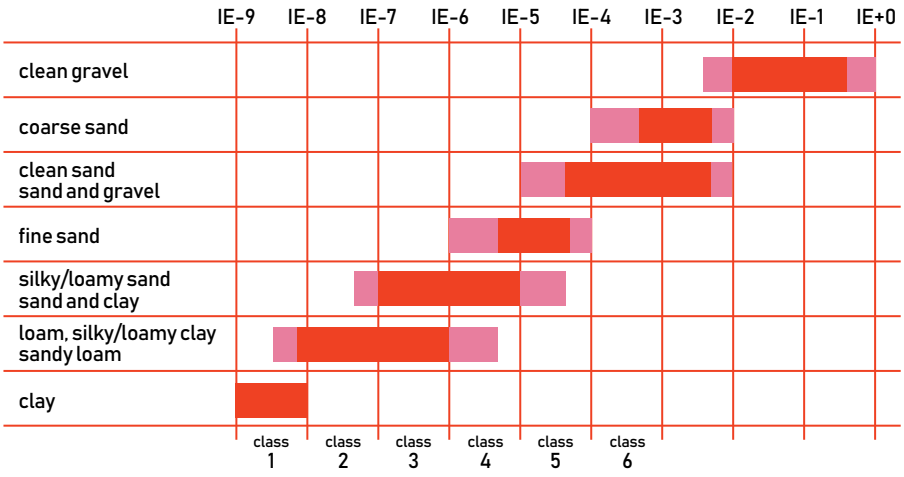




⇢ ASSESSING THE INFILTRATION CAPACITY OF THE SOILS. The infiltration rate depends on the intrinsic properties of the soil and on the geological layers through which the water filters to reach the underlying aquifer.
The permeability of saturated soil (defined by the permeability or hydraulic conductivity factor k), is its ability to infiltrate a fluid into the soil.
Generally, water infiltration into the soil above the aquifer level takes place under partly saturated conditions in which behaviour is approximated by determining the infiltration rate with factor k.
If the water is free to vertically infiltrate an unsaturated soil, the infiltration rate is equivalent to the saturated hydraulic conductivity k.
The hydraulic conductivity or infiltration rate depends on soil texture, and, based on this parameter, the soil can be divided into 6 hydraulic conductivity classes, according to the definition adopted by the USDA Soil Survey Manual as shown in the table below.
In general, it is advisable to exclude the use of infiltration systems in soils with hydraulic conductivity classes 1, 2 and 3 (soils with hydraulic conductivity from low to moderately low). In any case, the infiltration system performance must be evaluated at the design stage using appropriate calculation models, whether simplified or more detailed depending on the importance of the system in the overall reduction of hydraulic risk. In general, infiltration systems can be provided for in the presence of class 4, 5 or 6 soils.
The website of the Emilia-Romagna region shows the saturated hydraulic conductivity map (cm/h),

K = permeability coefficient or hydraulic conductivity

CLASS	HYDRAULIC CONDUCTIVITY	Ksat (cm/h)	Ksat (m/s)
1	Very low	< 0,0036	$< 1 \cdot 10^{-8}$
2	Low	0,0036 – 0,036	$1 \cdot 10^{-8} \div 1 \cdot 10^{-7}$
3	Moderately low	0,036 – 0,36	$1 \cdot 10^{-7} \div 1 \cdot 10^{-6}$
4	Moderately high	0,36 – 3,6	$1 \cdot 10^{-6} \div 1 \cdot 10^{-5}$
5	High	3,6 – 36	$1 \cdot 10^{-5} \div 1 \cdot 10^{-4}$
6	Very high	⇢ 36	⇢ $1 \cdot 10^{-4}$



which provides an initial indication of the expected infiltration rate.
Maps of texture classes, content of surface layers of clay, sand, apparent density and hydrological groups of plain soils are also available. The latter take into account the permeability of the least permeable layer, as well as the depth of the aquifer.
In addition to consulting the thematic maps, it may be necessary and/or appropriate to perform soil permeability tests in situ, the consistency of the plan of in-situ permeability surveys (number and type of surveys) and its spatial size are to be defined according to the specific case and type of measurements taken (surface and deep infiltration, point or area elements) given the great spatial variability and the numerical extent of the variation in the geological and hydrogeological parameters. There is a wide variety of on-site tests widely used in hydrogeological practice, including tests using infiltrometer (hollow cylinder stuck into the ground and filled with water up to a certain head), Lefranc test (in borehole), with piezocone (CPTU), dilatometer, and pumping tests.[3]
In addition, more specific laboratory analyses, which are generally not necessary, may be carried out.
The texture of the subsoil can be defined by means of special geognostic tests, such as continuous core drilling, during which soil cores are extracted to determine the stratigraphy of the subsoil.

ASSESSING THE AQUIFER LEVEL

The aquifer level must be studied in order to verify that the infiltration medium is placed at least 1 m above the maximum aquifer level, so as to ensure sufficient unsaturated soil depth to increase infiltration performance and protect the underlying aquifer from possible pollution.

ASSESSING THE RISK OF SOIL INSTABILITY OR SUBSIDENCE

It is necessary to ascertain the absence of risk of instability (e.g., due to the presence of supporting walls, slopes, embankments made of poorly consolidated ground) or danger of subsidence and related phenomena of instability of buildings and other structures.
General speaking, and in particular in these cases, it is important to analyse the nature of the soil, verifying the absence of swelling clays, the behaviour of the soil in saturated conditions, the possible effect of the leaching of fine particles on the stability of the soil, as well as liquefaction.

3 - Map of texture classes, content of surface layers of clay, sand, apparent density, saturated hydraulic conductivity and hydrological groups, piezometric and underground water quality maps *(https://ambiente.regione.emilia-romagna.it/it/geologia/suoli/proprieta-e-qualita-dei-suoli/proprieta-fisico-idrologiche-suoli)*

1:10,000 geological map of the Emilia-Romagna region *(https://ambiente.regione.emilia-romagna.it/it/geologia/cartografia/webgis-banchedati/webgis)*

1:10,000 geological map of the Emilia-Romagna region *(https://ambiente.regione.emilia-romagna.it/it/geologia/cartografia/webgis-banchedati/webgis)*

"Soil survey Manual", March 2017 USDA (U.S. Department of Agriculture) Handbook No. 18 *(https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054262)*

In the upper layer, the differences depend on the materials used.
The activity with which this top layer can be removed is called excavation or discharge or milling.

In the lower layer the differences depend on the geological characteristics.
The activity with which this layer can be removed is called excavation.

UPPER LAYER

NATURAL UPPER LAYER

TOPSOIL

S1	TOPSOIL	superficial layer with rich humus, nutrients, microorganisms

MINERAL UPPER LAYER

ASPHALT PAVING

S2	ASPHALT	layer of bituminous conglomerate
S3	DIRT ROAD	layer of mixed dirt road

CONCRETE OR STONE PAVING (streets, cyclepedestrian ways, squares)

S4	CONCRETE	concrete paving
S5	STONE	stone paving
S3	DIRT ROAD	layer of mixed dirt road

POROUS ASPHALT PAVING (streets, sidewalks, squares)

S6	POROUS/DRAINING ASPHALT	layer of porous/draining bituminous conglomerate
S3	DIRT ROAD	layer of mixed dirt road

POROUS CONCRETE PAVING (streets, cyclepedestrian ways, squares)

S7	POROUS/DRAINING CONCRETE	layer of porous/draining concrete
S3	DIRT ROAD	layer of mixed dirt road

CALCESTRE PAVING (streets, sidewalks, squares)

S8	CALCESTRE	porous calcestre paving
S3	DIRT ROAD	layer of mixed dirt road

LOWER LAYER

ON SITE NATURAL SOIL

LOW PERMEABILITY CALSS

I1 o	very low permeability	clay
I2 o	low permeability	loamy clay, loam
I3	medium-low permeability	loam, sandy loam, sanda and clay

HIGH PERMEABILITY CALSS

I4 o	medium-high permeability	sandy loam, fine sand
I5 o	high permeability	fine sand, clean sand
I6	very high permeability	sand, sand and gravel

ASSESSING THE RISK OF RUN-OFF WATER POLLUTION

When there are contaminated sites, it is very important to analyse the exact spatial location and vertical distribution of the contaminants compared to the position of infiltration systems through on-site investigations to place them at an adequate distance; it is also important to investigate the nature of the contaminants and whether they can be mobilised and washed away by infiltration water.

The use of vertical geomembranes positioned along the perimeter of the infiltrating element can be adopted to minimise the risk of horizontal filtration routes in the surrounding contaminated soil. Infiltration systems in contaminated sites are normally not recommended.

ASSESS THE RISK OF RUNOFF WATER POLLUTION

In the event that surface run-off waters are potentially polluted, it is necessary to design physical or biochemical purification treatment systems upstream of the entrance to the underground infiltration structures, or to adopt other risk mitigation measures.

In common practice, these treatment systems are made with rainwater tank systems, either prefabricated or built on site, but it is also possible to use other sustainable management systems based on phytodepuration.

4 MANAGING EXCAVATED SOILS AND ROCKS

All construction sites produce 'waste', i.e. materials, which, from a traditional first reading, no longer appear to be usable at the site and therefore need to be taken away from the place they were produced to a new destination, which is often difficult to identify.

This applies both to new construction sites and to urban regeneration and the desealing of mineral soils that are being reclaimed. Each individual site, with its own building permit and its own specific peculiar features, has to manage excavated materials, soil or rocks, rubble, by-products, and waste with the relative complexity of determining battery limits, at times uncertain, as well as the related and certain costs.

The desealing of urban land to be returned, where possible, to its original natural state as it was prior to transformation is rewarding from every point of view for the purposes of Nature-Based Solutions (NbS) and Sustainable Urban Drainage Systems (SUDS), but must be adequately guided for proper management within the complex regulatory framework, which very often leads to a more 'precautionary' or 'convenient' interpretation, without considering the opportunities that are opening up within the circular economy to reuse and the adoption of green procurement.

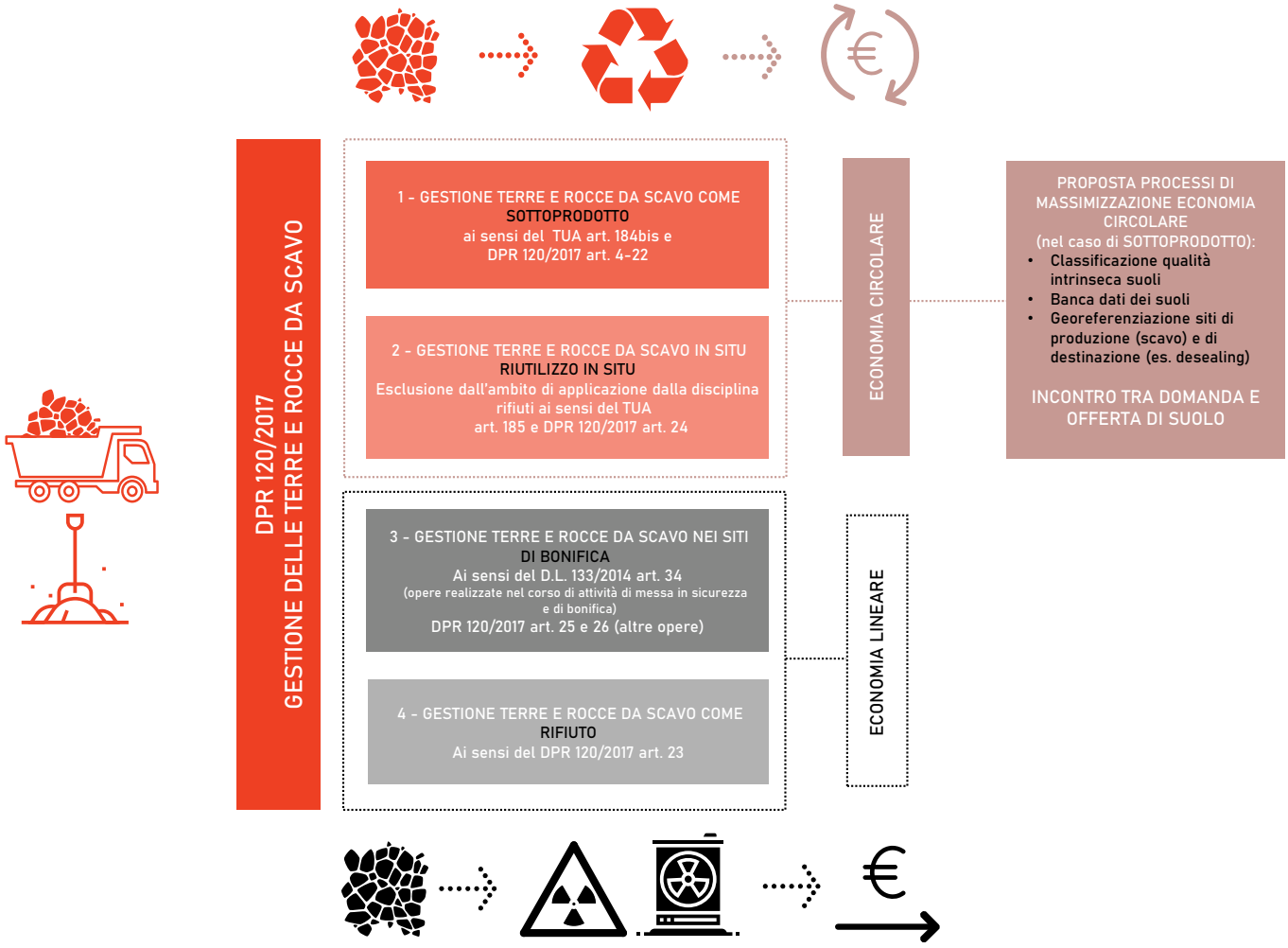
STRATEGIC APPROACH

In addition to reducing the production of soil treated as waste, as required by law, it is essential to better manage its reuse in urban or peri-urban areas, or to identify the most suitable destinations and uses according to the intrinsic characteristics of the soil (both excavated and at destination).

The fundamental principle is that the more the initial characteristics of the topsoil (the topmost layer of soil, richer in humus, nutrients, microorganisms and root systems) remain unchanged, the more it is possible to keep the eco-system services intact, favouring the formation of new soil. Therefore, the aim is to combine the environmental characterisation already provided for by regulations with an agronomic characterisation (of a qualitative nature) of the soil, also to be carried out before excavation, which depends in particular on the texture characteristics (grain size class), the nutrient content (N, P2O5, K2O) and the organic matter content.

⇢ IDENTIFYING THE QUALITY OF SOILS WITH REGARD TO THE QUALITY OF THE EXCAVATED MATERIAL AND ROCKS. The British Standard N.3882:1994, which classifies topsoil into 3 levels of quality as premium, general purpose or economy grade, is provided as an example. Each of the 3 levels assumes a certain reuse of the excavated material:

- ⇢ premium grade: natural topsoil. Without the presence of compact fill, with high intrinsic fertility, loamy and well-structured texture; it can be reused for the most demanding situations, such as in plant nurseries, gardens, horticulture amenity and landscape sites, etc.; it is not necessary in most applications;
- ⇢ general purpose grade: topsoil with average fertility, texture and structure characteristics, as well as high quality topsoil deteriorated due to poor management, and topsoil with the presence of compact fill. It can be used for good quality agriculture, silviculture, amenity horticulture and landscape sites supporting crops, grass, trees, shrubs, herbaceous and other planting;



The management of excavated earth and rocks generated by a construction site, if carried out in synergy between all the actors involved (companies, municipalities and control bodies), can take place according to the circular economy principles - and not the traditional linear economy - facilitating the encounter between supply and demand of material/by-product, after the necessary characterisation.

⇢ economy grade: topsoil of lower quality, select subsoil or material, which is suitable for plant growth. This material is suitable for amenity woodland, wildlife conservation areas, less intensively used amenity grassland and agricultural land of low inherent productivity.
Agronomic characterisation can be carried out either by means of a soil survey (e.g., in the case of large construction sites where the overall size of the work makes its costs sustainable) or, in the case of small construction sites or for which the cost of a soil survey is not sustainable, referring to maps developed based on the map of soils, organic matter, nutrient content, and texture, and the geological map. In the case of small construction sites, there is no need to test, but only to consult the available thematic maps, which municipal offices are also able to verify without specific technical advice. The references of the maps to characterise the quality of the soil are provided in the appendix.

⇢ SELECTING THE DESTINATION SITE (WITH THE AID OF THE DATABASE IF AVAILABLE). Once the possible reuses of the excavated soil have been determined, the destination site needs to be chosen.

⇢ The use of a public computer database is effective in this respect. The platform can be managed, for example, by municipal administrations and must provide a geo-referenced database of the destination and intermediate sites and the relative characteristics of the required soils.

This would facilitate the matching of demand (demand for soils, e.g., for desealing and urban regeneration measures) and supply (production of soils with certain quality characteristics), thereby maximising the principle of the circular economy. Public administrations must therefore play a leading role in this process, digitally managing and controlling the procedural and construction site management process of excavated earth and rocks and identifying possible destination sites. These same Administrations must encourage the mechanism of reuse of excavated soil and rocks, also through appropriate public-private sector agreements to carry out preventive analyses and qualitative characterisations of the soils and the concerted identification of the destination sites.

⇢ APPLYING MEC (MINIMAL ENVIRONMENTAL CRITERIA) IN PUBLIC PROCUREMENT.

An incentive mechanism for the reuse of excavated soil and rocks is the application of MEC (Minimal Environmental Criteria) in public procurement. The Ministerial Decree of 24/12/2015 defines the Minimal Environmental Criteria (MEC) for the various product categories indicated in the PAN GPP 'Action plan for the environmental sustainability of consumption of Public Administration' (adopted by Interministerial Decree of 11/04/2009 and updated by the Decree of 10/04/2013), and of which it is an integral part.

The Minimal Environmental Criteria are technical indications to help Public Administrations make purchases, identifying products, services and works that produce a low environmental impact. To date, the MEC have been adopted for 17 categories of supplies and contracts, and the MEC being defined also include 'Design services and works for the new construction and maintenance of roads', for which the European Commission has already produced the related Guidelines.

The European Commission Staff Working Document on 'EU Green Public Procurement Criteria for Road Design, Construction and Maintenance' of June 2016 (downloadable from the European Commission's ec.europa.eu website) contains the following significant elements on excavated earth and rock in the guidelines for green public procurement:

- ⇢ design and manage the site to maximize the on-site re-use of excavated materials and soils (including topsoil);
- ⇢ maximize the reuse/recycling of construction and demolition waste (C&DW) and of waste from other industrial processes and use construction materials with a high recycled or re-used content including by-products.

When awarding contracts, public administration must take a rewarding approach to these aspects, in particular the reuse of land (on site or as a by-product), in accordance with the circular economy principle.

The following tables show two flow charts summarising the management methods for excavated earth and rocks in the case of reuse on site and use as by-products, identifying both the regulatory elements of the regulation of excavated earth and rocks pursuant to Presidential Decree 120/2017, and the proposals for improving the excavated earth and rock management process to be implemented through joint action by public administrations and private entities that carry out works.

5

INCREASING THE ENVIRONMENTAL AND PERFORMANCE REQUIREMENTS OF PUBLIC WORKS
minimal environmental criteria

An incentive mechanism for land reuse and excavation rocks is the application of MECs (Minimum Environmental Criteria) in public procurement. The D.M. of 24/12/2015 defines the Minimum Environmental Criteria (MEC) for the different product categories indicated in the PAN GPP 'Action Plan for the Environmental Sustainability of CONSUMPTION of the PA' (adopted by Interministerial Decree of 11/04/2009 and updated with Decree of 10/04/2013), and of which it is an integral part.
The Minimum Environmental Criteria are technical indications to help the Public Administration to make purchases, identifying products, services and works that produce a lower environmental impact. To date, CAM has been adopted for 17 categories of supplies and entrustments, and among the CAMs being defined there is also 'Design Services and Works for The New Construction and MAINTENANCE of Roads', for which the European Commission has already produced the document with its Guidelines.

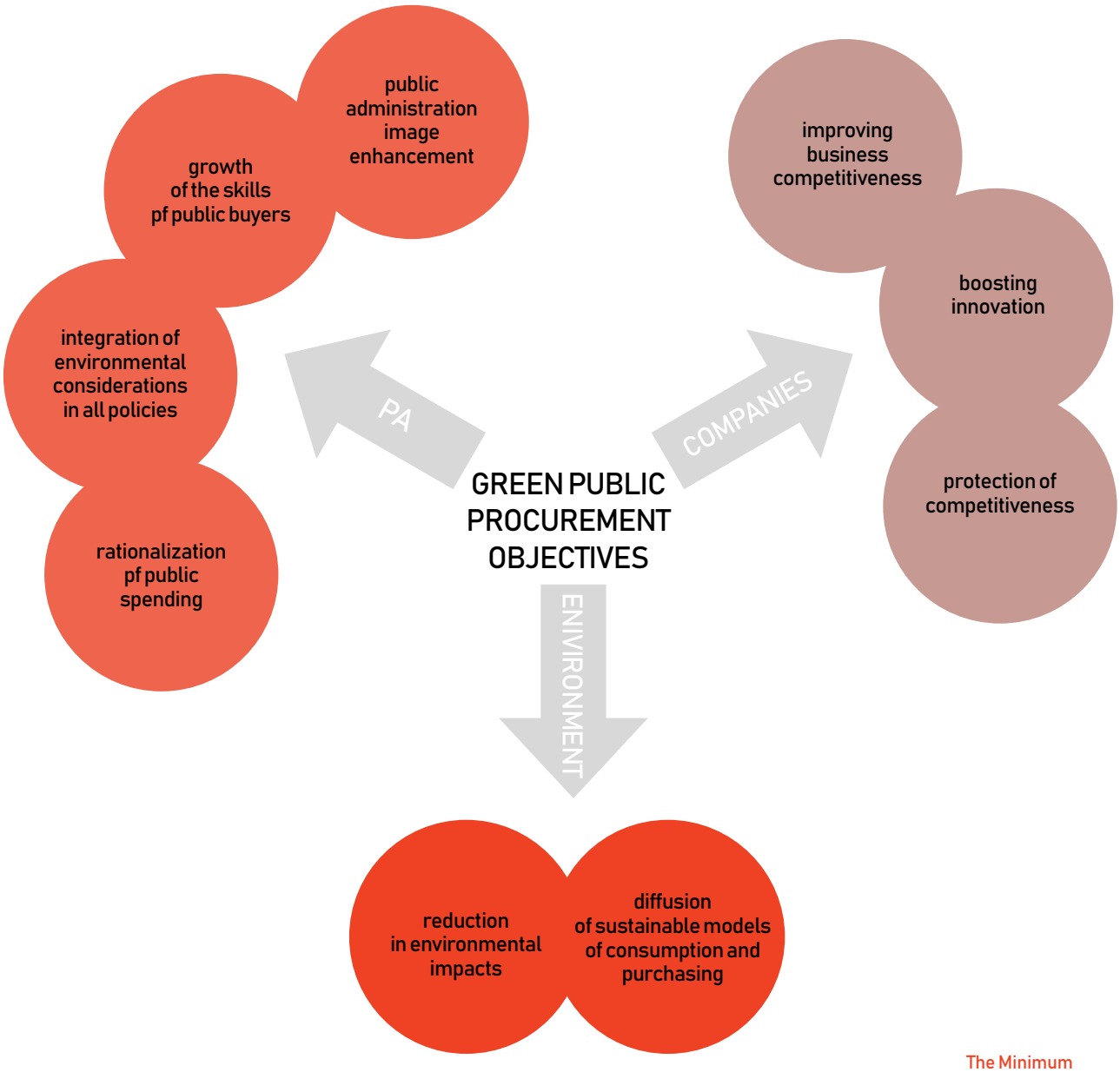
The European Commission's services working paper, relating to the 'EU Criteria for Green Public Procurement on Road Design, Construction and MAINTENANCE' dated June 2016 (downloadable from the European Commission ec.europa.eu website), lists the following significant elements on land and rock digging in the European Commission's website ec.europa.eu:

- design and manage the site to maximize on-site reuse of excavation materials and soil (including the top layer of the soil);
- maximize the reuse/recycling of construction and demolition waste and waste from other industrial processes and use building materials with high recycled or reused content, including by-products.

The public administration, in the awarding phase of tenders, must take a rewarding approach to these aspects, in particular land reuse (on site or as by-products), in accordance with the principle of the circular economy.
The following tables include two flowcharts summarizing the way land and rocks are managed for excavation in cases of on-site reuse and use as by-products, identifying both the regulatory elements of the discipline of land and digging rocks under DPR 120/2017, as well as proposals to improve the process of managing TRS to be implemented through the joint action of the Public Administrations and private entities that carry out the work.

PUBLIC PROCUREMENT + SUSTAINABILITY = CAM

MINIMUM ENVIRONMENTAL CRITERIA



The Minimum Environmental Criteria (CAM) are the environmental and ecological requirements defined by the Ministry of the Environment aimed at directing public administrations towards a rationalization of consumption and purchases by providing guidance for the identification of environmentally better design solutions, products or services.

nature-based solutions and interventions

1. RAIN GARDENS
2. INFILTRATION TRENCHES AND FILTER DRAIN
3. SOAKAWAYS
4. NOUE PAYSAGERE SWALES
5. WET GARDENS
6. DETENTION BASINS
7. FLOODABLE PARKS
8. WATER SQUARES

1

RAIN GARDENS
manage rainwater in urban environments

Rain gardens are linear elements that channel rainwater collected from roofs, streets, parking lots or squares by using sloping ground.
They feature a scant surface depression - approx. 10-20 cm - and structured sections with mineral edge elements or "loose" sections with sides covered with grass, plants or trees. They are designed to reduce the natural infiltration process on unprocessed soil.
They are an excellent micro-scale urban decoration: they can be placed within the lots or along main roads and pedestrian areas, and on roundabouts, squares or parks.

Rain gardens help:
- reduce surface runoff and improve infiltration into ground water *(effectiveness based on the terrain characteristics)*;
- remove pollutants through filtering and biological absorption mechanisms performed by plant species *(medium-high effectiveness)*;
- reduce flood peaks in receiving bodies *(medium effectiveness)*;
- promote biodiversity and increase local landscape value *(high effectiveness)*;
- reduce the urban heat island effect *(high effectiveness)*.

Rain garden made between a residential street with high bike and pedestrian use and the garden square of Tosinge Plads. We are in the district of Esterbro, the subject of a project to adapt public spaces in Copenhagen.
(Project by Tradje Nature, photo by Luisa Ravanello)

Pedestrian boulevard and roadside rain gardens in the eco-district of Boulogne-Buillancourt, built in the area of the former Renault factory near Paris, in the Ele-de-France.
(Agence TER landscape project, photo by Luisa Ravanello)

CONSTRUCTION ASPECTS

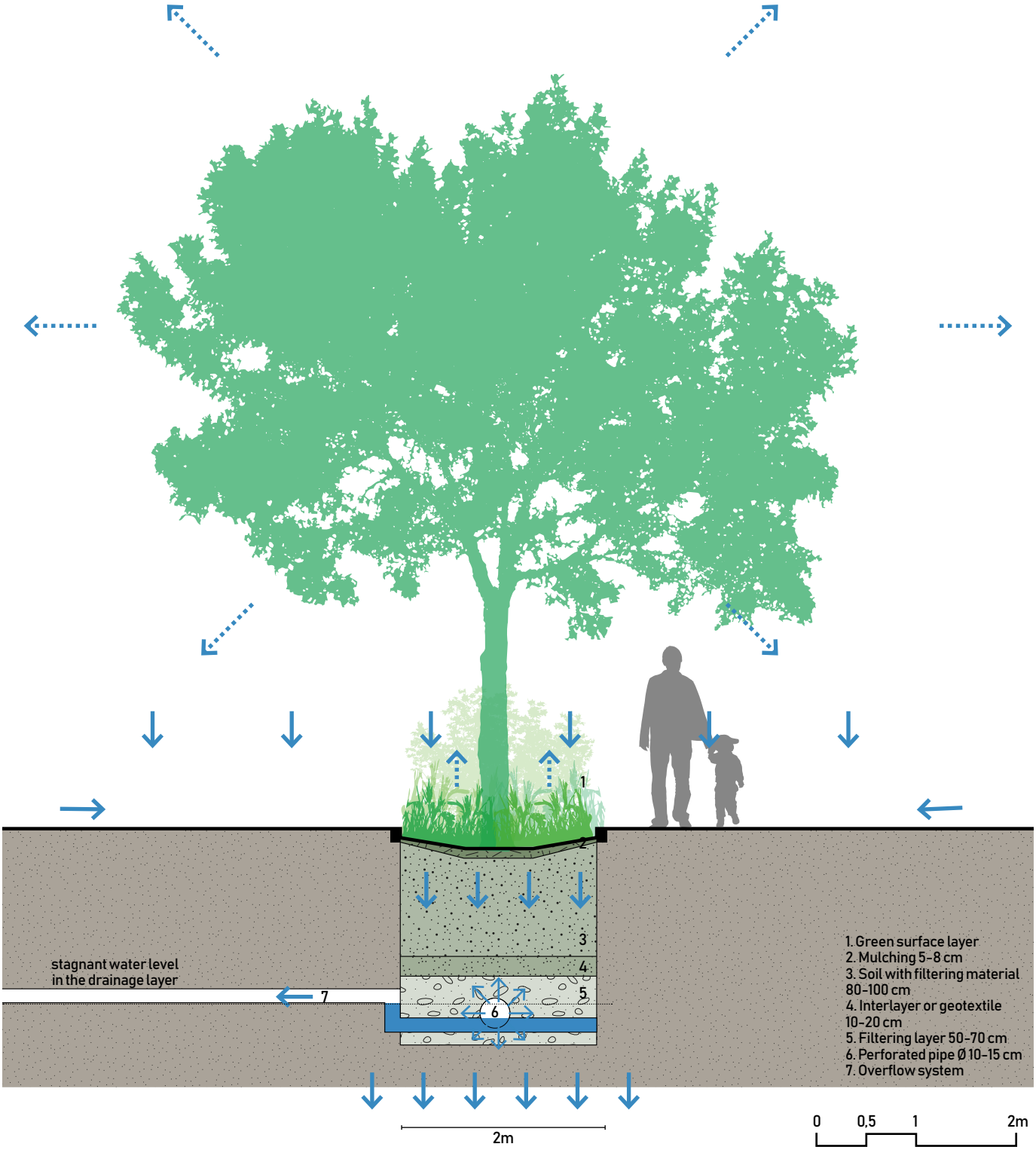
Rain gardens are linear elements with a 1-2 meter width (albeit they can reach widths of 10-15 meters) and a 1-1.5 meter depth. They can handle the first 5 mm of rain for a surface of about 5 times the rain garden area.
They are transitioning systems, linked to weather events: in case of heavy - and short-lasting - rainfall, the garden and the plant species are flooded; after the event, the initial conditions are quickly restored and the garden is once again visible.

Since these systems can be adapted to a great variety of situations, the design approach may differ, based on the context and the desired results. In general, a rain garden comprises the following main elements:
- RUNOFF WATER COLLECTION/INFILTRATION in the rain garden
- SURFACE VEGETATION
- FILTERING LAYER
- TRANSITIONAL LAYER
- DRAINAGE LAYER with perforated pipe (if needed).

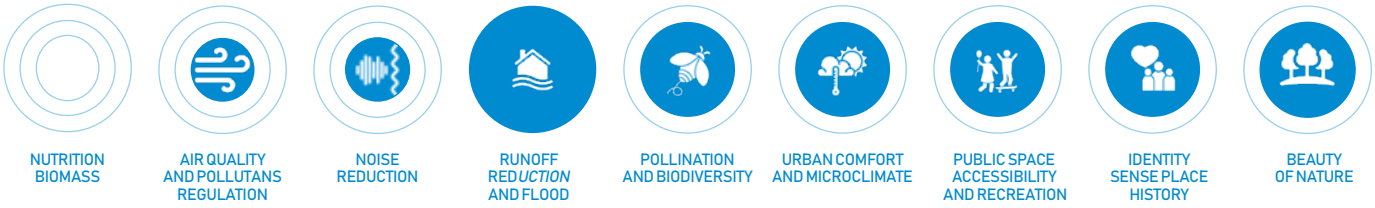
The feeding system should be designed to prevent material erosion and transportation, and promote a uniform distribution of the water runoff on the filtering surface. To this end, it may include flush curbs (to make the water runoff distribution as uniform as possible) or lowered sections and/or openings along the curb.

Vegetation significantly affects the rain garden's capacity of decreasing the pollution load, and, if the system has been properly designed, it substantially reduces suspended solids, total phosphorous and metal concentrations, and, to a lesser extent, the amount of nitrogen. Species selection is site-based.

Rain garden type section.



ECOSYSTEM SERVICES PROVIDED



The filtering layer houses the garden plant species and a soil (20-25%), organic compost (20-25%) and sand (50-60%) mixture to provide nutrients for the plants. In some cases, the garden features a top layer of mulching with bark or volcanic lapillus, which works to keep the soil humidity level constant.
Recommended thickness ranges from 75 to 100 cm, albeit it can be reduced for very simple systems. If only ground cover plants are present, a minimum thickness of 40 cm is recommended.
In the case of very simple rain gardens covering small areas (such as roofs), the filtering layer and the drainage bed are generally replaced by a 20-50 cm thick layer comprising native soil mixed with organic compost/sand or another specific mixture.
The transitional layer has a finer particle size, and its function is to prevent run-off of the upper filtering layer fine particle toward the drainage bed below, and to maintain a certain level of humidity in the plant roots. Thickness must be defined according to the filtering criteria, and it is generally greater than 10 cm. Alternatively, a geotextile can be used, although it increases the risk of clogging.
The filtering bed collects water from the filtering layer and promotes its infiltration in the underlying soil. A perforated drainage pipe can be installed to evenly distribute the flows along the drainage layer. The thickness of this layer also depends on the perforated pipe diameter (roughly ranging between 100 mm and 250 mm), and it generally includes 10 cm of covering and 10-15 cm of pipe bedding.

Although rain gardens help mitigate hydraulic issues in case of intense events, they cannot solve them; therefore, an overfill system to collect the water that did not seep toward the sewage system is always required.
Filtering systems are designed with 24-48 hour water drainage times, in order to ensure a suitable residence time to remove pollutants and prevent stagnation and insect proliferation at the same time.
When they are built on significantly sloping gradients, small water containment structures should be included to promote an even distribution of the water volume to be infiltrated over the entire garden surface.

APPLICATION CONTEXTS AND LIMITS

In residential areas, they can be designed as flowerbeds outside the buildings.
On roads, they can be used inside roundabouts, in the green areas along parking lots, and along carriageways or pedestrian areas.
In commercial and production areas, they can be designed as flowerbeds in the green areas outside the buildings, especially to filter roof runoff. Based on the level of pollution and traffic, a first rainfall treatment system may be necessary.

SPACE REQUIRED

These linear elements have low space requirements, and they are commonly associated with small impermeable surfaces.

TYPE OF SOIL AND PRESENCE OF GROUND WATER

Rain gardens require a permeable soil and ground water located at least 1 meter away from the bottom of the filtering bed, to promote a good level of pollutant reduction.

VEGETATION AND RECOMMENDED SPECIES

The plant species that can be included in a rain garden must be capable of adapting to flooding conditions and droughts, and of surviving in polluted atmospheres. A thick plant system (about 6-10 plants/sqm, based on the species) is needed to improve the density of the root system and promote soil permeability.




In those systems with significant development areas, the different species must be distributed based on their resilience in extreme conditions.
Shrub species are effective thanks to their capillary root system, and they can be used as green barriers to prevent access, if required.
Choosing the right type of plant depends on the site and on the relevant climatic context.
There are many riparian species to choose from:

- HERBACEOUS PLANTS impatients noli-tangere, filipendula, marsh fern, iris;
- SHRUBS cornus, frangula, shrub willow, viburnum;
- TREES bald cypress, alder, poplar, willow trees.

USABILITY AND ATTRACTIVENESS OF PUBLIC SPACE

The rain garden surface cannot be directly exploited; however, it can be added to a urban context to create an added landscaping value, since these gardens can be developed along walkways or bicycle paths.

MAINTENANCE

The phytopurification system performance and the underground infiltration capacity depend on the maintenance level, with particular attention to plant species.
Maintenance should be thorough in the first few months after creation: the system must be inspected after storms, assessing the quantity of sediments deposited to check the drainage and filtering layers infiltration capacity.
After this initial period, ordinary maintenance should be performed on a quarterly basis to:

- collect waste (harmful from an aesthetic and landscape standpoint);
- clean the road runoff collection area, to reduce the sediment volume;
- check the plants conditions and prevent the proliferation of invasive species;
- check and clean trench drains (if present) - once a year.

Extraordinary maintenance is performed to replace the mulching and/or the other filtering and drainage layers, in case of clogging.

INDICATIVE COSTS

- 20-30 euro/sqm to dig a 1 meter deep trench, including disposal and lawn surface finish;
- 30-40 euro/lm to create a filtering layer for a B100xH50cm garden;
- 5-30 euro/smq to plant the species.

CASE STUDIES AND BEST PRACTICES

- Østerbro, Copenahgen -DK / Case study F37

Top left, next page: Rain gardens on the side of the road in Portland. Note the entrance for water obtained by the interruption of the flowerbed kerb. (Metro Transportation Planning and Development project and photo)

From the top right and for all the images of the page next to and this page: photo section and construction details of the rain gardens of Esterbro in Copenhagen. The curbs have breaks every 150-200 cm to collect the meteoric waters inside the depressed flower beds.

When the rain gardens develop in a linear pattern, cross passages can be predicted every 20-30 meters, allowing people to cross them without getting dirty and trampling on vegetation and soils. In these cases the pavements must be made of isolated blocks, made of stone or concrete, so as not to obstruct the collected rains. Inside the rain gardens it is possible to place drainage pipes, having the care to use perforated covers of larger wells.

Details of the vegetation and draining trinciee inside the rain gardens. (Project by Tradje Nature, photo by Luisa Ravanello)

2

INFILTRATION TRENCHES AND FILTER DRAINS
drain urban rainwater

Channel or trench drains are linear elements filled with permeable gravel material (or plastic prefab elements) where rainwater is channelled and slowly infiltrated underground.
These elements are large-scale surface water-restraining systems to be installed on single lots.
Channel drains can be maintained with gravel or green surfaces, and designed as urban decoration elements along paved areas.

Trench drains are installed to:
- improve infiltration into groundwater *(effectiveness based on the terrain characteristics)*;
- remove pollutants through filtering and biological absorption mechanisms by plant species *(low effectiveness)*;
- reduce flood peaks in receiving bodies *(medium effectiveness)*.

Trench drain on the side of the building that houses the Public Library in the Bottière Chênaie ecodistrict of Nantes, France. (Landscaping project and photo by Atelier de Paysage Bruel-Delmar)

Trenches in the Zollhallen Plaza in Freiburg, Germany. (Project by Ramboll Studio Dreiseitl and photo by B.Doherty)

CONSTRUCTION ASPECTS

Channel drain implementation requires good knowledge of the soil and subsoil, to ensure sufficient subsoil permeability (soil permeability coefficient k→10-5 m/s).
Trenches are 1-2 m deep, with the trench bottom at least 1 meter from the maximum level of the surface ground water. Their width ranges from 0.5 m to 2 m.
In general, a perforated drainage pipe is installed in the drain, to promote an even distribution of rainwater along the trench, and ensure the flow of the non-infiltrated portion toward the exit (sewage system or other receiving water body).
In general, the trench width should be equal to the pipe's diameter plus 15 cm on each side.

The trench infill comprises scree/washed gravel with an average 30% porosity (or, alternatively, lava granulate or prefab plastic elements, with a porosity value that can exceed 90%), protected on the outer perimeter by a geotextile filter that prevents clogging by fine materials.
The surface layer varies based on the surface use and on the trench feeding methods:
- DIRECTLY FROM SURFACE WATER, the surface finish must be permeable (e.g. with draining grit or with grit and topsoil);
- INDIRECTLY FROM THE SEWAGE SYSTEM, the surface may be impermeable.

Any material that can clog the drainage surface - such as sand - should be avoided.
Installing inspection pits along the trench filter is strongly recommended, to facilitate drain cleaning operations. The trench filter size should allow complete emptying within 12-24 hours after the storm ends.

Trench drain type section.

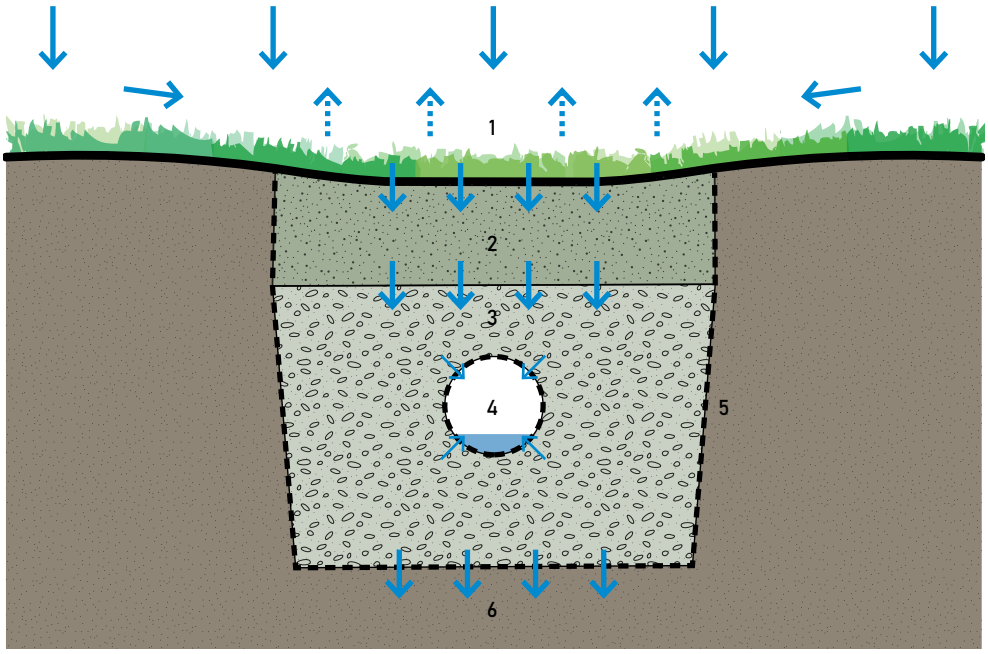
Trench drain construction phases and different surface finish options. Trench excavation. (Technopole in Bourgogne, project by Mayot-Toussaint)

Trench filling. Gravel finish. (Parking lot of the Faucigny-Glières Public Swimming Pool, project by Atelier Alice Tricon)

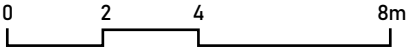
Finish with stones and groundcover plant species. (Warroad Land Port of Entry, project by Coen+Partners)

Finish with groundcover plant species and wooden walkway (Presqu'île Rollet, project by Atelier Jacqueline Osty)

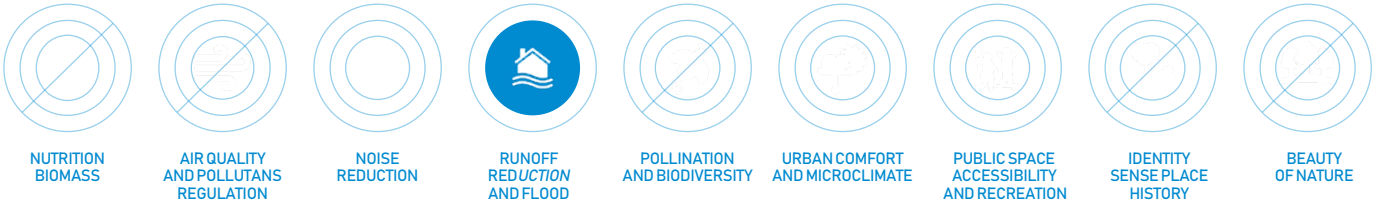
Trench drain in the La Confluence residential district, in Lyon. (Landscaping project by Michel Desvige, photo by Luisa Ravanello)



1. Green surface layer
2. Scree (50%) and topsoil (50%) mixture 50-70 mm
3. Washed gravel Ø 50-70 mm
4. Drainage perforated pipe
5. Geotextile
6. Native soil



ECOSYSTEM SERVICES PROVIDED



APPLICATION CONTEXTS AND LIMITS

In residential areas, they can be installed in public spaces of small urban areas to collect roof (with limited pollution load) and permeable area runoff.

In the road network, they can be installed in green flowerbeds along the road or next to parking spaces; based on the pollution and traffic level, a first rainfall treatment system may be necessary.

In commercial and production areas, they can be used in significantly sealed areas with little permeable surface available, to promote partial infiltration; based on the pollution and traffic level, a first rainfall treatment system may be necessary.

SPACE REQUIRED

Trenches are linear elements with low space requirements (normally, less than 10% of the adjoining impermeable surface), commonly associated with small impermeable surfaces.

TYPE OF SOIL AND PRESENCE OF GROUND WATER

Trenches require permeable soil underneath the trench bottom to promote dispersion in ground water. The surface ground water should be located at least 1 meter away from the bottom, to promote a good level of pollutant reduction. This solution cannot be adopted in groundwater protection areas.

PLANT SPECIES

Trenches can be maintained with gravel or groundcover surfaces (Chap. 4.4.3), designed as urban decoration elements along paved areas. The best species are:

- IN SHADY AREAS dichondra, ivy, Pachisandra, saxifraga;
- IN SUNNY AREAS Achillea millefolium, Bellis perennis, Elymus arenarius, Helxine soleirolii, Hernaria, Isotoma fluviatilis, Lotus corniculatus, Phyla nodiflora, Sagina subulata, thyme, clover.

PUBLIC USAGE

Depending on the intended use, the area can be made accessible (for instance, as a pedestrian path) or can become a green decorating element. If the trench is located near the road or a parking lot, the risk of vehicles running over the filtering drains must be reduced, to prevent drain movement and the underground infiltration capacity.

MAINTENANCE

Ordinary maintenance must be performed regularly on a semi-annual basis to:
- inspect and remove any sediments/leaves from the permeable surface, inspection pits and pre-treatment systems (if present);
- remove any sediments from the pre-treatment systems (if present).

Extraordinary and occasional maintenance is performed to:
- make sure no roots are present in the drains;
- clean the perforated drainage pipes and pits;
- clean and replace the surface filtering layer, drainage medium and geotextile (if required, in case of clogging).

Maintenance costs are mid/high, because regular inspections and possibly extraordinary maintenance interventions are required.

INDICATIVE COSTS

Construction costs vary, based on the trench geometry and excavation depth.
Indicatively:
- 80-100 euro/linear meter for a 1sqm trench section.

CASE STUDIES AND BEST PRACTICES

- Zollhallen Plaza, Friburgo - DE / Case study C25

3

SOAKAWAYS
drain urban rainwater

Dry wells or soakaways are an alternative to trench drains: they are point elements that promote rainwater underground infiltration in a concentrated manner, and are particularly suitable in those areas with limited surface space, as micro-scale interventions.
They consist of a well of varying depth, with filtering rings where rainwater is collected and stored before slowly infiltrating into the subsoil.
The dry well surface area can be finished with a permeable gravel layer, and it can be integrated in urban or public green areas.

Dry wells are implemented to:
- improve infiltration into groundwater *(effectiveness based on the terrain characteristics)*;
- remove pollutants through filtering and biological absorption mechanisms by plant species *(low effectiveness)*;
- reduce flood peaks in receiving bodies *(medium effectiveness)*.

Dry wells in public spaces of the Vulcania Centre Européen du Volcanisme in Saint-Ours-les-Roches, France. (Landscaping project by Atelier CAP)

Draining well inside a raingarden. (Østerbro-Copenhagen, project by Tredje Nature)

CONSTRUCTION ASPECTS

Dry well implementation requires good knowledge of the soil and subsoil, to ensure sufficient subsoil permeability (soil permeability coefficient k→10-5 m/s).
Soakaways are constructed with perforated rings of different diameters (between 100 cm and 200 cm) and with a total depth between 2 m and 5 m (deep wells). The vertical or tilted sides excavation is filled, according to the type of soil, with granular material with a high permeability coefficient.
The well bottom is filled with coarse-size material (such as pebbles, coarse gravel).
The well is protected on the external well and excavation perimeter by a geotextile filter that prevents clogging by fine materials.
Depending on the type of infiltration water, a water pre-treatment pit can be installed upstream of the well, to promote oil and sediment deposition.
The well can be completed by an overflow system to channel the water runoff toward a sewage system/water body, even in case of extraordinary events.
The surface layer can comprise draining grit, to improve integration in an urban landscape.

APPLICATION CONTEXTS AND LIMITS

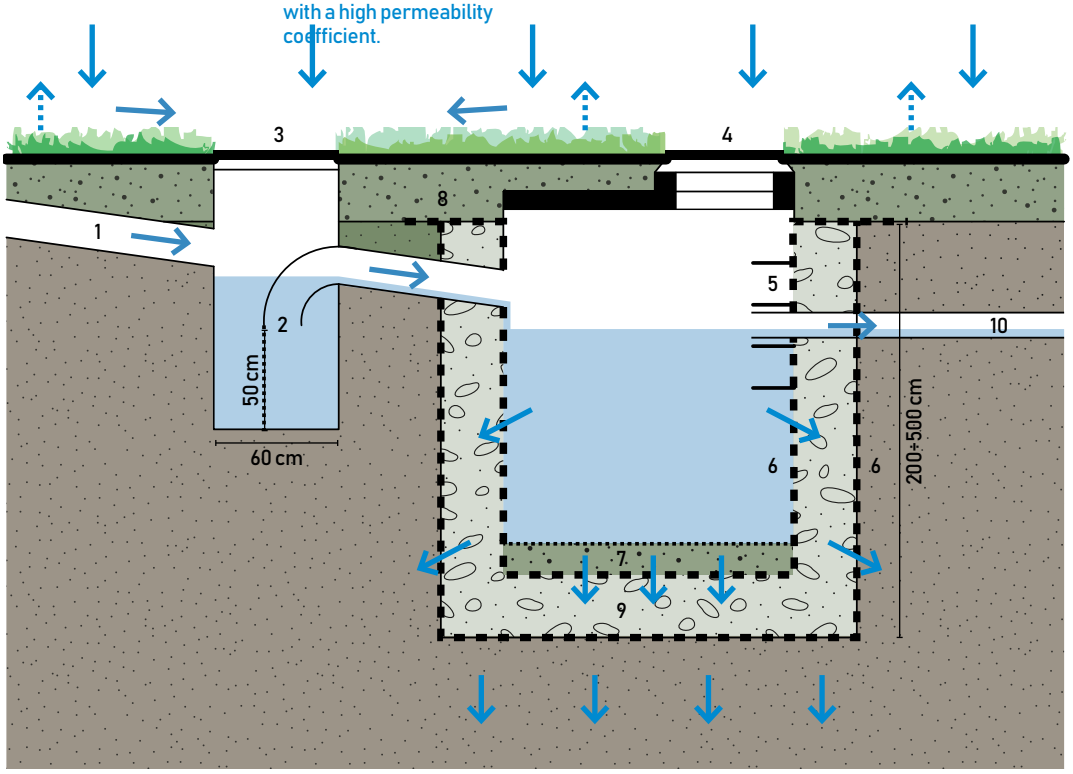
In residential areas, they can be installed in small urban areas to collect roof (with limited pollution load) and permeable area runoff.
They can be easily integrated in public areas.
In the road network, they can be installed in green flowerbeds along the road or in parking lots; depending on the pollution and traffic level, a first rainfall treatment system may be necessary.
In commercial and production areas, depending on the level of pollution and traffic, a first rainfall treatment system may be necessary.

Dry well type section.

Dry well construction phases.
2-meter deep excavation.
Laying of the perforated rings and filling of the well bottom with filtering materials, such as pebbles or coarse gravel.
Infill with granular material with a high permeability coefficient.

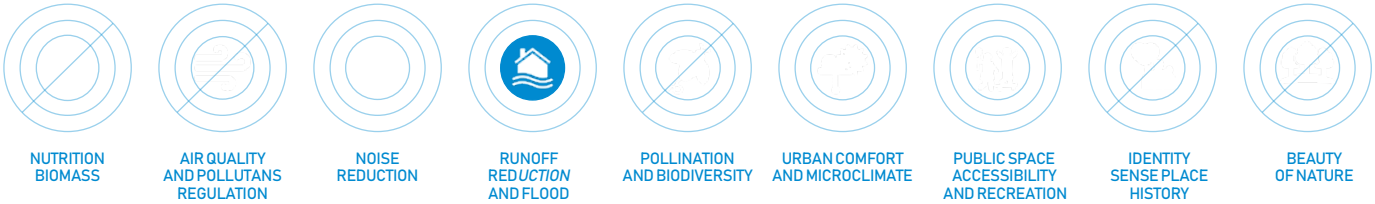
Surface finish with draining grit.
(www.notrenidauparadis.blogspot.com)

Example of dry well with permeable scree surface finish, on a private green area.
(www.building1120.wordpress.com)



1. Rainfall collection
2. Siphon pipe
3. Inspection manhole cover/ storm drain
4. Inspection manhole cover over dry well
5. Perforated ring
6. Geotextile filter
7. Filtering layer (coarse gravel)
8. Topsoil
9. Permeable granular material (coarse gravel and pebbles)
10. Overflow pipe

ECOSYSTEM SERVICES PROVIDED



SPACE REQUIRED

Dry wells are point elements with low space requirements (normally, less than 1% of the adjoining impermeable surface); they are commonly associated to small impermeable surfaces.

TYPE OF SOIL AND PRESENCE OF GROUND WATER

Dry wells require permeable soil underneath the well bottom to promote dispersion in ground water. The surface ground water should be located at least 2 meters away from the well bottom, to promote a good level of pollutant reduction.
This solution cannot be adopted in groundwater protection areas.

PLANT SPECIES

Dry wells can be topped with a gravel surface or groundcover species, and designed as urban decoration elements along paved areas.
The best species are:

- IN SHADY AREAS dichondra, ivy, periwinkle, Pachisandra, saxifraga;
- IN SUNNY AREAS Achillea millefolium, Bellis perennis, Elymus arenarius, Helxine soleirolii, Hernaria, Isotoma fluviatilis, Lotus corniculatus, Phyla nodiflora, Sagina subulata, thyme, clover.

PUBLIC USAGE

These elements are at regular distances require limited surface space.
In general, considerations made for trench drains apply.

MAINTENANCE

Routine maintenance must be performed regularly on a semi-annual basis to:
- inspect and remove sediments from the dry well and the pre-treatment well;
- check permeability over time (cleaning drainage surfaces, replacing the topsoil layer if overly compact, etc.), if the surface finish has been created with a permeable layer (soil and vegetation, drainage layer).

Extraordinary and occasional maintenance is performed to:
- make sure no roots are present in the drainage layer;
- purge the dry well;
- clean and replace the geotextile layer (in case of clogging).

Maintenance costs are medium/high, because regular interventions and extraordinary maintenance interventions may be required.
The dry well effectiveness is strictly related to its degree of maintenance.

INDICATIVE COSTS

Construction costs vary, based on the dry well geometry and excavation depth.
Indicatively:
- 1,500–2,000 euro/unit, based on an internal well diameter of D=2.0 m and 2.5 m depth.

CASE STUDIES AND BEST PRACTICES

- Østerbro, Copenahgen -DK / Case study F37

4

NOUE PAYSAGERE OR SWALES
drain, laminate and filter urban rainwater

Noue paysageres, or swales as they are also known, are open channels similar to shallow and wider ditches (20-40 cm) with very gently sloping sides covered with plants. Their function is to collect rainwater, phyto-purify and mitigate surface runoff through slow infiltration into the subsoil.
Urban bioswales can be adapted to different contexts - such as road networks, parking lots, bicycle/pedestrian paths or existing green areas - with aesthetically-pleasing results, often creating attractive and accessible green corridors.
In vegetation, swales can be made green in different ways, so as to adapt to the landscaping and climate scenario where they are created, and by varying the species along the green corridors according to the surrounding environment.

Swales are installed to:
- improve infiltration into groundwater (effectiveness based on the terrain's characteristics);
- remove pollutants through filtering and biological absorption mechanisms by plant species (medium effectiveness);
- reduce flood peaks in receiving bodies (medium effectiveness);
- promote biodiversity (medium-high effectiveness, based on the plant species);
- reduce the urban heat island effect (medium-high effectiveness, depending on the size).

Unfathomable ditch within the Martin Luther King park, built to collect the waters of a green area equipped with about 10 hectares and the urban fabric adjacent to the park. We are in the area of Clichy-Batignolles, northeast of Paris, where the old disused railway station has been the subject of a process of urban and real estate transformation. (Landscape project by Jaqueline Osty, photo by Elena Farnè)

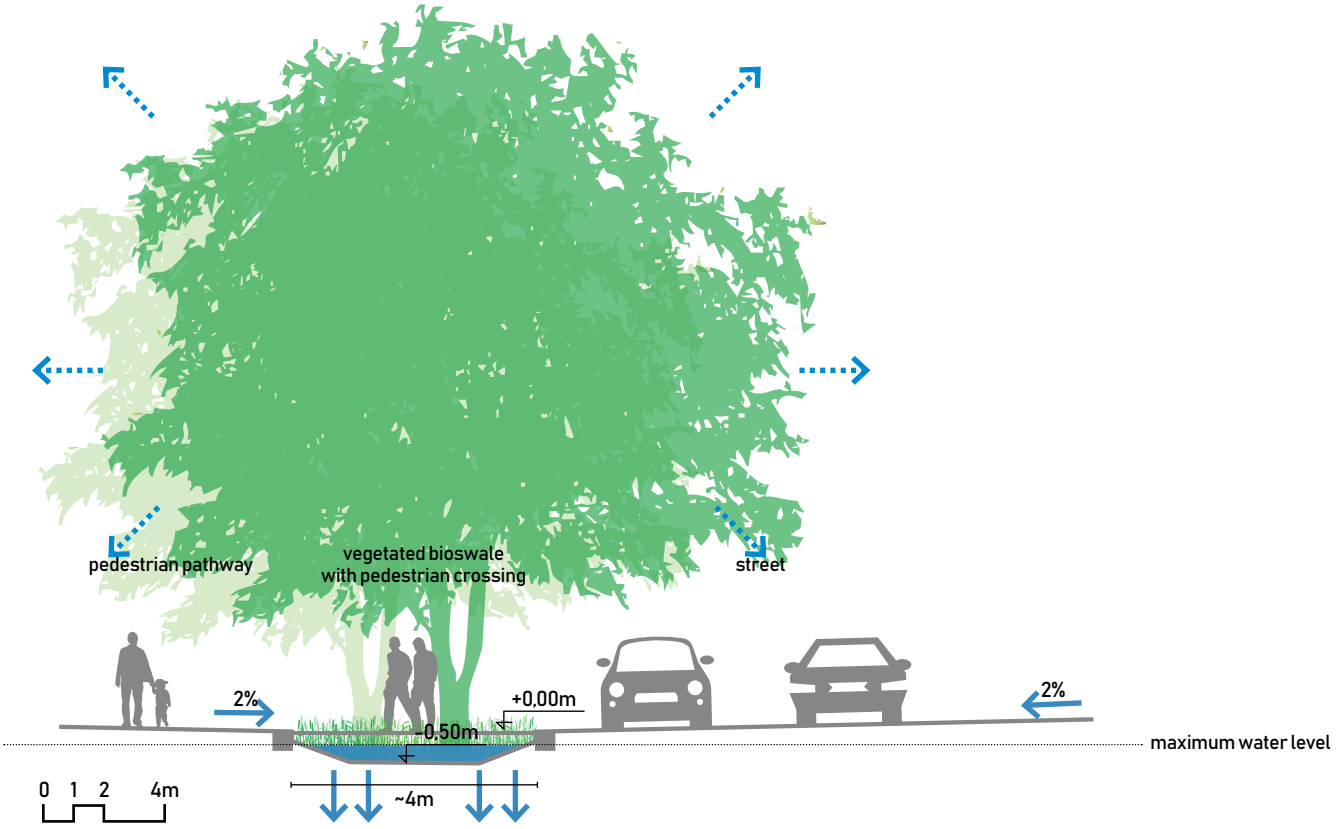
Flooded ditch in the central park of the Eco-Neighborhood of the Parc du Trapeze in Boulogne-Billancourt, France. (Landscape project Agence TER, photo by Luisa Ravanello)

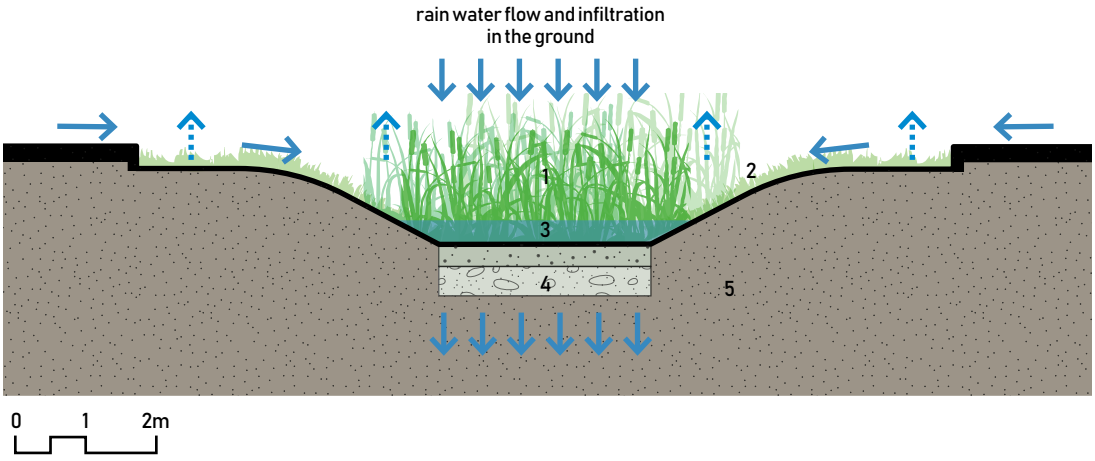
CONSTRUCTION ASPECTS

Swales are shallow depressions, 20-40 cm deep and up to 10 m wide, with a bed section comprised between 0.5 and 2 m.
The width of the elements must be defined so as to determine very limited water levels and suitable water processing (thus ensuring a reduced maximum speed and sufficient retention times), and prevent the possible formation of sedimentation or erosion areas.
For instance, considering a 15-minute critical climate event (applicable if the swale collects water from a road), we can consider as suitable project parameters a flow depth of 10 cm, a maximum speed of 0.3 m/s to promote infiltration into the ground, and a residence time of 15-20 minutes. In case of extreme events, we can consider a maximum flow speed of 1 m/s (or 2 m/s, if the soil stability and erosion conditions allow it).

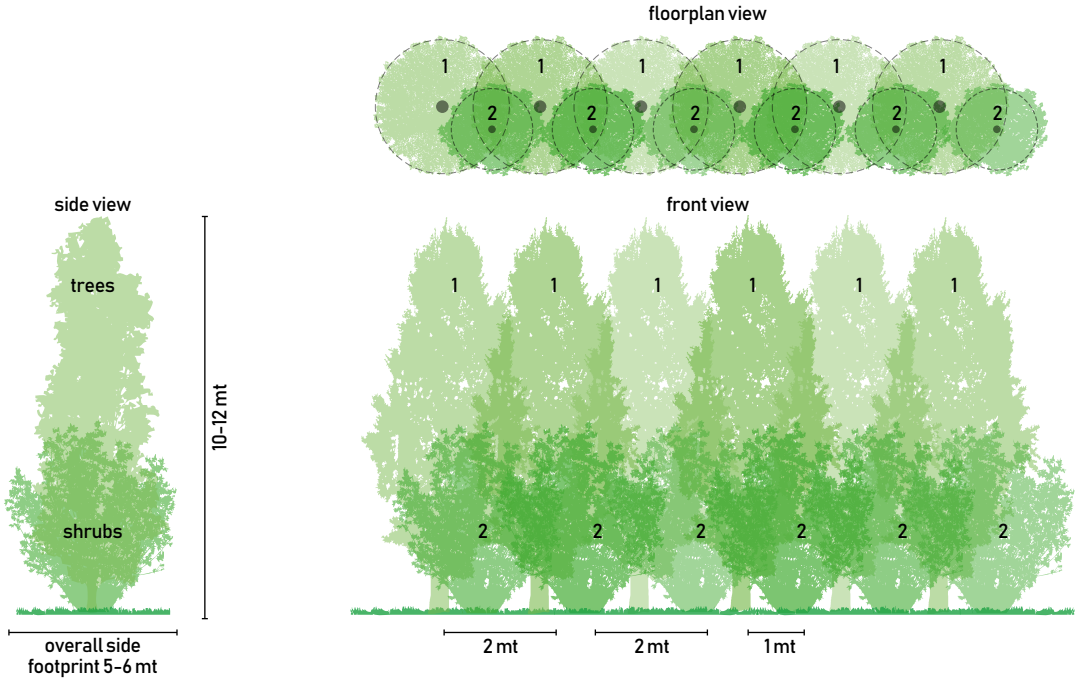
The sides must be as gently sloping as possible, in order to promote runoff water pre-treatment and maximize the infiltration surface (maximum gradient 1:3, recommended: lower than 1:4).
When they are built on areas with significant gradients, small water containment structures should be included to promote an even distribution of the water volume over the entire swale length.
Since they are shallow and very gently-sloping linear depressions, installing barriers against accidental falls is not required.

The swale may be unevenly shaped, to adapt to the available surface or to the project needs, with widenings and bottlenecks.
The sections are divided into:
- STRUCTURED with edge mineral elements delimiting them;
- SOFT with very gently sloping sides covered with grass.



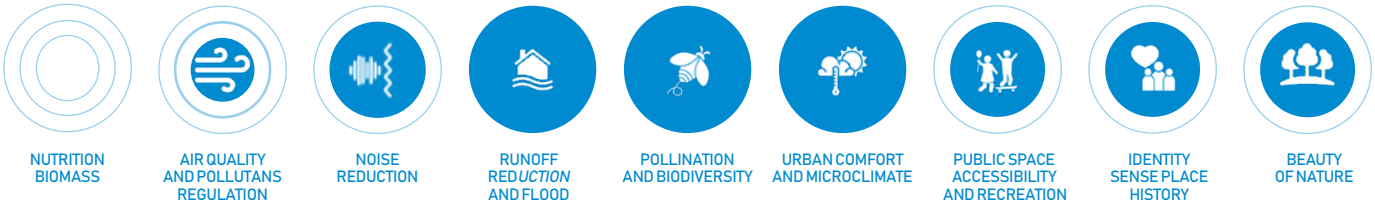


1. Plant species
2. Sides covered with grass with 1:3÷1:4 gradient
3. Maximum water level
4. Gravel and sand draining layer (optional)
5. Native soil



Plant system composition:
→ TOP LAYER
with trees
→ INTERLAYER
with high shrubs
or tree bases (1)
→ BOTTOM LAYER
with shrubs and
herbaceous plants (2)

ECOSYSTEM SERVICES PROVIDED



Cross-section of a structured swale with mineral elements on the edges.

Detailed cross-section of a swale with gently sloping sides (1:3÷1:4 with respect to the swale bottom).

Swale plant system composition.

If the soil is not highly permeable, infiltration can be promoted by creating a gravel drainage bed on the swale bottom. In general, infiltration can be calculated based on the groundwater vulnerability and on the quality characteristics of the infiltrating water.
Although swales help mitigate hydraulic issues, they cannot solve them; therefore, in case of intense events, one or more overflow areas above the project maximum water level should be included to channel excess water toward a routing system leading to the public sewers.
If these elements are installed near a high-traffic road network with highly polluted runoff water, a first rainfall pre-treatment system is required.
These systems are designed with 24-hour water drainage times, in order to ensure a suitable residence time to remove pollutants and make the rainwater reservoir volume available for another event at the same time.

APPLICATION CONTEXTS AND LIMITS

In residential areas, they can be designed as green corridors along the edges of lots and parking areas.
If they are installed along a road network, swales can be easily implemented alongside carriageways, pedestrian areas and parking lots.
Swales can be easily integrated in city parks, also to provide an added landscaping value.
In commercial and production areas, they can be designed as green corridors along the building perimeters, especially to filter roof runoff. Based on the level of pollution and traffic, a first rainfall treatment system may be necessary.

SPACE REQUIRED

They are linear elements with significant spacial requirements, due to their gently-sloping sides; in general, they are difficult to integrate in densely urbanized areas with limited space.

TYPE OF SOIL AND PRESENCE OF GROUND WATER

Swales require permeable soil and ground water located at least 1 meter away from the bottom of the swale or filtering bed (if present) to promote a good level of pollutant reduction.
In groundwater protection areas, green ditches can be made impermeable with a waterproof sheet.

PLANT SPECIES

As in the rain garden sheet, choosing the right type of plant depends on the site and on the relevant climatic context. In this case, trees are more frequent and their combination with shrubs can recreate natural hedges, by removing thorny species.
The swale vegetation must be selected based on the site's characteristics, and choosing species that can survive in polluted atmospheres, in the presence of road runoff water.

In general, plant species should be capable of:

- ENDURING PERIODICAL FLOODS ALTERNATED WITH EXTENDED DRY PERIODS, and sediment/debris build-up;
- TOLERATING SALT, if the swales are used near impermeable surfaces subject to salting in the winter;
- BASAL LAYER comprising shrubs up to 2-3 meters high, such as euonymus, privet, symphoricarpos, viburnum and herbaceous plants;
- INTERLAYER comprising shrubs, such as hazel, cornel, elder, viburnum, privet and euonymus ranging between 2 and 5 meters in height;
- TOP LAYER comprising tree canopies, such as willow, poplar, plane, alder and maple trees.

PUBLIC USAGE

Their use can be modulated based on the expected weather volumes: during storms, they are an important water mitigation site, while in dry periods, they can also be used as pedestrian paths, and leisure and relaxation areas.
Swales can also house pedestrian/bicycle paths that are transversal (with localized crossings) or longitudinal (along the swale path) to the swale, if the element is only partially green. It should be considered that circulation inside the swale is forbidden during storms; therefore, alternative paths should be included.

At the top and center.
Examples of structured swales with mineral elements on the edges: the Martin Luther King Parc swale, Paris, in different seasons.
(Landscaping project by Atelier Jacqueline Osty)

Examples of swales with gently sloping sides covered with grass and featuring trees and shrubs in the Parc du Trapeze ecodistrict in Boulogne-Billancourt, France.
(Landscaping project by the AAUPC Agency, photo by Elena Farnè)

Bottom right.
Examples of swales with loose section and very gently-sloping sides covered with grass, on the Mardeuil roadside, North-East of France.
(Project and photo by Agencie Vysages)

MAINTENANCE

The main routine maintenance activities can be performed by unskilled labour once a month, and they mainly include:

- mowing;
- ditch inspection to prevent the onset of erosion;
- checking for the presence of sediments and/or waste and removing them.

Extraordinary maintenance includes planting new areas where plant growth is limited, also by choosing different species that are best suited to the context.
Maintenance costs are low, since intervention frequency is limited, and they can often be carried out while maintaining adjoining public and road spaces, with very little increase in costs.

INDICATIVE COSTS

Construction costs vary, based on the plant types and the installation of a bottom trench drain. Indicatively:

- 10-15 euro/sqm to dig a 0.5 m deep trench, including disposal and lawn surface finish;
- 40 euro/ml for a filtering layer on the bed (approx. 100x(h)50cm)
- 20-25 euro/sqm to plant the different species.

CASE STUDIES AND BEST PRACTICES

- Eco-district Parc du Trapeze in Boulogne-Billancourt - FR / Case study A6
- Eco-district di Clicy-Batignelles a Parigi - FR / Case study A8

5

WET GARDENS
clean, infiltrate and retain urban rainwater

Wet gardens are basins with one or more permanent bodies of water to collect and process (phytopurify) rainwater. They can feature a great variety of emergent and submerged water plants, along the basin banks and in the wetlands; this variety is excellent for phytopurification purposes, and as an element of biodiversity and landscape value.
They are used to drain and treat both limited and wide areas (even larger than 10 ha), and they can be integrated in residential, commercial and industrial contexts. They can be implemented in newly-developed or reclassified areas.
Wet gardens also have an attractive function, thanks to their aesthetic and landscaping value; for this reason, involving different figures - such as engineers, agronomists and landscape architects - in their design is really important.

The purpose of wet gardens is to:
- remove pollutants through filtering and biological absorption mechanisms by plant species *(high effectiveness)*;
- reduce peak floods in the receptor bodies (*medium/high effectiveness, depending on the project goals)*;
- increase biodiversity *(high effectiveness)*;
- reduce the heat effect and noise *(medium effectiveness)*.

The rolling areas Belval North residential district in Belval, Luxembourg, based on a disused steel area. The basins are built as a system of progressive wet gardens, rolling and phytopurification of the neighborhood's rainwater. (ELYPS Landscape Design and Photo Projects)

The wet garden with permanent water inside the Martin Luther King park in Paris, with the typical aquatic and marsh vegetation and the walkways for use. (Landscape project by Atelier Jacqueline Osty, photo by Elena Farnè)

CONSTRUCTION ASPECTS

The system comprises a wet environment artificially recreated in a waterproofed basin and crossed by different water flow regimes.
The shape can be adapted to the surrounding landscape: in open green spaces, wet gardens are generally less structured and have a more natural appearance, while in urban contexts, their geometry is neater and more linear, and they become part of the urban decoration thanks to the use of mineral edge elements and/or reinforced containment walls (e.g. gabions, concrete curbs, etc.).
Wet gardens are characterized by the presence of typical wetland plant species - hygrophile macrophytes - rooted to a medium or floating on the water. The plant density promotes pollutants adhesion, absorption and aerobic decomposition, and prevents particle re-suspension. They can include deep and shallow areas, promoting the diversity of water plant species used.
For safety reasons, the depth should range from 0.5 and 1 m, although it is possible to make it deeper or shallower, by adopting suitable measures.

The existing phytopurification systems that can be implemented in a wet garden are divided by function, based on the macrophyte used:
- FLOATING MACROPHYTES;
- SUBMERGED ROOTED MACROPHYTES;
- EMERGED ROOTED MACROPHYTES;
- MIXED SYSTEMS

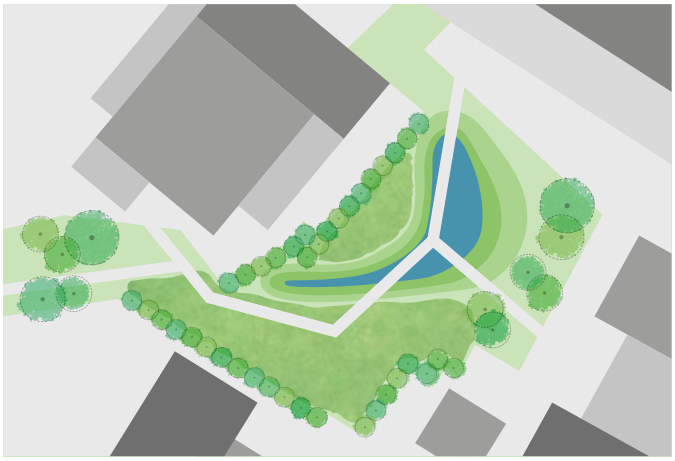
and based on the water flow, which can be:
- HORIZONTAL SUBMERGED FLOW, when a basin filled with inert material is created, where drain water flows horizontally; the related plant species are emerged rooted macrophytes;
- VERTICAL SUBMERGED FLOW, when a basin filled with inert material is created, where drain water flows vertically; the related plant species are emerged rooted macrophytes;
- FREE FLOW, recreation of a natural wetland, where water is in direct contact with the atmosphere and shallow; the related plant species are hydrophytes and helophytes.

Wet garden scheme with subalveous phytopurification and horizontal submerged flow system that captures urban rainwater.

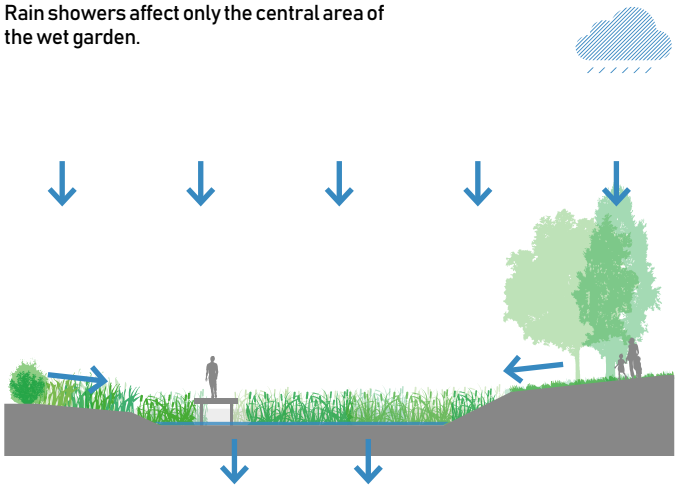
ECOSYSTEM SERVICES PROVIDED

NUTRITION BIOMASS | AIR QUALITY AND POLLUTANS REGULATION | NOISE REDUCTION | RUNOFF REDUCTION AND FLOOD | POLLINATION AND BIODIVERSITY | URBAN COMFORT AND MICROCLIMATE | PUBLIC SPACE ACCESSIBILITY AND RECREATION | IDENTITY SENSE PLACE HISTORY | BEAUTY OF NATURE

ORDINARY RAINFALL EVENT

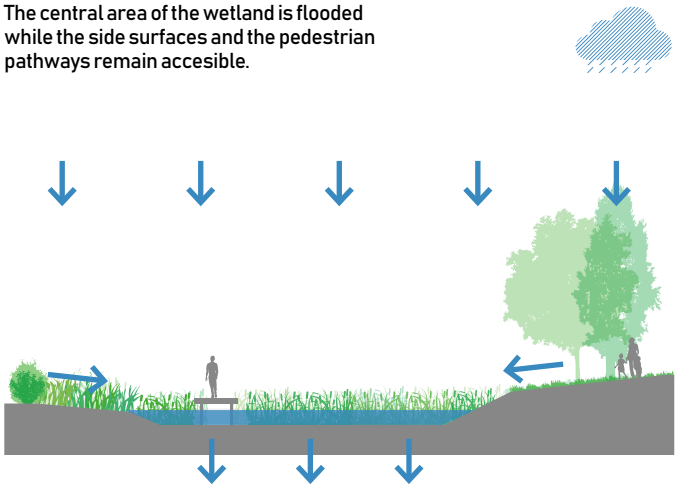


Rain showers affect only the central area of the wet garden.



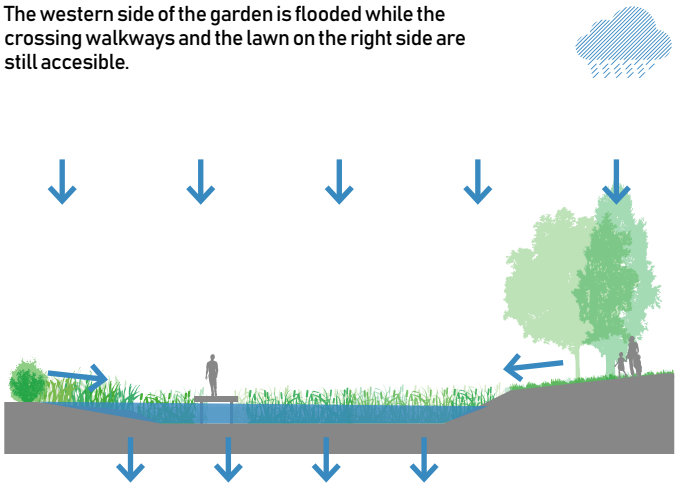
MEDIUM INTENSITY RAINFALL EVENT (R.T. ~ 2 YEARS)

The central area of the wetland is flooded while the side surfaces and the pedestrian pathways remain accesible.



EXCEPTIONAL/EXTREME RAIN EVENT (R.T. ~ 100 YEARS)

The western side of the garden is flooded while the crossing walkways and the lawn on the right side are still accesible.



Right. The residential district north of Belval, Luxembourg. The real estate intervention was conceived from a system of wet gardens - all downstream of buildings and carved along the sliding axis of an existing drainage channel - with the aim of treating urban rainwater without burdening the existing sewage system. Through earth movements along the canal - downstream of the building - and thanks to the insertion of some barriers, a system of wet gardens has been created capable of collecting and laminating the surface urban rainwater. The rains resulting from the neighborhood are thus laminated, purified and deposited naturally, in dry weather; while in case of heavy rains the capacity of the wet gardens to invade slows their flow downstream, preventing the overload of the urban sewer system. Thanks to the vegetation, the wet gardens also perform the function of water phytopurification. A system of walkways and paths, built alongside the canal and connected to the Belval cycle system, allows the people of the neighborhood and the town to enjoy the wet gardens and enjoy the evolution of the landscape in the seasons.
(Photo and projects by ELYPS Landscape Design)

The best layout is assessed on a case-by-case basis, based on the characteristics of the water to be processed, the local climate conditions, etc. Different systems can be combined.
In general, a wet garden includes:

- A SEDIMENTATION BASIN to accumulate coarser sediments near the rainwater inflow point; this prevents sediments from being transported and built-up in other areas of the wet garden, affecting plant growth, and allows concentration of the most frequent sediment removal activities in a limited area;
- A PERMANENT WET AREA with the water volume that remains in the wet garden throughout the year, net of the evaporation and infiltration phenomena. This is where the main phytopurification treatments occur, promoting finer sediment deposition; this area features submerged or floating macrophyte species, with limited emergent plants. In order to ensure plant preservation and a good phytopurification performance, the basin water volume to be maintained must be assessed in the project, to include a water flow that can compensate the evapotranspiration and infiltration phenomena. Empirical studies have demonstrated that a prolonged drought (over two months) can affect the number of plant species. These areas have a depth of between 0.5 and 2 m, and the maximum water level should be equal to the drain structure;
- AN EXPANSION OR OVERFLOW AREA, a temporary reservoir above the permanent wetland maximum level, affected when the water level rises during a storm, to ensure a reduction of peaks outflows from the system;
- A WETLAND OR "SHALLOW WATER" AREA with limited vessel draught - lower than 0.5 m - housing emerging water plants; these areas are outside the permanent wet area, or in the middle of it.

Wet gardens preserve a minimum permanent water level by applying an impermeable membrane or bentonite geocomposite, or, in the event of clay soil, the soil itself prevents or reduces infiltration into the subsoil.
Where the soil may be contaminated, the basin needs to be sealed, to prevent contact with the groundwater below.
The garden is filled by one or more channels upstream, and inflow points must be protected with suitable materials, to create a calm-water area (e.g. with stone elements) and prevent erosion. The sides with grass and plants are gently sloping, with a 1:3/1:4 gradient.
The overflow section - i.e. the water volume above the permanent level - is emptied within a 24/48 hour period, to make it available for a following storm, through a pipeline toward the water receptor body (sewage system, surface water body, etc.) calibrated to limit the outflow capacity.
An emergency overflow system should be included for intense events, for higher values than the project event (e.g. a storm with RT=100 years).

In larger wet gardens, the surface should be divided in different areas, with diverse depth and plant characteristics, to improve water quality (thanks to longer flows that promote pollutant removal), guaranteed reservoir volume and biodiversity.

Crossing the wet garden and managing the meteoric waters.

APPLICATION CONTEXTS AND LIMITS

In residential areas, wet gardens can be easily integrated both in newly-built areas and in redeveloped contexts, provided that a sufficient surface is available.
Wet gardens can be integrated into existing green areas to add great landscaping value.
They cannot be implemented in steep areas (possible land instability) or in highly populated areas (not enough space).

SPACE REQUIRED

They take high spatial requirements and a limited water height.

TYPE OF SOIL AND PRESENCE OF GROUND WATER

In groundwater protection or polluted soil areas, this solution can be adopted by completely sealing the bottom with a waterproof geocomposite/membrane.

PLANT SPECIES

Wet garden plants are responsible for purifying water, increase sidewall stability and prevent erosion; they are also important as natural habitat and to increase the site landscaping value.
Usually, plant density ranges between 0.2-8 plants/sqm, depending on whether trees (lower density) and shrubs are used, or just herbaceous plant (higher density).
Since the wet garden soil is compacted in the construction phases, rather big and deep pits should be digged around the planting area, and filled with loose soil, to promote the development and penetration of the roots system.
If the wet garden soil lacks sufficient nutrients and organic matter to promote plant growth, additional soil and organic matter should be added in the planting areas (a 15 cm thickness is sufficient for grassy areas, up to 45 cm for shrubby areas).
The species that best adapt to this kind of environment are those indicated in Chapter 4_2.6 - for water and riparian plants - and Chapter 4_2.4 - for hedges that can be planted along wet areas.

At the top right, the wet garden in the middle of the road roundabout in Osterbro, Copenhagen. Four residential streets and the rainy water from as many rain gardens flow into the roundabout. The roundabout has been completely reshaped, reducing the roadway on board and obtaining in the center a wet, depressed and vegetated basin; the latter performs the function of sewage and rainfall retention of several blocks. The vegetation in the middle of the roundabout is dense and rustic and at the lowest point there is a thick aquatic vegetation that performs the function of phytopurification. The roundabout has the appearance of a garden: people can cross it thanks to a series of circular paths in stabilized land, at the edges of which are several benches that favor the rest and observation of the colors of trees and shrubs. Thanks to the vegetation and low speed of the cars - on the roads there is the limit of 40 km/h - in the middle of the roundabout there is a lot of quiet and a strong sense of protection. (Tradje Nature project, photo Elena Farnè)

Bottom right, the System of Crossing the wet garden and managing the meteoric waters.

PUBLIC USAGE

The wet garden area cannot be accessed, since it is permanently wet; however, its use can be aided by creating raised walkways and/or footbridges.
In addition, the majority of the areas is generally dry and will flood only in case of intense rain, so it can be opened to the public, when it does not rain.

MAINTENANCE

Ensuring easy access to maintenance vehicles and staff is crucial. The paths should grant access to all hydraulic structures and humid/flooding areas.
Routine maintenance includes:
- monthly inspection of the hydraulic adjustment structures and sides, and visual inspection of their conditions and possible clogging;
- waste and debris removal, once a month, or as needed;
- grass mowing, 2 times a year, in spring and autumn;
- check of silt and fine particle build-up in shallow wetland areas, and definition of a suitable sediment removal schedule;
- annual cutting of emerging and submerged water plants for no more than 25% of the wet garden total extension (to minimize the impact on biodiversity) and dead plant removal before the growth season.

Extraordinary maintenance is performed to:
- remove sediments from the wet area, in case of significant volume reduction (about 20%);
- repair hydraulic structures;
- stabilize the sides after erosion phenomena;
- replanting, if required.

Maintenance costs are mid-low, since they are not very frequent and can be carried out at the same time as those in adjoining public and road spaces.
However, any task concerning the system vegetation should be entrusted to qualified workers.

INDICATIVE COSTS

- 40-50 euro/sqm for a 1.5 m deep trench and related disposal or reuse for terrain modelling;
- 20-30 euro/sqm to create a gravel medium (for vertical or horizontal submerged flow systems);
- 10-20 euro/sqm for paving the surface (in case of mineral systems);
- 10-15 euro/sqm to seal the bottom with a membrane or bentonite geocomposite;
- 25-30 euro/sqm to plant species that can survive in wet soil;
- 300-600 euro/linear meter for the wooden footbridge.

CASE STUDIES AND BEST PRACTICES

- Eco-district Parc du Trapeze in Boulogne-Billancourt - FR / Case study A6
- Østerbro, Copenahgen - DK / Case study F 37
- Along the Canal of Medicina - IT / Case study F41

Basins and Wet Gardens La Vallée verte, in the Breton municipality of Lannilis, France.
The intervention, carried out at the edge of the fabric, urban develops and restores wet areas for environmental and educational purposes.
As can be seen from the site images and photos of the completed intervention, through the modelling of the land, areas in the shape of an invader have been created, which perform the function of retrying and purifying rainwater connected to the urbanization works. These spaces are integrated into the landscape with a system of walkways and paths, to enhance the wetlands on the one hand and improve their accessibility, usability and observation, and on the other to connect the intervention to schools and other public facilities.
The low altitude of the wet gardens is home to aquatic vegetation and trees that can live in humid environments.
(Project and photo by Agence Laure Planchais Paysagiste)

6

DETENTION BASINS
manage urban rainwater

Floodable basins are public spaces located in urban parks, which, in the event of intense rain, temporarily collect rainwater, aid its infiltration into the subsoil, together with the sedimentation of suspended materials. Floodable basins are implemented to drain wide areas (even bigger than 1 ha).
Their size is designed to tackle weather events with return times ≥ 10 years, in order to ensure a complete emptying within 24-48 hours, to prevent the proliferation of mosquitoes and foul odours, and prepare them for a future storm.

The purpose of wet gardens is to:
- promote infiltration into groundwater *(medium effectiveness)*;
- remove pollutants through filtering and biological absorption mechanisms by plant species *(low effectiveness)*;
- reduce flood peaks in receiving bodies *(high effectiveness)*;
- reduce the heat and noise effect *(medium effectiveness)*.
- increase biodiversity *(medium effectiveness)*.

Basin in the Desjardins a Angers ecodistrict - Maine-et-Loire, France, spread over a 7 ha area occupied by the French army until 1998. After its decommissioning, the site was separated from the district by a long perimeter wall for several years, and the urban requalification project - in which the citizens took part by establishing a district advisory board - began only in 2003.
Also based on the citizens' indications, the project for the new public park and for the entire district sought to foster community meetings, the re-appropriation of a space that was once inaccessible to the residents, and its integration into the existing urban landscape.
A de-paving operation took place, extending permeable surfaces from 0.2 ha to approx. 3 ha.
The park offers multiple options, from resting and relaxation areas, to playgrounds and the educational garden.
(Landscaping project by Phytolab - Masterplan and photo by Enet Dolowy – Urbanisme Paysage)

CONSTRUCTION ASPECTS

The basin is constructed on a permeable bed with a 20-30 cm organic soil surface layer.
It may also include small permanent wet areas for recreational and/or landscaping purposes.
The basin is filled by one or more channels upstream, and inflow points must be protected with suitable materials, to create a slow-flow area (e.g. with stone elements) and prevent erosion. It features gently-sloping sides (1:3 or 1:4) covered with grass.
The basin is emptied through a pipeline toward the receiving water body (sewage system, surface water body, etc.) calibrated to limit the outflow capacity.
In high-traffic areas with highly-polluted runoff water, a first rainfall pre-treatment system and an oil separator system are required.
An emergency overflow system should be included for particularly intense events, for higher values than the project event (e.g. a storm with RT=100 years).

APPLICATION CONTEXTS AND LIMITS

In residential areas, permanent wet areas are not recommended, because of the proliferation of mosquitoes and foul odours.
Basins can be implemented even in existing or new green areas.
Depending on the pollution and traffic level, a first rainfall treatment system may be necessary in the road network; they can be installed inside roundabouts or in marginal green areas.
In commercial and production areas, depending on the level of pollution and traffic, a first rainfall treatment system may be necessary.

SPACE REQUIRED

They have high spatial requirements and a limited water height.

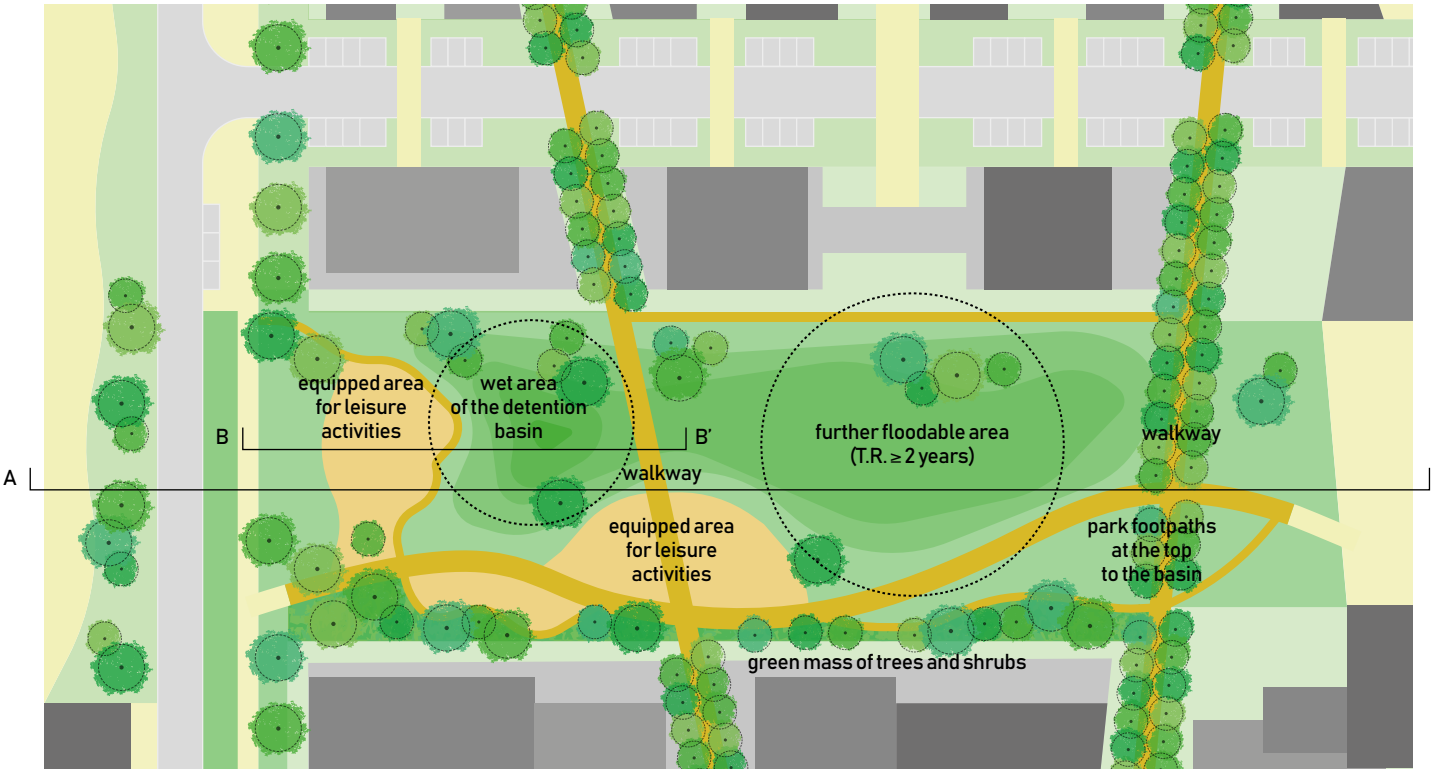
TYPE OF SOIL AND PRESENCE OF GROUND WATER

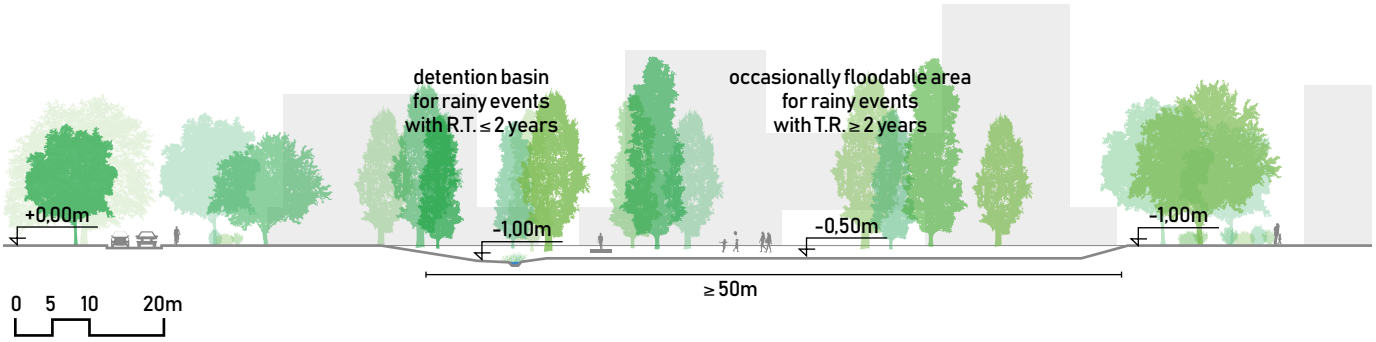
Basins require permeable soil and ground water located at least 1 meter away from the bed, to promote a good level of pollutant reduction. The floodable basin bed should be placed higher than the surface groundwater, to ensure its reservoir capacity.

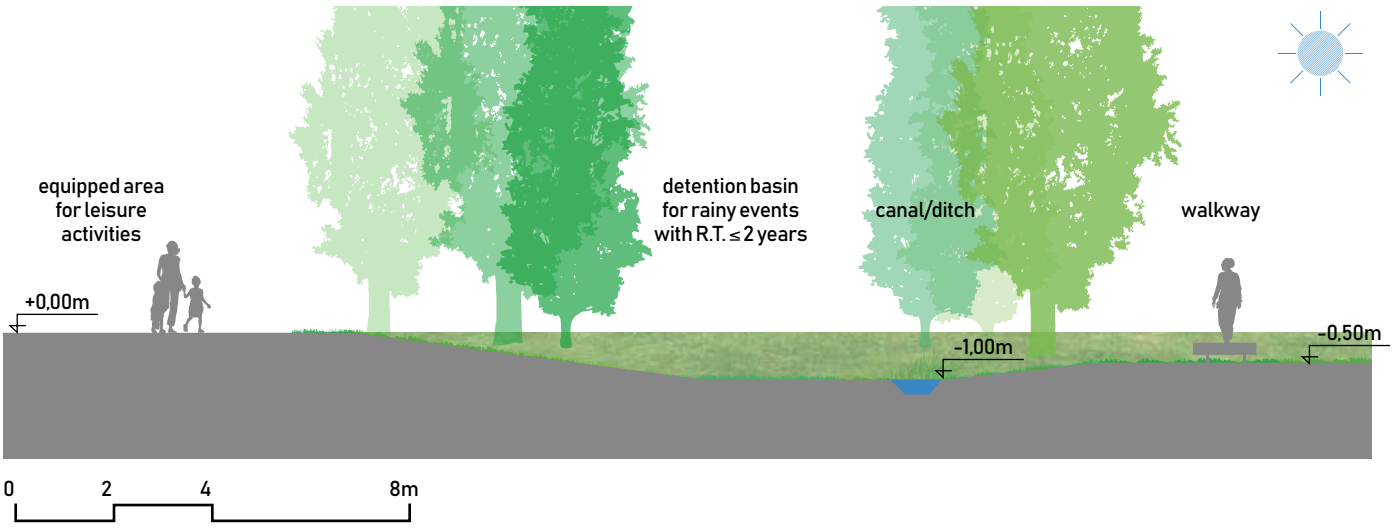
Floodable basin layout with two floodable areas for events of varying size.

Basin cross-section A-A' and detailed section B-B', highlighting the basin bottom distances and the floodable portions, based on the type of weather event.

Diagram of the possible basin functional layout, based on varying weather events: the extended basis area increases according to the event intensity level.







ECOSYSTEM SERVICES PROVIDED

NUTRITION BIOMASS

AIR QUALITY AND POLLUTANS REGULATION

NOISE REDUCTION

RUNOFF REDUCTION AND FLOOD

POLLINATION AND BIODIVERSITY

URBAN COMFORT AND MICROCLIMATE

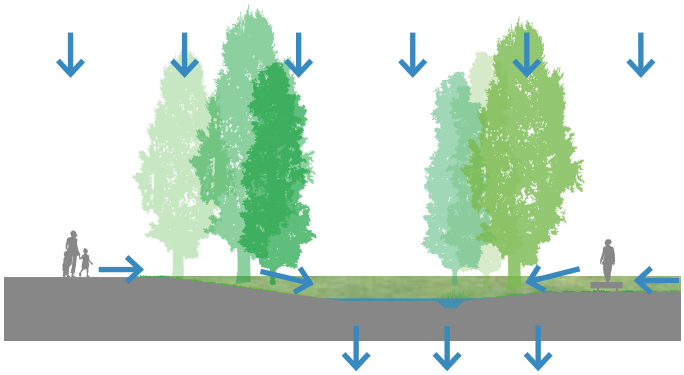
PUBLIC SPACE ACCESSIBILITY AND RECREATION

IDENTITY SENSE PLACE HISTORY

BEAUTY OF NATURE

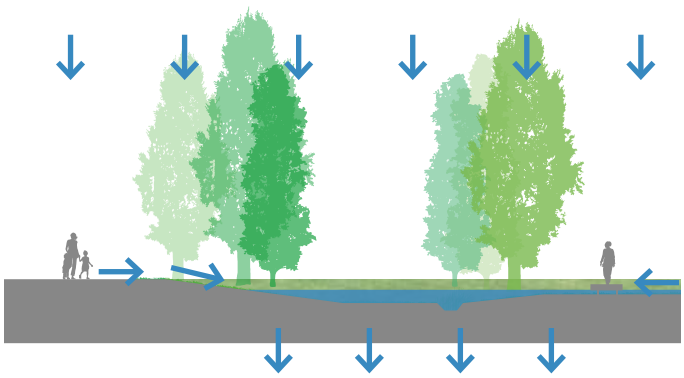
ORDINARY RAINFALL EVENT

The basin area remains accessible and the rainfall affects only the area near the low-flow channel/ditch.



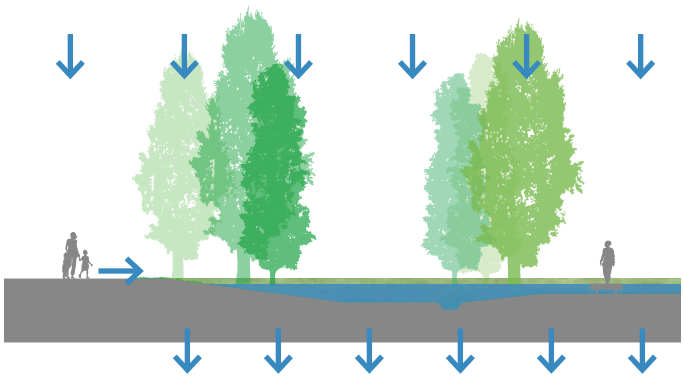
MEDIUM INTENSITY RAINFALL EVENT (R.T. ~ 2 YEARS)

The wet area is flooded, while the right section and the footbridge remain accessible.



EXCEPTIONAL/EXTREME RAIN EVENT (R.T. ~ 100 YEARS)

The right section too is flooded, while the footbridge remains accessible as a crossing path.



Flood-seeling basins and crossing paths. The basins are grassy meadows with slight slopes, all crossed by bridges or stone blocks that allow people to pass when, in case of heavy rains, the meadows are saturated with water. The spaces are designed to dispose of rains in a short time, between 24 and 36 hours. Flood basin in the park of the Salengro-Verlaine headquarters in Paris.
(Project and photo by Agence Philippe Hamelin)

Basin within the Eco-district Desjardins in Angers - Maine-et-Loire in France (Landscape Project by Phytolab - Masterplan and photos by Enet Dolowy – Urbanisme Paysage)
Basin inside the park of the Desjardins Quarter in Angers - Maine-et-Loire France.
(Landscape project Phytolab)

VEGETATION AND RECOMMENDED SPECIES

They are usually covered with a lawn surface, to promote public use in normal conditions; however, when they are flooded, the grassy plants usually suffer. The most resilient species are poa and dichondra. When the phytopurification function is combined with hydraulic purposes, water and riparian plant species capable of absorbing pollutants should be included, which can survive only in permanent water or wet conditions. Pollutant reduction capacity depends on the filtering layer comprised between the basin bed and the groundwater: it should be at least 1 m thick. Planting different species - apart from promoting the depolluting effect - increases the landscape and biodiversity value.

USABILITY AND ATTRACTIVENESS OF PUBLIC SPACE

The basin area usability level may differ:

- COMPLETELY ACCESSIBLE in dry conditions, when the basin becomes a public park and it can be crossed on the walkway. Inside the basin, people can play, run, and workout for most of the year.
- PARTIALLY ACCESSIBLE due to modest storms that determine a partial flooding of the area, although with very limited water height, thanks to the creation of footbridges and elevated walkways;
- NOT ACCESSIBLE - ONLY CROSSABLE in the event of critical events, thanks to the creation of footbridges and elevated walkways to cross the basin.

MAINTENANCE

Ensuring easy access for maintenance vehicles and personnel is essential, and should be planned in the project phase.
The basic maintenance is both periodical and extraordinary, and it involves the inflow/outflow hydraulic structures, following intense weather events. It should include lawn mowing, structure inspection, cleaning, checking for sediments and their removal.

INDICATIVE COSTS

- 20-25 euro/sqm to dig a 1 meter deep trench, including disposal and lawn surface finish;
- 10-20 euro/sqm for de-paving the surface (in case of mineral systems);
- 5-30 euro/sqm to plant the different species;
- 300-600 euro/linear meter for the wooden footbridge.

CASE STUDIES AND BEST PRACTICES

- Eco-district Parc du Trapeze in Boulogne-Buillancourt - FR / Case study A6
- Eco-district Gosbenarealet, Aalbrog - DK / Case study A2
- Østerbro, Copenahgen - DK / Case study F 37
- Along the Canal of Medicina - IT / Case study F41

7

FLOODABLE PARKS
manage, infiltrate and retain urban rainwater

Public parks can be designed as multi-functional spaces integrated with urban drainage sustainable management criteria, by designing the best synergy between the "water, biological and social" circuits.
A park can be designed as a mutable element that serves a function of rainfall meadow: partially accessible in case of extreme events, and fully accessible during drier periods.
This way, even the most complex drainage issues in wide areas can be solved, while improving the citizens' quality of life, both from a social (the park as a place to gather, socialize and relax), environmental (in terms of air and water quality and biodiversity), and economic (increased district appeal and support to the establishment of business activities) standpoint.

The purpose of floodable parks is to:
- promote infiltration into groundwater *(medium effectiveness)*;
- remove pollutants through filtering and biological absorption mechanisms by plant species *(medium effectiveness)*;
- reduce flood peaks in receiving bodies *(high effectiveness)*;
- reduce the heat island effect and the noise *(medium effectiveness)*;
- increase biodiversity *(medium effectiveness)*.

The flood area of the Parc du Trapez in Boulogne-Billancourt in Paris.
The public park is a large equipped green area of about 7 hectares which receives, especially due to the topographical gradient of the land, the rainwater of the entire neighborhood. The park features a series of elements in which water is the protagonist: wet basins, rustic meadows and flooding noue, wooded areas and large grassy areas.
(Project by Agence Ter with Setec TPI + Biotope, photo Luisa Ravanello)

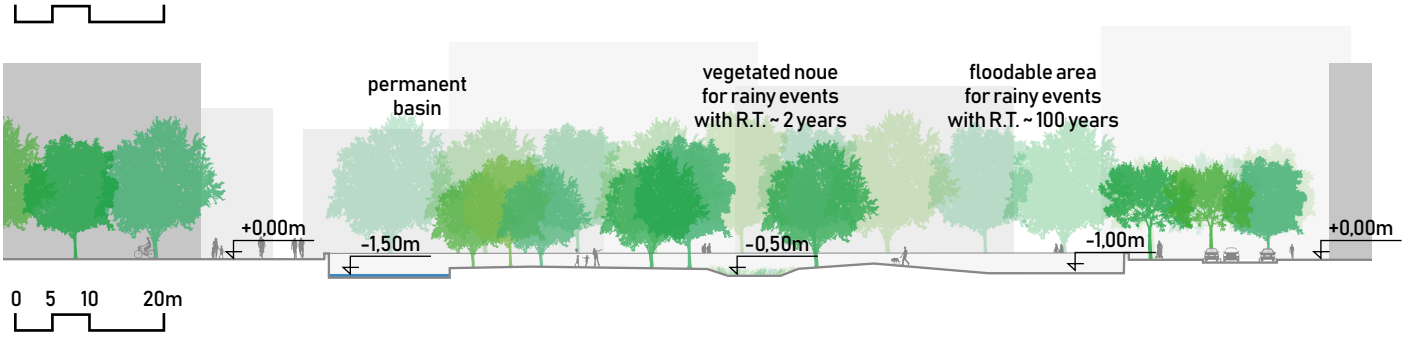
CONSTRUCTION ASPECTS

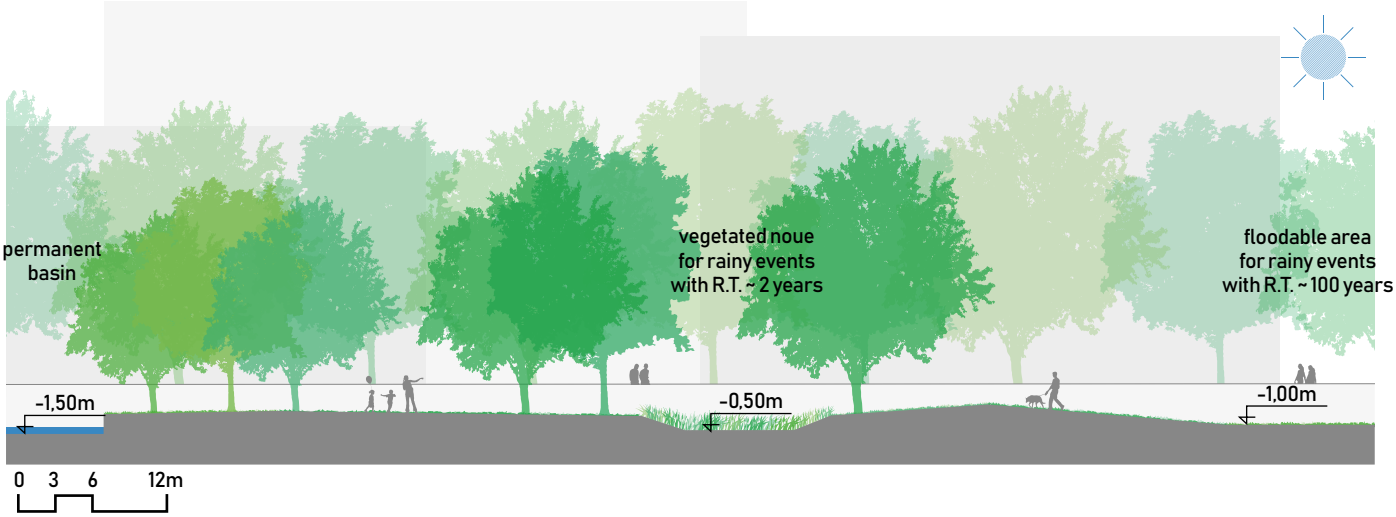
Floodable parks are multifunctional spaces with variable size, up to several hectares, if designed according to the district scale, with permeable surfaces where the green and natural components vastly prevails. They are created with the purpose of draining rainfall in a sustainable manner, through a wide variety of design solutions combining different elements, such as softly-sloping depressions, wet basins, rain gardens, ditches, swales or trench drains, ponds or wet gardens. The height, slopes and surfaces of these green areas are designed to collect and temporarily store rainwater runoffs from impermeable surfaces.
The safety of people must be ensured at all times: this is why they include raised paths along the perimeter and across the park, to ensure access to the same even during the most intense events.

Floodable parks can be divided into:
- URBAN FLOODABLE PARKS to tackle urban drainage issues related to the rainfall of the urban areas near the park (such as Martin Luther King Park in Paris or the Parc du Trapez in Boulogne Billancourt);
- FLOODABLE RIVER PARKS wider spaces with a higher scale influence to solve the issues of the rivers crossing urban areas (such as Luis Buñuel Agua Park in Saragozza, Spain).

In both cases, the park serves a dual purpose: being accessible to citizens and ensure flood safety in the territory.

BOULOGNE BILLANCOURT PARC DU TRAPEZE (PARIS)
The Boulogne Billancourt ecodistrict in Paris, developed in the former Renault industrial facility area, on the banks of the Sein, now houses production and commercial activities, offices, research centres and houses, around Parc du Trapeze, a large public park spreading over approx. 7 ha.
The district was designed to adapt to climate change, and, in particular, to tackle the different rainfall events from a flood standpoint, through strategies and solutions implemented in the projects of various size:
- residential buildings and public squares feature permeable spaces and gardens;
- avenues and pedestrian paths feature rain gardens and swales;
- the public park collects rainwater from the entire district, mainly because of its topographical gradient, and features a series of water-based elements (wet basins, rustic lawns and swales, tree-lined areas and large lawns);
- open floodable areas reduce the importance of the traditional sewage system.
Diversification of public spaces helps enhance the value of the context and urban biodiversity, with multiple benefits for the residents' quality of life.





ECOSYSTEM SERVICES PROVIDED

NUTRITION BIOMASS

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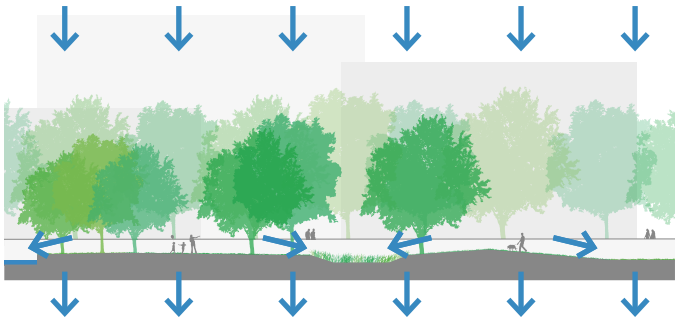
IDENTITY SENSE PLACE HISTORY

BEAUTY OF NATURE

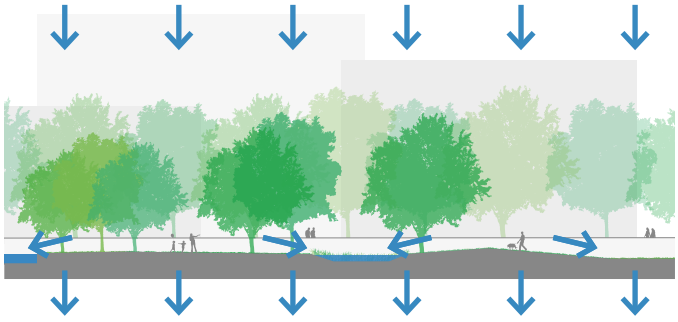
ORDINARY RAINFALL EVENT

The water level of the permanent basin rises, while the rest of the park remains completely accessible.

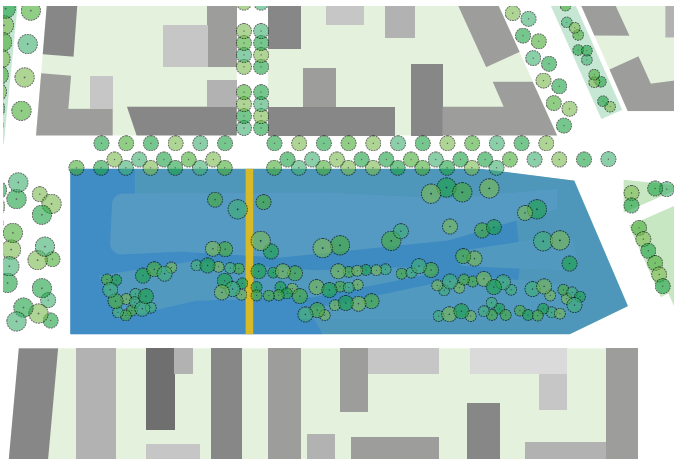


MEDIUM INTENSITY RAINFALL EVENT (R.T. ~ 2 YEARS)

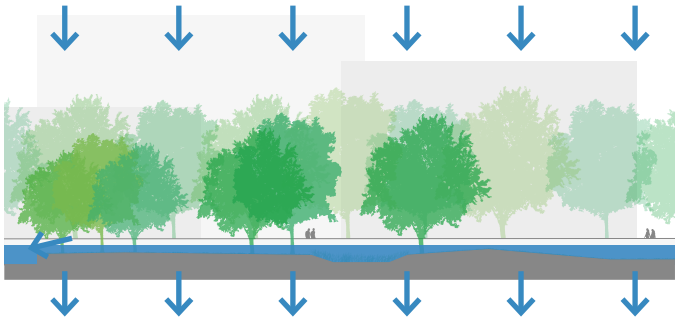
The flooded portion extends to the vegetated ditches, while the lawn areas remain usable, connected by higher walkways.



EXCEPTIONAL/EXTREME RAIN EVENT (R.T. ~ 100 YEARS)



The park is completely flooded with the exception of the higher paths that allow people to cross the site.



Floodable parks are designed according to a multi-disciplinarian approach that must take into account:

- SUSTAINABLE RAINFALL MANAGEMENT, by designing floodable or wet areas to tackle climate change; the sustainability of the measures adopted is based on suitable mitigation of the most intense rainfall events, on reusing rainwater for irrigation or cooling in the hot summer days, and on improving the local microclimate;
- STRENGHTENING BIODIVERSITY AND GREEN COMPONENTS in urban areas, by carefully selecting plants that are attractive and, above all, suited to the intervention site (agronomic, ecological, functional, aesthetic, maintenance requirement), and by correctly choosing the planting methods and subsequent plant care;
- CREATION OF NEW ENJOYABLE AND MULTIFUNCIONAL URBAN SPACES to improve the residents' well-being (with playgrounds and relaxing areas), promote social aggregation (with areas designed for events, public debates, concerts and shows), and recreate natural environment as much as possible, to foster a direct connection between citizens and nature; this is why the residents should be actively involved right from the start of the project.

The choice of the right technical solutions to mitigate the different environmental components - especially to manage rainfall, heat, air pollution and noise - should be based on the site environmental parameters, and on social access and aesthetic enhancement parameters, according to the guidelines set forth in each Nature-based element sheet.

APPLICATION CONTEXTS AND LIMITS

In residential areas, floodable parks can manage the rainfall of urban areas with relatively small (e.g., a small 1 ha residential area) or very large surfaces (districts of several dozen hectares).

A floodable park can be easily implemented in an existing green area, by suitably modelling the terrain and inserting a surface or underground runoff water collection system inside the floodable area.

The water flowing from roads or pedestrian/bicycle paths can be suitably conveyed to the floodable areas of a public park, via nature-based open systems, such as swales and rain gardens, or via the sewage network.

Rainfall flowing from commercial and production areas can be managed inside a floodable park, after assessing that there is no risk of contaminating or polluting the site.

In general, based on the level of pollution and traffic, a first rainfall processing system may be required. This system can be achieved both by nature-based solutions, such as suitably sized phytopurification basins, and in the traditional way, with underground systems for oil sedimentation and separation.

SPACE REQUIRED

Floodable parks have high spatial requirements and a limited water height. They are transitional system that can be designed to gradually flood and remain partially (during rainfall events) or totally accessible (in dry conditions).

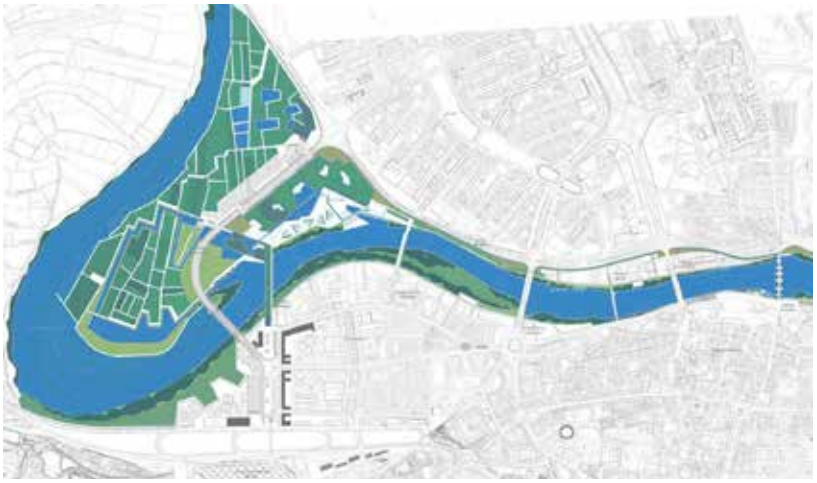
TYPE OF SOIL AND PRESENCE OF GROUND WATER

Floodable parks require permeable soil and ground water located at least 1 meter from the bottom, to promote a good level of pollutant reduction.

The floodable basin bed should be placed higher than the surface groundwater, to ensure its reservoir capacity.

ZARAGOZA WATER PARK
The Zaragoza Water Park occupies an area of 125 hectares and is located in a meandery of the River Ebro, in a suburban urban area upstream of the old town, formerly used mainly for agricultural production.
The project, developed on the occasion of Expo 2008 on the theme of water and sustainable development, has the function both as a park and a major work of hydraulic safety for the city.

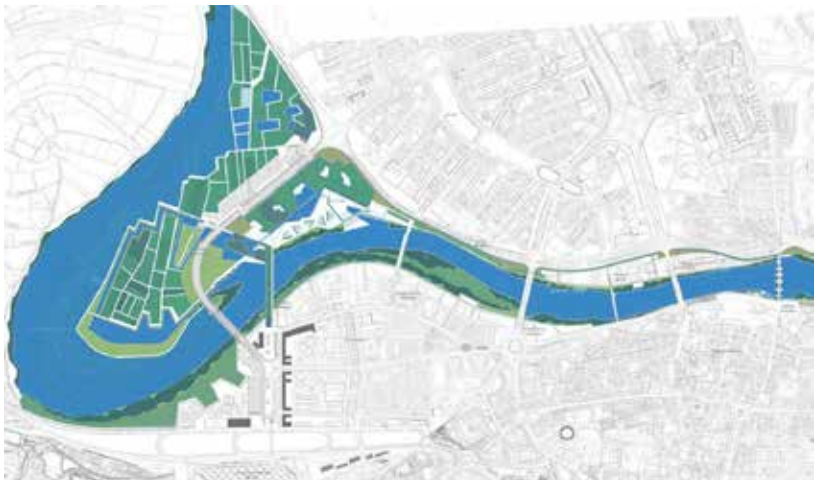
MEDIUM INTENSITY RAINFALL EVENT (R.T.~ 10 YEARS)



Historically this area had a dual function: hydraulic safety, serving the city as an expansion basin for river floods, and agricultural production, with land cultivated thanks to a system of irrigation channels, dams and small locks.
The idea behind the project is to put the water back in place, not forgetting that by nature the waters must be able to wander a little.

With a medium-intensity rainfall event, only a small portion of the park is not accessible and the water level reaches 198.5m.

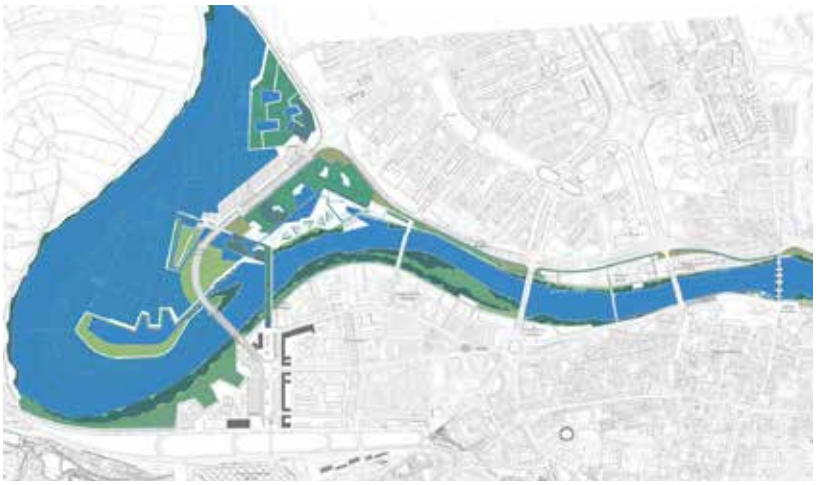
VERY INTENSE RAINFALL EVENT (R.T.~ 25 YEARS)



The strength of the project was to accept the idea of flooding and not to expect the area to remain always dry, clean, perfect.

With a very intense rainfall event, the area of the park is not accessible and the water level reaches 199m.

EXCEPTIONAL/EXTREME RAIN EVENT (R.T.~ 100 YEARS)



The project preserved the function of the place, that is to protect the city from the most violent floods of the river, while creating a park for citizens who have accepted the idea that at times it can be flooded.

In the case of exceptional rainfall events, only built lots are accessible, while public spaces are 'sacrificed' to protect the city from flooding of the Ebro River.

Floodable parks of different urban sizes and overgrown areas.

Permeable, depressed and floodable sports area with lawn finish, in the Godsbanearealet ecodistrict in Aalborg, Denmark.
(Project by Polyform Arkitekter, photo by Wichmann+Bendtsen)

Floodable area of Parc du Trapez in Boulogne-Billancourt, Paris.
The public park is a 7 ha green area with recreational features that collects the rainwater of the entire district, especially due to the terrain's topographical gradient.
The park features a series of water-based elements: wet basins, rustic lawns and swales, tree-lined areas and large lawns.
(Project and photo by Agence Ter with Setec TPI + Biotope)

The Zaragoza Water Park has an extension of 125 hectares and is located in a meander of the Ebro river, in an urban peripheral area upstream of the historic center, previously mainly used for agricultural production.
The park, created for Expo 2008 on the theme of water and sustainable development, also serves as a major hydraulic safety work for the city. Thanks to a series of banks and ditches that can accommodate the waters of the river, the park floods functioning as an expansion tank.
(Project and photo by Atelier Christine Dalnoky)

PLANT SPECIES

Floodable parks are usually mainly covered with grass, while trees are planted in perimeter areas or in central scrubs.

- LAWN robust, such as poa and dichondra
- TREES bald cypress, alder, poplar and willow (classic species that tolerate water-saturated soil for short periods), Liquidambar stryraciflua, Quercus palustris, Sorbus aucuparia; there are more suitable species than for water squares, thanks to the greater quantity of soil available;
- SHRUBS Amelanchier canadensis, Physocarpus, Sambucus nigra.

When the phytopurification function is combined with hydraulic purposes, water and riparian plant species capable of absorbing pollutants should be included, which can survive only in permanent water or wet conditions. Pollutant reduction capacity depends on the filtering layer comprised between the basin bed and the groundwater: it should be at least 1 m thick. Planting different species - apart from promoting the depolluting effect - increases the landscape and biodiversity value.

PUBLIC USAGE

A floodable park can be:

- FULLY ACCESSIBLE over its entire surface, in dry conditions, with playgrounds, cultural activities, leisure and relaxation areas;
- PARTIALLY ACCESSIBLE on part of its surface, in case of moderate events that cause partial flooding of the area (with very low water height), also by creating raised walkways;
- NOT ACCESSIBLE, ONLY CROSSABLE in case of critical events, thanks to the creation of raised walkways to cross the floodable areas.

For safety reasons, the park floodable areas that can be accessed by the public, should be less than one meter deep.

MAINTENANCE

Ensuring easy access to maintenance vehicles and staff is crucial. (Routine and extraordinary) maintenance should be performed both on inflow and outflow hydraulic structures, following intense weather events, and on the plant component. Specifically:
- inspecting and cleaning the structures;
- checking the presence of sediments and removing them;
- mowing and planting;
- replacing any dead plants.

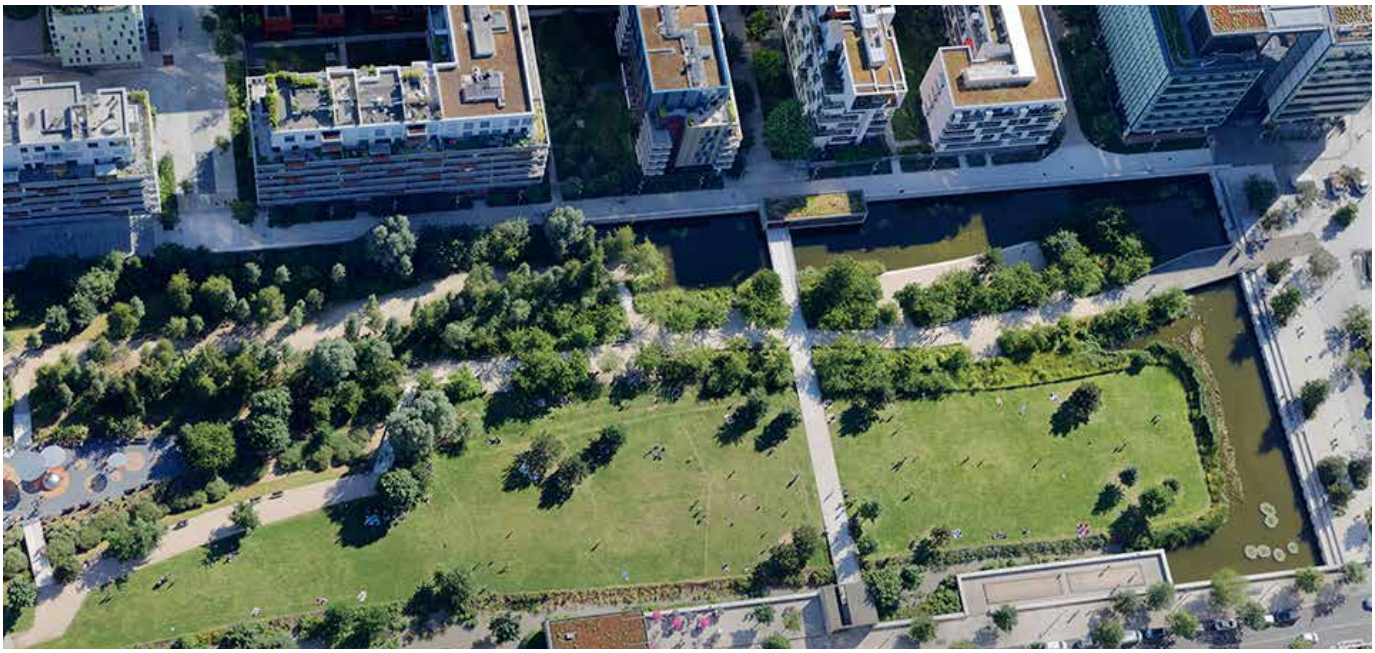
Maintenance costs are medium-range, since the frequency of the interventions is limited, and they can often by carried out while maintaining adjoining public and road spaces, with very little increase in costs. In any case, they are mainly affected by the plant system chosen, and they should include management and maintenance costs over time (choosing plants that can adapt to climate change, that tolerate pathogens, that do not damage any paved areas, non-invasive, etc.).

INDICATIVE COSTS

Indicatively, construction costs are:
- 20-25 euro/sqm to dig a 1 m trench, including disposal and lawn surface finish;
- 10-20 euro/sqm for de-paving the surface (in case of mineral systems);
- 20-25 euro/sqm to plant species that can survive in wet soil;
- 300-600 euro/linear meter for the wooden footbridge.

CASE STUDIES AND BEST PRACTICES

- Eco-district Parc du Trapeze in Boulogne-Billancourt - FR / Case study A6
- Eco-district Gosbenarealet, Aalbrog - DK / Case study A2
- Quartiere di Østerbro, Copenahgen - DK / Case study F 37



8

WATER SQUARES
manage flood risk in dense built-up urban areas

Water squares are accessible urban spaces, designed as playgrounds, relaxation or gathering areas, which, in case of intense rainfall, can be extended, wholly or partially, to help tackle rainwater management. For the majority of the year, they retain their function as public squares and gathering areas, and can be fully accessed by the citizens. In case of an exceptional weather event, they can temporarily store excess water and gradually release it into the sewage system, preventing its overload. Additional systems to reuse temporarily stored water for irrigation or other purposes (water features) may also be introduced.

Water squares are used to:
- reduce flood peaks in receptor bodies *(high effectiveness)*;
- reuse water as a resource *(high effectiveness)*;
- increase biodiversity and reduce the heat island effect, in case of partial de-paving and creation of green flowerbeds *(medium effectiveness)*.

The Benthemplein water square in Rotterdam: it features 3 basins that collect water from the square, the pedestrian paths and the roofs of the surrounding buildings. Each one of the 3 basins is activated based on the rainfall intensity. (Project and photo by De Urbanisten)

The Zollhallen Plaza water square in Freiburg, Germany, alternating permeable paved areas and green elements. (Project by Ramboll Studio Dreiseitl and photo by B.Doherty)

CONSTRUCTION ASPECTS

The water square size is suited to tackle weather events with a return time ⇢= 10 years, and to ensure their complete emptying usually within 24 hours, for sanitary reasons.
In case of ordinary rainfall, rainwater can be collected via surface channels toward permeable areas, such as green flowerbeds, to promote their infiltration into the subsoil. In case of events of greater intensity, the excess flow can be collected by surface channels, grids or drain and pipe systems that can direct the water toward the water square or flood the square surface directly, wholly or partially. They can also feature additional underground storage units, such as prefab tanks or boxes.
In case of significant sediment build-up, before directing the water to the water square, a sedimentation and pre-treatment system should be implemented.
Construction systems may include:
- MINERAL PAVING with laying methods that ensure partial permeability (e.g. draining joints or porous materials);
- SEMI-PERMEABLE MATERIALS;
- GREEN AREAS such as flowerbeds or lawns.

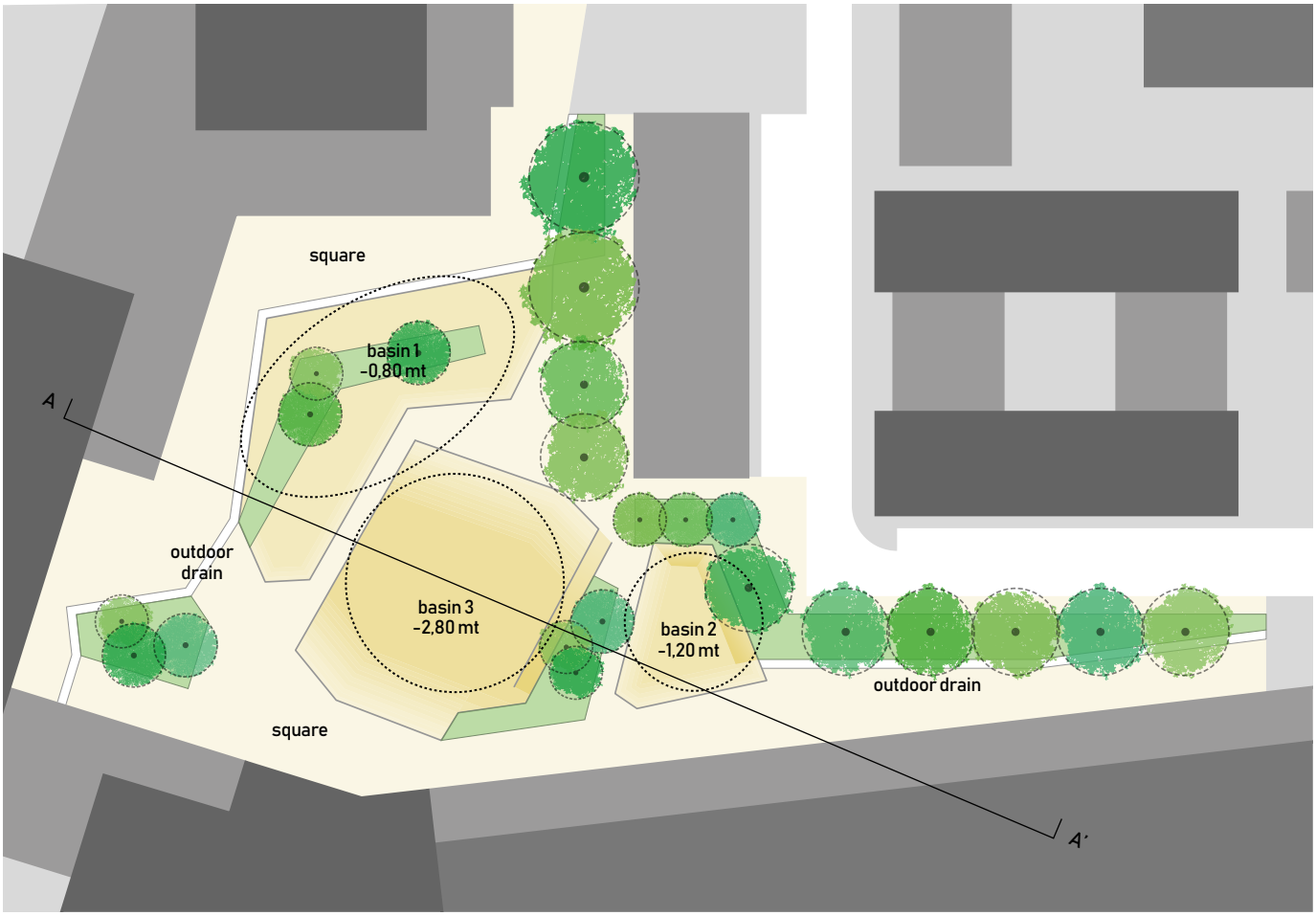
The system's hydraulic operation can be more or less complicated, depending on the project layout, which can include "progressive extension" sectors (areas that can be flooded depending on the rainfall intensity). Water squares can be designed with variable sections and depths, for progressively floodable areas or compartments, depending on the event intensity, to maximize access and modulate its flood potential. Even when extended to its fullest, perimeter and crossing paths are ensured, so that the surrounding space can always be accessed.

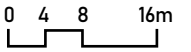
Generally, one or more overflow connections to the sewage system should be included, to tackle extreme rainfall events.

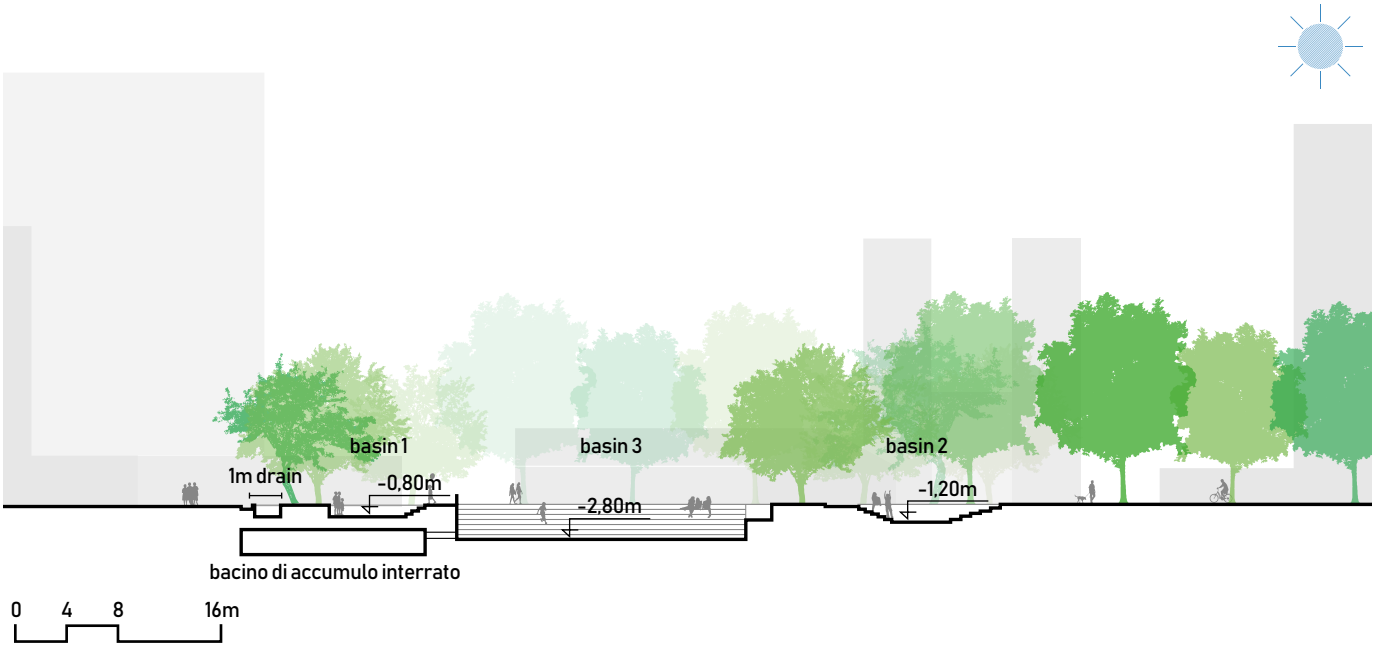
APPLICATION CONTEXTS AND LIMITS

These spaces can be implemented on a small (district squares) or large scale (approx. 1 ha surfaces), both in newly-developed contexts and in redeveloped public spaces. They are mainly used in highly built-up urban contexts.
In general, these interventions can replace former mining lots, squares and other urban spaces, revitalizing them and improving their flood resilience and attractiveness.

Water square layout with three floodable areas for events of varying size.



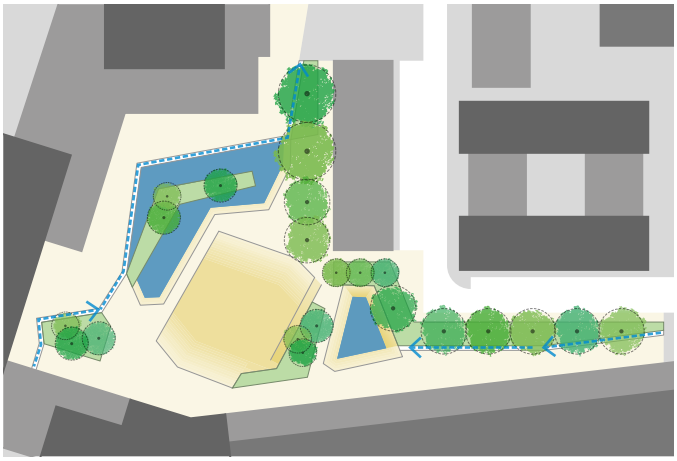




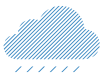
ECOSYSTEM SERVICES PROVIDED

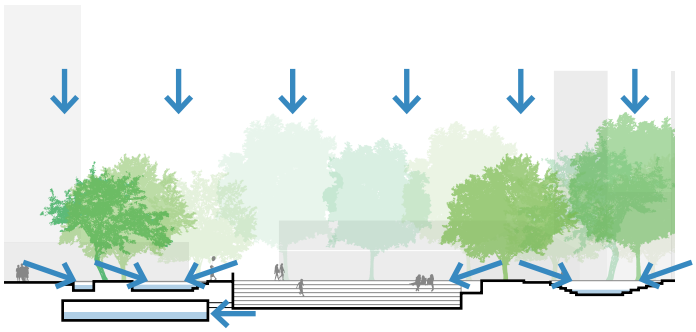
NUTRITION BIOMASS
AIR QUALITY AND POLLUTANS REGULATION
NOISE REDUCTION
RUNOFF REDUCTION AND FLOOD
POLLINATION AND BIODIVERSITY
URBAN COMFORT AND MICROCLIMATE
PUBLIC SPACE ACCESSIBILITY AND RECREATION
IDENTITY SENSE PLACE HISTORY
BEAUTY OF NATURE

ORDINARY RAINFALL EVENT

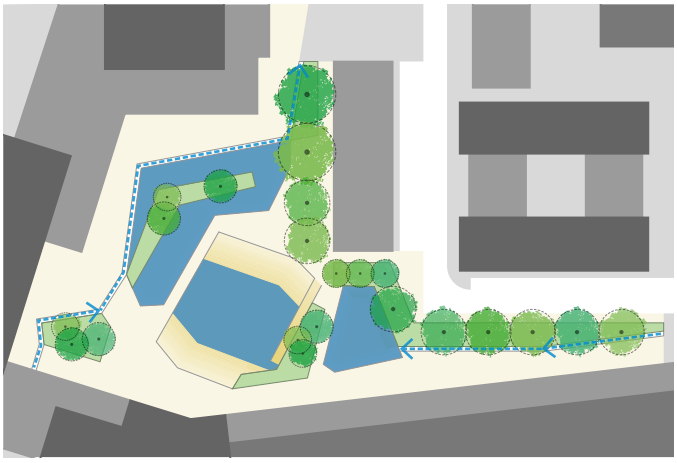


The main square space remains accessible, and the rainfall flows only into surface basins 1 and 2.

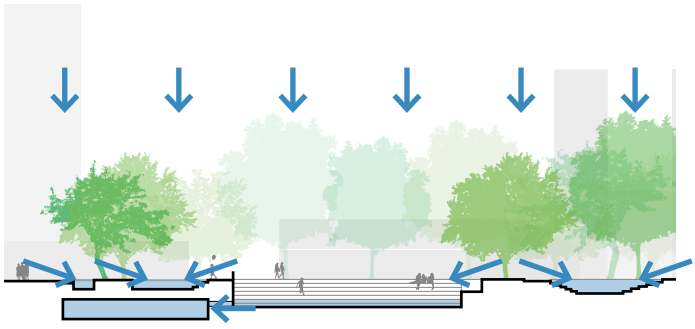




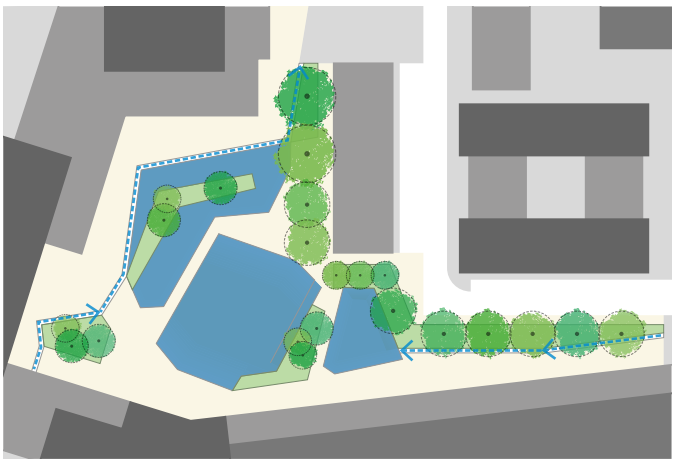
MEDIUM INTENSITY RAINFALL EVENT (R.T. ~ 2 YEARS)



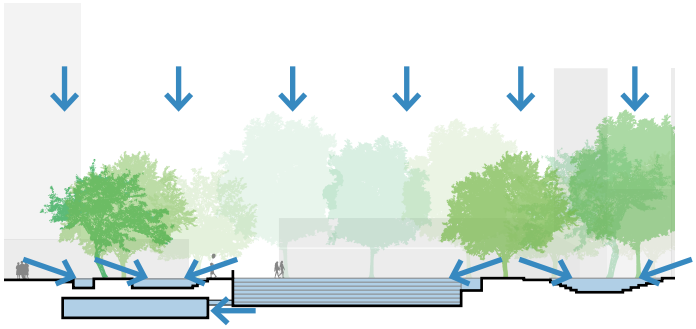
Apart from surface basins 1 and 2, also the central portion of main square 3 is partially flooded.



EXCEPTIONAL/EXTREME RAIN EVENT (R.T. ~ 100 YEARS)



All 3 basins are completely flooded, and only the raised perimeter walkways are accessible.



Top right. The Benthemplein square in Rotterdam in a wet version, following a rain event. Thanks to a series of long open-air channels, made with weak slopes, the water is collected in the basins of the lowered square.
(Project and photo by De Urbanisten)

Right, bottom. Zollhallen platz in Freiburg is a mineral square that stores rainwater underground thanks to two large vegetated spaces at the edges of the urban space: a garden with a grassy lawn on one side, a draining pavement with small flowering trees on the other. From the center of the square, rainwater flows at the edges towards the infiltration areas thanks to weak slopes (2%). The large portions of lawn and draining floors allow the water to infiltrate and then be stored in the accumulation basins built under the square. The storage basins allow a slow release towards the aquifer thanks to the disposable containers.
The square is thus able to manage weak and intense rain events, ensuring the urban fabric and commercial activities on its margins to remain dry.
(Project Rambool Studio + Herbert Dreistl, photo Luisa Ravanello)

Mineral and green water squares.

SPACE REQUIRED

They have significant spatial requirements, but they can be used most of the year.

TYPE OF SOIL AND PRESENCE OF GROUND WATER

In case of infiltration area, the groundwater vulnerability and the existing soil infiltration capacity should be assessed.

PLANT SPECIES

Although water squares are made with mineral materials, the project can be integrated with green surfaces, such as perimeter/edge flowerbeds, that can promote partial infiltration, act as urban decoration elements and improve microclimate (by reducing the heat island effect).

TREES

This is a rather complex situation for tree survival; suitable choices include those species that live near river beds and tolerate water-saturated soil for short periods, such as bald cypress, alder, poplar and willow, although the alternation between prolonged summer droughts and sporadic flooding - as is the case in many continental regions - does not allow the plants to adapt to a constant water regime with abundant or scarce water. Today, the projects completed are too few and too recent to draw up a comprehensive case study in order to ensure that long-lasting trees can be planted. It is only a matter of trying to plant species that will probably survive longer and check that their development is well-balanced.

SHRUBS AND HERBACEOUS PLANTS

Species that can adapt to changing environments and that are easy to replace are recommended.

PUBLIC USAGE

The area can be:

- FULLY ACCESSIBLE over its entire surface, in dry conditions, with playgrounds, cultural activities, and relaxing areas;
- PARTIALLY ACCESSIBLE in case of moderate events that determine partial flooding of the square, by creating sections at different heights;
- INDIRECTLY ACCESSIBLE, by ensuring perimeter paths, in case of significant weather events, to grant access to edge walkways or to the areas surrounding the square.

MAINTENANCE

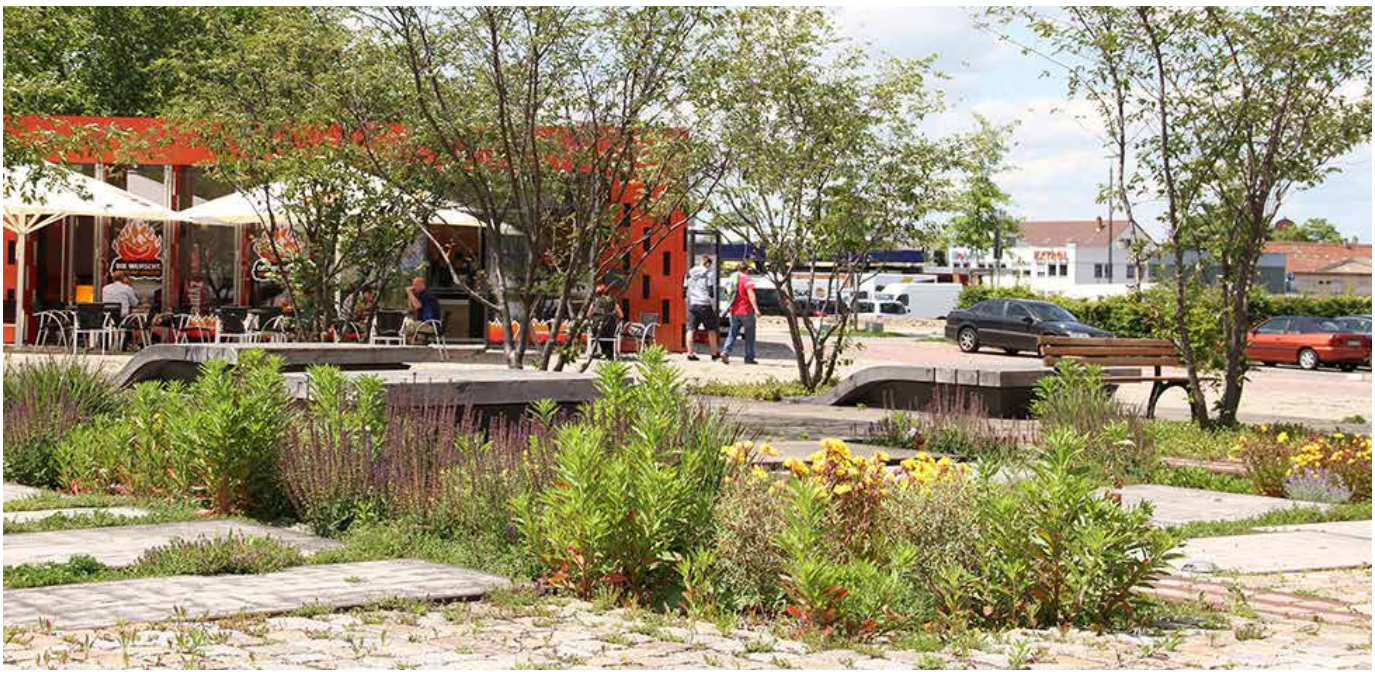
Periodical maintenance concerns both hydraulic/system and agronomic aspects:
- periodical inspection of the inflow/outflow hydraulic system, and inspection and cleaning of the collection network;
- checking for sediments and their removal, especially after intense weather events.

Ensuring easy access to maintenance vehicles and staff in the planning stage is crucial.
Maintenance costs depend on the project's complexity level.

INDICATIVE COSTS

Construction costs depend on the urban context, on the need to carry out preventive de-paving works, and on the square's architectural and landscaping project.
Indicatively:
- 400-500 €/sqm.


ZADKINE



9

POCKET PARKS
create permeable gardens and shade oases in dense built-up areas

Tiny or pocket gardens are urban green capillary point interventions developed in small spaces, with a high level of attractiveness and significant microclimatic benefits.
Indeed, pocket gardens can revitalize urban areas, city corners or small private spaces, thanks to accurate landscaping projects that perfectly blend in the context, where finishes, construction details, decorations and plant species create attractive and quality areas that combine function and aesthetics.
These gardens can help tackle climate change, especially in urban contexts, by improving air and water quality, promoting biodiversity, and offering a shelter to local fauna.

The purpose of pocket gardens is to:
- revitalize small and unattractive, unbuilt or abandoned urban areas;
- promote the reduction of the heat island effect and improve microclimate;
- increase biodiversity in highly populated and impermeable urban spaces.

Paley Park in New York, between Madison and 5th Avenue, on 53th Street, is a small garden, an oasis of tranquility from Manhattan's frenzy and traffic.
The space features ivy covered walls and a suggestive waterfall, with a capacity of 7 thousand litres of water/minute, which, with its thundering sound, helps drown traffic noise. It also houses some original fragments of the Berlin Wall.
(Project by Zion & Breene Associate)

Balsley Park is a small garden located on the West Side of Manhattan, created following the conversion of Sheffield Plaza, a sparsely frequented mineral square. Following protests and failed attempts to redesign the square, the city council supported the decision to create a small garden, depaving part of the soil and creating a kiosk, a cafeteria, a playground and a local market. For safety, the garden is crossed by a transversal path open on the sidewalk of the neighborhood.
(Project and photo by Thomas Balsley Associates)

CONSTRUCTION ASPECTS

Pocket gardens can be developed also in very small areas, by taking advantage of altitude gains, planting species of different heights, or adding structures such as pergolas or covers, to maximize the available space and expand vertically.
There are multiple depth, perspective and light effects, and contrasting colours and patterns to embellish the spaces.
The plant component is the main element in pocket gardens: species can be selected afrom mong a great variety, depending on the desired aesthetic effect and, above all, on the site environmental parameters. This is combined with the use of structures that promote plant growth (pergolas, vertical wooden boxes, etc.), and the use of pavements - including impermeable ones - as transitioning elements between the different green areas.
A wide variety of containing elements can be employed, provided that they are waterproof, to promote water absorption by the plants. Succulents can also be a valid alternative, thanks to their minimal water demand.
Urban furniture, such as primary or secondary seating elements, helps improve garden accessibility and increase its social value.

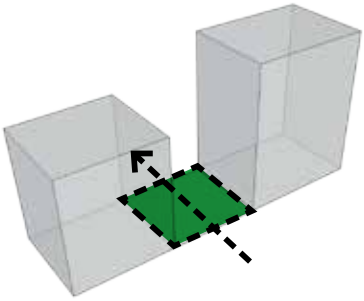
APPLICATION CONTEXTS AND LIMITS

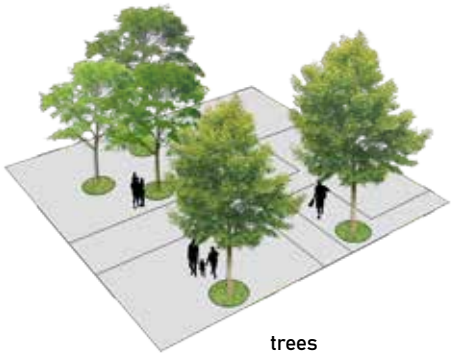
Pocket gardens can be implemented anywhere, since, as the name implies, they are "tiny" and can be adapted to any space available.
With very limited work, an unused space - that could generate antisocial behaviour - can be transformed in an accessible and controlled space, to organize events, and promote socialization, cultural exchange and a sense of community.

PLANT SPECIES

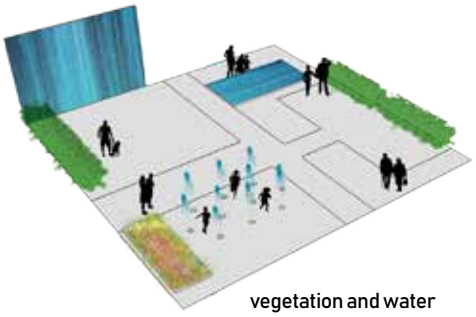
There is a wide variety of plants to choose from: the choice mainly depends on the space available, the level of direct sunshine, the irrigation options, and the climate.
Given their tiny size, no planning mistake can be made in these gardens, albeit they can give great satisfaction to anyone capable of combining layout and botanical knowledge, to create false perspective and illusions with vertical green systems and suitable supports. They are often entirely visible, this is why choosing night-time foliage transparency - and day-time invisible patterns (like all large-leaved begonias) is very important from an aesthetic standpoint.

Abacus of the elements that characterize pocket gardens:
⇢ LOCATION the area is usually surrounded by buildings but can be crossed;
⇢ GREEN ELEMENTS such as trees or vines to create shade, small shrubs and flower beds to increase comfort;
⇢ presence of WATER such as waterfalls, water blades, fountains, bodies of water or misting systems to improve comfort;
⇢ use of different MATERIALS, permeable or semi-permeable, to differentiate main and secondary routes;
⇢ presence of primary and secondary SEATS to encourage parking and socialization;
⇢ LIGHTING to allow usability even in the evening with lights on the ground to indicate the main routes, perimeter lighting to identify the driveways and / or detailed light sources to identify the accesses;
⇢ presence of SHADING systems such as pergolas, canopies or roofs to protect against atmospheric events.

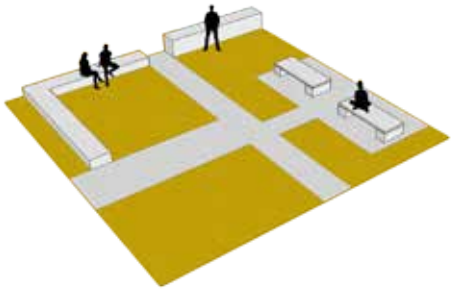




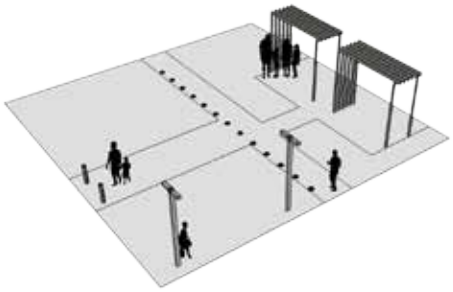
trees



vegetation and water

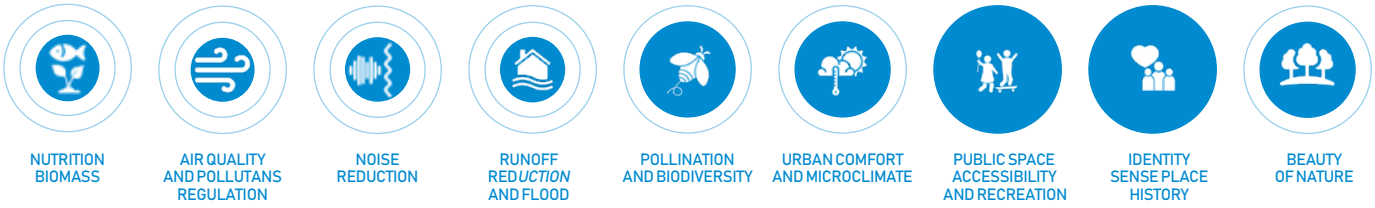


pathways and sittings



lighting and shading systems

ECOSYSTEM SERVICES PROVIDED



Pocket gardens can house:

- SIZE THREE CLASS TREES
- SHRUBS clerodendrum, hawthorn, Boemia olive tree, phillyrea, European plum, tamarix, oleander, pomegranate tree, Judas tree, manna ash, rowan, laurel, lagerstroemia, albizia, loquat and other fruit shrubs.

PUBLIC USAGE

Pocket gardens can revitalize urban areas, city corners, and small private spaces, thanks to the attractiveness of the green elements and light/water features, etc. and the inclusion of seating elements (edge walls, benches, etc.).

MAINTENANCE

Maintenance costs can be low, provided that the plants chosen require little care and are not invasive.
Generally, the substrate is limited, so it should be carefully irrigated to avoid soaking a non-drained soil that dries rapidly. An automated irrigation system should therefore be installed, unless extensive green roof construction techniques are implemented, albeit with poorer aesthetic results.

INDICATIVE COSTS

Average construction costs.

- 120-150 euro/sqm for works ranging from a simple lawn to more articulated green spaces.

Left, clockwise, top to bottom.
Paley Park in New York, between Madison and 5th Avenue, on 53th Street, is a small garden, an oasis of tranquility from Manhattan's frenzy and traffic.
The space features ivy covered walls and a suggestive waterfall, with a capacity of 7 thousand litres of water/minute, which, with its thundering sound, helps drown traffic noise. It also houses some original fragments of the Berlin Wall.
(Project by Zion & Breene Associate)

Iron Street Park in Boston was designed as an "Urban Living Room", as a small green area for the neighbourhood. The central area, featuring formal and informal seating elements, is protected against traffic by perimeter flowerbeds with permanent and seasonal plants, and by slow-growth ginkgo rows.
(Landscaping project by Halvorson Design and photo by Ed Wonsek)

The Jardin Deca, a small 1,000 sqm garden created for the Casacor, in São Paolo. The project sees permeable floors, furnishing elements and wooden seats and a widespread system of trees that can shade the space.
(Project and photo by Alex Hanazaki)

The Ashton Morph Sukhumvit 38 residential complex garden, in Bangkok. On the ground floor, public and private spaces are divided by a small linear hybrid garden, crossed by a pedestrian walkway and shaded by a row of pine trees planted in grass and pioneer species flowerbeds.
(Project and photo by Shma Landscape Architecture)

10

COMMUNITY GARDENS
cultivate green areas and permeable gardens for sociality

Urban vegetable patches and gardens are community green spaces for cultivating vegetables, fruit, herbs and flowers.
They are often developed in degraded or disused areas, to revitalize unused spaces, promote sharing/socialization, and generate a sense of belonging in the community.
The social component is essential for shared vegetable patches and gardens to work: they are generally managed by the community, by establishing common rules and a manager.
From an environmental standpoint, they are permeable spaces that reduce rainwater runoff and the heat island effect, help improve air quality and biodiversity, and tackle climate change, especially in urban contexts.

The purpose of community vegetable patches and gardens is to:
- revitalize small and unattractive, unbuilt or abandoned urban areas;
- promote the reduction of the heat island effect and improve microclimate;
- increase biodiversity in built-up and impermeable urban spaces;
- enhance the urban green infrastructure.

The Jardin d'Amaranthes in the Mazagran district, Lyon, which has been populated by blue collar workers and immigrants since the 19th Century.
The community garden has been created by the residents, under the guidance of artist Emmanuel Louisgrand, on an area that formerly housed a parking lot and a series of run-down buildings that had to be demolished.
(Photo by Elena Farnè)

CONSTRUCTION ASPECTS

A community vegetable patch/garden should include:
- DIFFERENT TYPES OF SPACES, such as cultivable land, paths and common areas;
- MANAGEMENT METHODS, with the creation of a regulation to manage spaces and activities, and define a manager and a set of rules of conduct, etc;
- FUNCTIONAL FURNISHING ELEMENTS, such as tables, seats, small structures to store equipment or lighting systems that allow using the spaces and increase their social value.

Sustainable space management criteria should be observed as much as possible:
- USE OF COMPOSTING CONTAINERS for green waste;
- CREATION OF SMALL RESERVOIRS for rainwater to reuse for irrigation purposes;
- AVOIDING CHEMICAL PESTICIDES.

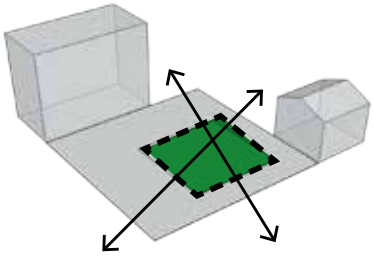
Small sheds - generally temporary - can be installed to store equipment and machinery.
Cultivation and/or planting soil can be obtained directly on the ground or in tanks with backfill.
Plant species may range from perennial herbaceous plants, herbs, flowers, vegetables, trees and fruit trees.
Due to their multiple social and environmental value, several local administrations are implementing processes to involve the citizens in the creation of small public green areas, by encouraging them to create and manage urban community vegetable patches and gardens, with the purpose of promoting urban agriculture as a way to improve social relationships and promote a healthy diet and a more sustainable lifestyle.

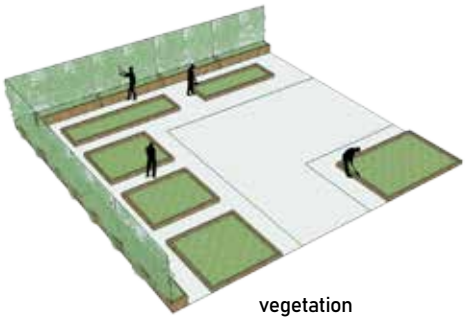
APPLICATION CONTEXTS AND LIMITS

Community vegetable patches and gardens can be created even in small public spaces of abandoned, unbuilt or degraded areas.
With budget micro-interventions, an unused space - that could generate antisocial behaviour - can be transformed in an accessible and controlled space, to organize events, and promote socialization, cultural exchange and a sense of community.

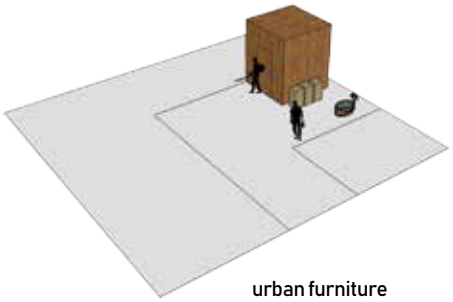

AMARANTH

Abacus of the elements that characterize shared gardens ancommunity green areas:
⇢ isolated POSITION near buildings, the area can be completely crossed and is often located in empty spaces awaiting transformation;
⇢ GREEN ELEMENTS with creepers to create shade and delimit the area, flower beds or boxes where to grow vegetables and aromatic herbs;
⇢ use of different MATERIALS, permeable or semi-permeable, to differentiate main and secondary routes;
⇢ presence of primary and secondary SITTINGS to encourage parking and socialization, especially where common services are concentrated;
⇢ URBAN FURNITURE such as storage areas for tools, waste containers and fountains to encourage the use and care of space;
⇢ LIGHTING to allow the space to be used even in the evening, with lights on the ground to indicate the main routes and overall perimeter lighting;
⇢ presence of SHADING systems such as pergolas, canopies or roofs to protect against atmospheric events.

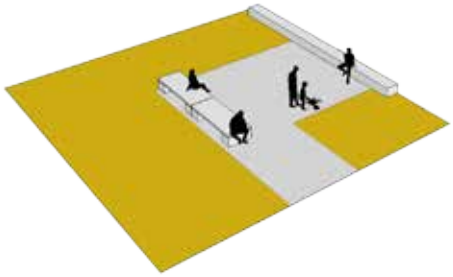




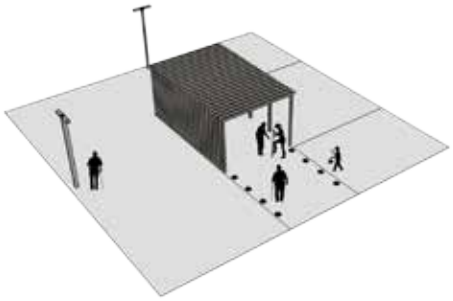
vegetation



urban furniture

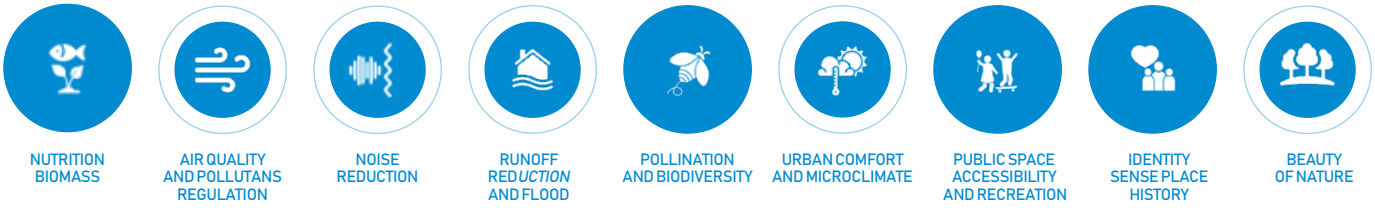


pathways and sittings



lighting and shading systems

ECOSYSTEM SERVICES PROVIDED



PLANT SPECIES

There are no limits to the species that can be planted, as long as their needs are suitable for the available workmanship, In these areas, it is not unusual to see edible species originating from the Countries of origin of those who undertake to care for them. Small vegetables and fruit and many herbs are very frequent.

PUBLIC USAGE

Community vegetable patches and gardens are designed for frequent and diversified use, and, in view of their intrinsic function of revitalizing degraded and/or abandoned urban areas, they are versatile spaces, where different kinds of activities can be organized. They often host educational workshops, meetings with schools or training courses on farming practices, and also outdoor readings, shows, artistic performances and concerts.

MAINTENANCE

Maintenance costs are low, and usually borne by the associations that manage the spaces, following an agreement with the owners of the area.
Sustainable criteria should be observed, when designing and managing the spaces, to reduce construction and maintenance costs.

INDICATIVE COSTS

Average construction costs.
⇢ 120-150 euro/sqm for works ranging from a simple lawn to more articulated green spaces.

Nature-theatre in the 'Orteo' courtyard in Bologna, with the 'Semi di Futuro' theatre performance by Lorenza Zambon. 'Orteo' is a horticultural space created in 2013 by Colletivo Làbas in the squatted courtyard of a former military barracks. (Photo by Federico Spaggiari)

The 'Ortelli', in Giardino Orselli of Forli: a vegetable patch-garden designed and created by the residents, with the students of the Maroncelli school, as a place to experiment with synergic, organic and biodynamic farming. (Project and photo by Associazione Gaia)

The 'Giardino di Gabrina' in Parco delle Acque Chiare of Reggio Emilia, was born as a demonstration garden for medicinal plants and herbs, to create an educational and informational space for the community. (Project and photo by Associazione Gramigna)

Children's shows and readings at 'Mondorto', the vegetable garden of the Mediteca of San Lazzaro, Bologna. (Photo by Mediateca)

The residents clean up an overgrown space to transform it into a small community garden in Via Monte Cisa, Reggio Emilia. (Photo by Federico Spaggiari)

The social vegetable garden by the Greenhouses in the Giardini Margherita park in Bologna, public greenhouses abandoned for years, that have been redeveloped as cultural confrontation and contamination spaces for social innovators, citizens, companies, non-profit organizations and public administration. Serre/Greenhouses is a metropolitan hub that promotes innovation and entrepreneurial culture, an entrepreneurial model with a strong social connotation, a hybrid between public and private, profit and no-profit. (Project by Kilowatt in partnership with the Municipality of Bologna, Emilia Romagna Region, Fondazione Golinelli and Aster, photo by Fruitbook Magazine)

11

COURTYARDS
create public-private permeable green spaces for comfort and sociality

Inn er courtyards are open semi-public spaces near residential, commercial or tertiary buildings, created to ensure suitable illumination and ventilation to the rooms overlooking them.
If they are well planned and equipped with urban furniture, green structures, and suitable ventilation and lighting features, they can become a gathering point for the community, shared, accessible, controlled and co-managed spaces to organize events, promote socialization, cultural exchange and the sense of community.
Differently from pocket gardens or shared public spaces, courtyards are more snug, cosy and protected by the facades of the surrounding buildings at least on two sides, giving them a greater sense of privacy, protection and belonging.

Shared courtyards help to:
- promote socialization and establish good neighbourly relations;
- promote the reduction of the "heat island" effect and improve microclimate.

Inner court of the Square des Bouleaux in Paris. The internal walls of the building - developed on a modest size lot - were very close and did not allow adequate privacy for the residents. Considering the proximity of the building to parks and public gardens, it was decided to recreate a 'grove' of birches inside the courtyard capable of promoting introspection and micro-climatic comfort and reducing the building's energy consumption. On the ground, a dense low-maintenance ground cover lawn intersperses the sidewalks. (project and photo Atelier Christine Dalnoky)

Courtyard 5-6 at Industry City in Brooklyn, New York. The space is designed to manage up to 2 mm/h rain, thus reducing the pressure on the sewage system. It is built with sustainable and green materials: the internal paths and the resting areas have been created with local EPP-certified wood, and the secondary paths with stabilizer obtained from 100% recycled materials, just like the turf. There are many plants - mainly native - that treat the subsoil. (Project and photo by Terrain-NYC)

CONSTRUCTION ASPECTS

The design of a courtyard must take the intended use (frequency of crossing and passing, possibility of staying for short or long periods of time, need to organize events, level of introspection, level of privacy/exposure) and the spatial effect desired (depth, perspective and light features, scarce/absent/massive/predominant vegetation, presence of large paved areas, etc.) into account.
The elements that characterize internal courtyards are:

- URBAN FURNITURE such as primary and/or secondary seating, to promote resting and socialization; pergolas, removable covers or canopies to shade and protect from weather events; playground; bike or equipment sheds;
- GREEN STRUCTURES tall trees, shrubs or groundcover plants that can characterize and differentiate the spaces and promote participation;
- VENTILATION, by studying the currents and wind distribution inside the space, to ensure suitable airing (summer) and prevent turbulence (winter);
- LIGHTING, both natural, during the day, and artificial, at night, to promote permanency throughout the day.

Their size, shape and development vary, depending on the available space (square, rectangular or circular, extended or compact) and they are generally closed on at least two sides by surrounding buildings.
The plant component is the main element in internal courtyards: species can be selected from a great variety, depending on the desired aesthetic effect and, above all, on the site environmental parameters.

APPLICATION CONTEXTS AND LIMITS

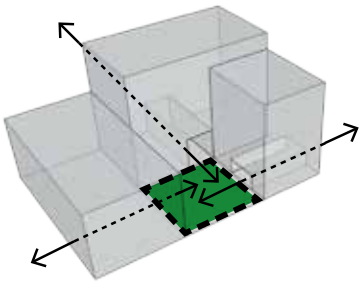
Semi-public internal courtyards are spaces pertinent to residential, office or tertiary (schools, universities or hospitals) buildings, that can be accessed from outside for most of the day, and act as a gathering place or crossing point to promote socialization.
The landscaping project for a semi-public internal courtyard can be adapted both in case of newly-built works, and in case of trasformation/redevelopment of existing open spaces, also in the city centre.

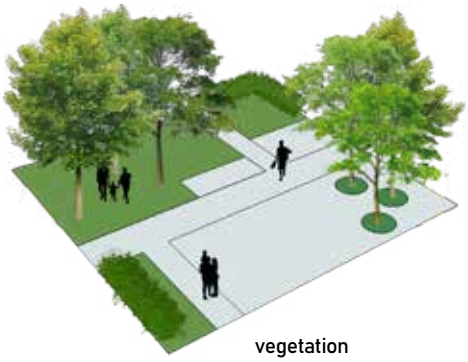
Abacus of the elements that characterize the courts:
⇢ LOCATION limited and enclosed by buildings with few semi-private entrances;
⇢ GREEN AREAS with trees of different sizes, planted in groups or in rows, shrubs and meadows;

⇢ use of different MATERIALS, permeable or semi-permeable, to differentiate main, secondary and rest areas;
⇢ presence of primary and secondary SEATS to encourage parking and socialization;

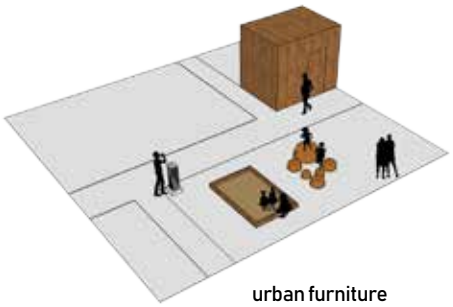
⇢ URBAN FURNITURE such as play areas, fountains or bicycle storage areas;
⇢ LIGHTING to allow the space to be used even in the evening, with lights on the ground or on time to indicate the routes and overall perimeter lighting;

⇢ presence of SHADING systems such as pergolas, canopies or roofs to protect against atmospheric events.

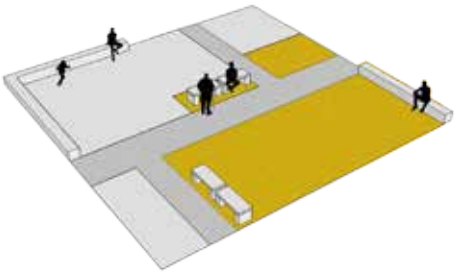




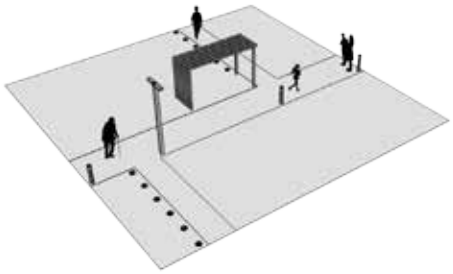
vegetation



urban furniture

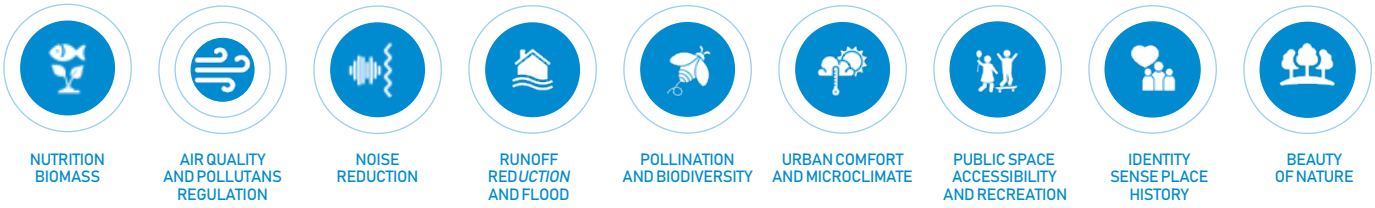


pathways and sittings



lighting and shading systems

ECOSYSTEM SERVICES PROVIDED



Courtyards can be created at ground level, on the existing bare soil for natural components, or in semi-basement or underground parking lots. In this case, particular attention should be paid when planning the green areas, analysing the thickness and technological suites more suited to ensure the plant species survival.

PLANT SPECIES

There is a wide variety of plants to choose from: the choice mainly depends on the space available, the level of direct sunshine, the irrigation options, and the climate.
Since they can't be seen from outside, leaf transparency and its capacity of promoting access and permanency is very important from an aesthetic standpoint.
Ideal plants for semi-public internal courtyards are:

- SIZE TWO OR THREE CLASS TREES
- SHRUBS clerodendrum, hawthorn, Boemia olive tree, phillyrea, European plum, tamarix, oleander, pomegranate tree, Judas tree, manna ash, rowan, laurel, lagerstroemia, albizia, loquat and other fruit shrubs.

PUBLIC USAGE

Semi-public courtyards are accessible during most of the day, and their function is to create attractive places for the people that regularly spend time in the buildings surrounding them. They are pleasant places to cross, equipped to rest during free time or work breaks.

Semi-private courtyards in the Østerbro district of Copenhagen. The courts have undergone processes of involvement of the residents for the implementation of the climate adaptation plan promoted by the Administration.
This process has triggered numerous private interventions: desealing actions for the permeability of the soils, forestry interventions, the reshaping of the soil to favor the absorption of rainwater, the insertion of plants for the recycling of water for the maintenance of the green .
The accessibility of the courtyards has also been rethought: during the day many gardens are open, allowing residents to stroll among the private courtyards, along shaded and protected paths. The spaces have also been redesigned to encourage socializing, defining shared management regulations: from the construction of flexible furnishings for condominiums to picnic areas, games and convivial lunches, from the shelter of tools and bikes, to the creation of small vegetable gardens or mobile chicken coops with poultry. (Photo Farnè, Lombardi, Ravanello)

MAINTENANCE

Maintenance costs can be low, provided that the plants chosen require little care and are not invasive.
In addition, the costs to manage the green areas can be shared with the citizens/ residents that undertake to take care of the semi-private spaces.
Sustainable criteria should be observed, when designing and managing the spaces, to reduce construction and maintenance costs.

INDICATIVE COSTS

Average construction costs.
150-200 euro/sqm for several interventions, ranging from creating semi-structured paths and green spaces with plants.

12

ROCK GARDENS
depave and reuse on site soil and excavation rocks

Rock gardens obtained from desealing are spaces created in former impermeable and mineral spaces that, after a desealing process - by 'breaking' asphalt or concrete paving - are made partially permeable and can house plant species.
They often feature seating elements and play-sports grounds, surrounded by a pioneer biodiversity context. They are implemented in disused paving redevelopment contexts (or at the initial stages of the same), and they are the first step towards a redevelopment project to improve the site resilience (permeability, soil improvement, green planting or preventive afforestation) at a lower cost.
They can be created in disused medium or large squares or parking lots (1,000 sqm - 1 ha), on the entire surface or parts of it.

The purpose of rocky gardens is to:
- reduce surface runoff and promote infiltration;
- reduce flood peaks in receiving bodies;
- prepare the soil for processes that improve its characteristics;
- plant pioneer species;
- implement preventive afforestation interventions;
- help reduce the heat effect and noise, and increase biodiversity.

Urban park at Flugplatz, Frankfurt am Main.
The park is located in the perfieria, in a peri-urban area of the city, on the site of a former abandoned heliport. The area has been the object of an imposing desealing action aimed at a process of spontaneous renaturalization and reuse of aggregates on site.
Most of the heliport runways - made of concrete blocks and slabs - have been crushed following different types of splitting, obtaining both fine aggregates - 1-2 cm in diameter - and blocks of 1 m per side - relocated in a way staggered or stacked together.
The equipped park today has a constantly evolving nature, ideal for the leisure time of families, who spend many weekends here with their children, to observe the evolution of habitats and plants.
The choice to reuse the inert suitable results on site, has made it possible to reduce disposal costs.
(GTL Landshaftarchitekten project, photo Luisa Ravanello)

CONSTRUCTION ASPECTS

Rocky gardens are obtained by "breaking" asphalt or concrete pavements by cutting the surface and digging it with suitable means, deep enough to unearth the drainage substrate, or even the top soil.
Desealing can be carried out even by keeping the resulting material and partially reusing it on the site, after a suitable analysis and permit acquisition.
The creation of a "rocky" garden requires a preliminary analysis of the quantity of excavated rock and land that will be generated, so as to identify the right methods and checks that need to be implemented. The regulatory and authorization aspects must be thoroughly considered, especially with reference to Italian Legislative Decree no. 152/06 and DPR no. 120/07: based on the scope of intervention and on the use plan or declaration, the earth and land (analytical or bibliographic) characteristics should guide the technicians in choosing the best reuse method - possibly on site - to pursue the principles of soil valorization, with consequent sharing, reuse and circular economy.

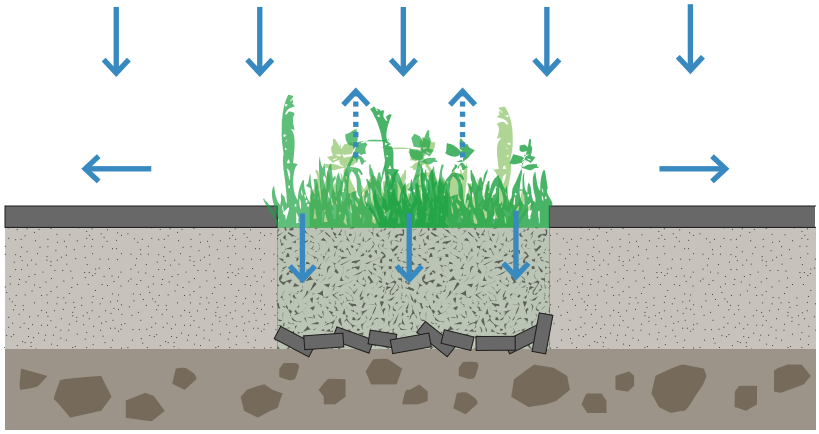
The mineral paving thickness to be removed depends on the context, although it is generally between 30 cm and 70 cm. If the soil underneath requires it, the drainage properties could be improved as soon as the desealing process is completed, to trigger biological re-mineralization processes. Surface water runoff should be thoroughly analysed by studying the gradients, so as to channel the excess portion toward highly permeable areas and/or drainage devices.

APPLICATION CONTEXTS AND LIMITS

In residential areas, they can be implemented on a small-scale basis, on the areas pertaining to the buildings.
They can be implemented on a greater-scale basis on disused squares and parking lots, to create biodiverse urban spaces.
In the event of large disused areas, they can be implemented as the first step toward a total redevelopment: based on the size and type, prior characterization is required.

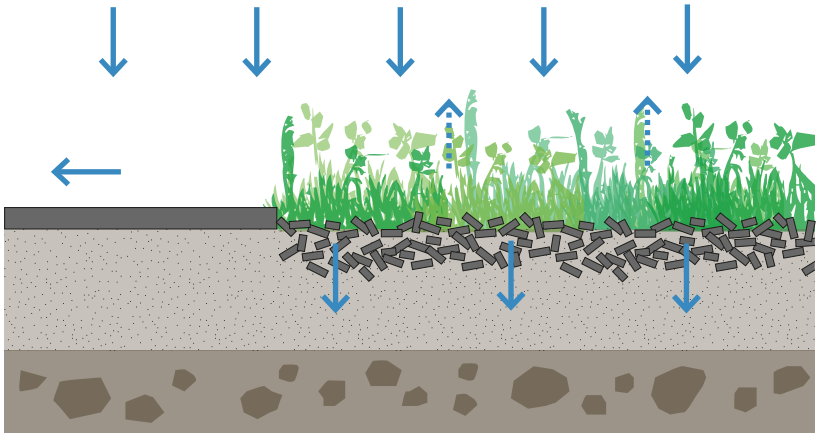

Public Buildings
Ibimet

Different ways of reusing
inert materials on site.



DESEALING
WITH FOUNDATION
REMOVAL

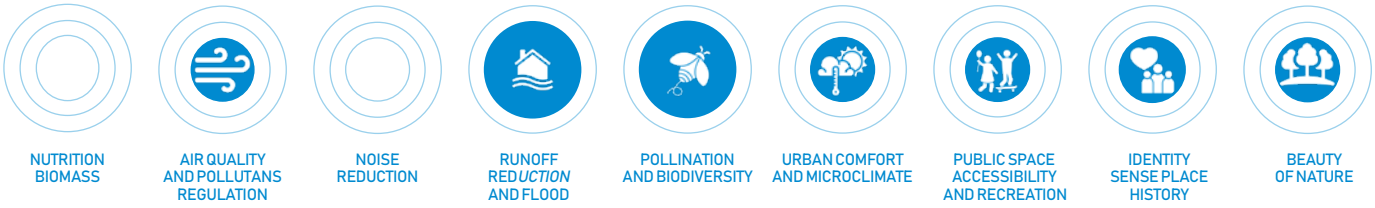
The material is crushed with a medium-fine grain: the larger blocks are used as the foundation for newly built green basins, while the substrate is mixed with plant soil where to sow high-growth herbaceous and/or flowering lawn or small shrubs.

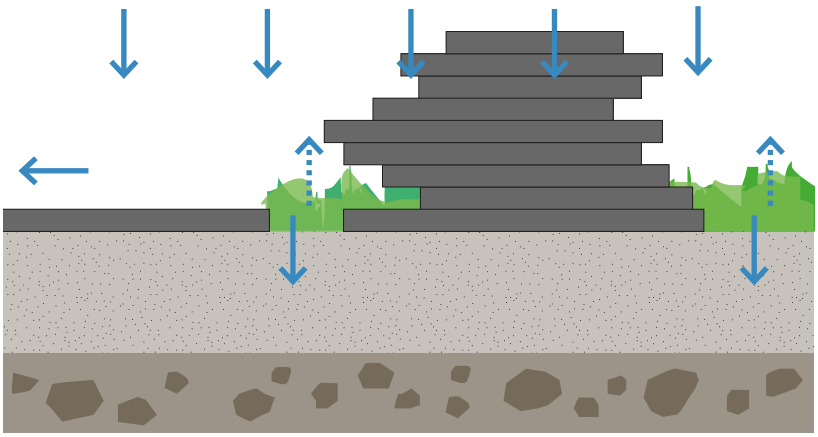


EXTRA-FINE
DESEALING

The material is crushed with a very fine grain except for a linear portion that remains as a cycle-pedestrian path. The desealed area is sown with high accretion herbaceous grass and/or flowering lawn.

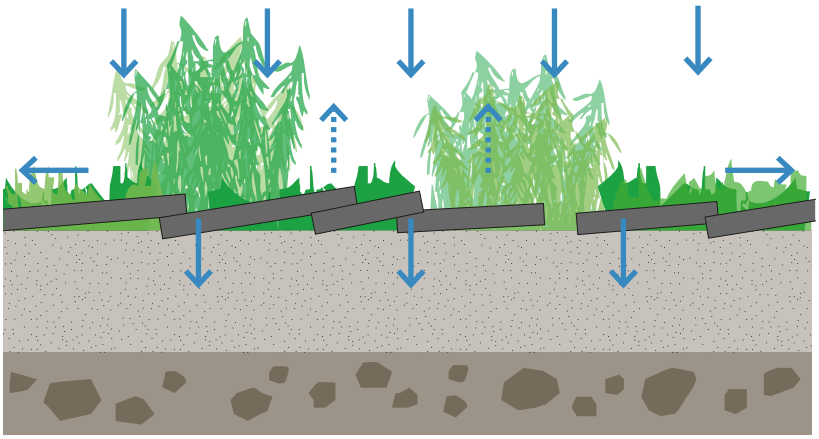
ECOSYSTEM SERVICES PROVIDED





EXTRA-LARGE DESEALING WITH MATERIAL REPOSITIONING

The material is removed in large blocks, then stacked in groups to create land-art works or stations for observing the surrounding landscape.
In the desealed areas, herbaceous and grasses can spontaneously grow.



ON-SITE EXTRA-LARGE DESEALING

The material is removed in large blocks, then offset and lifted from the ground to make room for mosses and grasses. In the spaces between blocks it is possible to plant fast-growing birch.

Top right. Different evolutionary stages of pioneer vegetation in the former heliport of Flugplatz, in Frankfurt on the Main, transformed into a park for leisure and sport. The central track is the only unpaved part, partly reused for skating, running and cycling.

The debris from the runway has been reused for different purposes: for the creation of gabions, the creation of substrates or left on site favoring the reconquest by the vegetation and the natural cycle of water. In fact, thanks to the presence of some ditches, part of the heliport has become a biotope for aquatic species. Pioneering species and numerous specimens of birch trees have developed in areas where debris is crushed into slabs. (Project by GTL Landshaftarchitekten, photo by Luisa Ravanello and Elena Farnè)

Bottom right. The former Aubervilliers car park, transformed into a temporary garden. The area has been subject to desealing and a gardening activity. Today the garden is used for educational purposes by the neighborhood schools. (Project and photo by Wagon landscaping)

SPACE REQUIRED

Rocky gardens obtained from desealing can be created both on a micro and macro-scale basis.

TYPE OF UNDERLYING SOIL

Concerning soil permeability, a suitable infiltration capacity of the unearthed subsoil is required. If this is not possible, additional meshes/drains to channel excess water are necessary.

Concerning the soil impoverishment, depending on the characteristics of the unearthed top soil, the best plant species will be chosen, based on their immediate rooting capacity and on the soil re-mineralization contribution they will make over time.

PLANT SPECIES

Rocky gardens from desealing are planted with pioneer species. In some specific cases, species capable of absorbing and metabolizing pollutants can be included.

Recommended species, apart from those indicated in Chapter 4.2.1 "Pioneer plants", are:

- RAPID DEVELOPMENT TREES, such as male poplars, European nettle trees, lindens, robinia (sterile varieties), elders and other species detailed below;
- NATIVE HERBACEOUS PLANTS AND SHRUBS suburban areas subjected to desealing will be rapidly invaded by numerous native herbaceous plants and shrubs, or from species coming from cultivated gardens and crops nearby. The natural settling mechanism should be preserved, whilst controlling the proliferation of allergenic plants, such as parietaria and Ambrosia artemisiifolia.

A possible application, after the partial and preventive desealing of mineral pavements, is the "urban productive forestation", e.g. the planting of rapid growing trees with a vital cycle compatible with the temporary use of the area as a productive wooded area, according to special public/private agreements.

PUBLIC USAGE

The area can be:

- ENTIRELY ACCESSIBLE, also with adventure trails;
- PARTIALLY ACCESSIBLE for all the typical park and garden uses;
- NOT ACCESSIBLE in the most arduous areas.

MAINTENANCE

Since pioneer species are planted, rocky gardens are virtually maintenance-free. In any case, the following activities should be performed:

- mowing;
- inspecting and cleaning the structures;
- checking that general safety conditions are preserved.

INDICATIVE COSTS

Indicatively, construction costs are:

- 10-20 euro/sqm for desealing without disposal and other special works (e.g. emergency meshes or drains, to be assessed on a case-by-case basis);
- 20-30 euro/sqm for desealing with transport and reuse in another area or construction site within a radius of a few dozen km (not disposed of as waste);
- 7 euro/sqm for integration of the top layer with wet soil;
- 2-5 euro/sqm for planting pioneer species.










REJOUER