LID

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SCUOLA DI ARCHITETTURA URBANISTICA E INGEGNERIA DELLE COSTRUZIONI
MASTER DEGREE IN ARCHITECTURAL DESIGN AND HISTORY

FINAL WORK

LOW IMPACT DEVELOPMENT PRACTICES IN HISTORICAL CITY-PRATO

PROF.PERABONI CARLO

GONG WEN 886309
MENG QINGYU 882568

PART 1

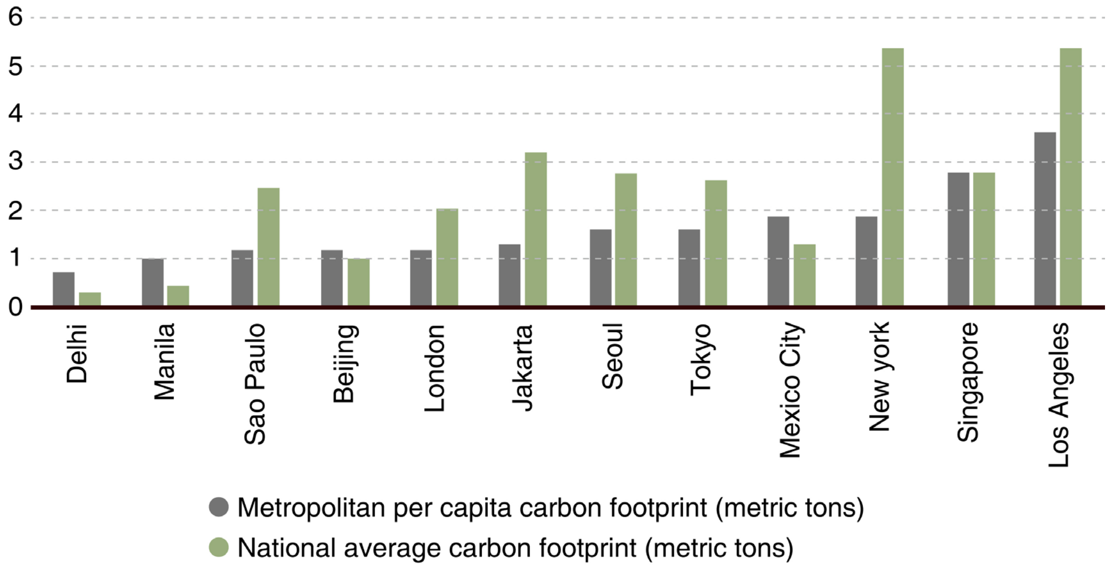
The context in the world: what are the problems in the cities around the world.

Cities create wealth, generate employment and drive human progress by harnessing the forces of agglomeration and industrialization.More people move to the city to seek more development opportunities and a higher standard of life space. According to the data, almost half the world population resides are settle down in urban areas. So urban areas around the world are facing enormous challenges and changes than they did 20 years ago. Cities are operating in economic, social, and cultural ecologies that are radically different from the outmoded urban model of the 20th century. Connected problems are newer trends in the urban governance and finance: emerging urban issues include climate change, exclusion and rising inequality, rising insecurity and upsurge in international migration.

Resource problem in the cities:

The resources of the city mainly include: electricity, heat and fuel which produced by a series of production methods and water which derived from nature only need processing and purification. These resources will bring some derivative problems to the city during production and emissions. Along with rapidly urbanizing areas and urban population increase must to respond to increasing resource need. The rapid growth of these resource demands has also aggravated the impact of derivative problems in cities. When the economic and technological development of cities cannot meet these problems, these problems become obstacles to inhibiting urban development and reducing the quality of life of residents.

Comparison between individual city and national carbon footprints per capita

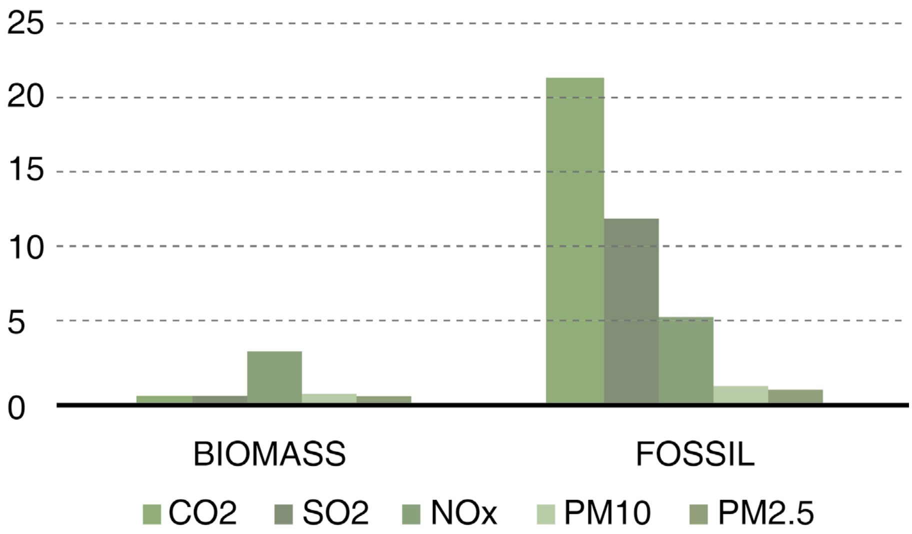


Energy resource pollution and shortage

Fossil fuels pollution:

Most of the world's urban energy resources are produced by burning fossil fuels. For example: thermal power for electricity , heating, traffic power, etc. Fossil fuels are currently one of the main sources of energy. The annual burning of fossil fuels produces about 21.3 billion tons of carbon dioxide, but nature can only absorb half of it, so about 10.7 billion tons of carbon dioxide is added to the atmosphere every year. Cities are responsible for more than 70% of global carbon dioxide emissions.Between 1950 and 2005, the level of urbanization increased from 29 % to 49 %, while global carbon emissions from fossil-fuel burning increased by almost 500 %.

Compare the harmful substances generated after burning BIOMASS and FOSSIL



The United States has less than 5% of the world's population, but because of the larger homes and private cars, Americans consume a quarter of the world's fossil fuel supply. The US urban population accounts for 80% of the total US population in the month, which means that less than 4% of the world's population consumes about a quarter of the world's fossil fuels and provides a quarter of carbon dioxide.In the United States, more than 90% of greenhouse gas emissions come from the burning of fossil fuels.

Pollution from these fossil fuels consumed by the city will return negative impacts to the city.The main environmental effect are：

●Greenhouse emissions: Scientists have reported that 2015 was the hottest year in history by wide margin, as average temperature for the year was 0.75°C warmer than the global average. This has been attributed to increase in greenhouse emissions caused mainly by the burning of fossil fuels.

● Acid rain: The acidic substances produced by the burning of fossil fuels can be mixed with the water and gas in the air and land on the ground to form acid rain, which has corrosive effects on the natural environment and buildings. Among them, statues and monuments made of marble or limestone are particularly vulnerable to damage and are easily corroded by acid.

Energy resource shortage:

Nowadays, the shortage of urban energy resources comes from two main reasons:

The first reason is, Fossil fuels are exhaustive energy that takes millions of years to generate and consumes much faster than they can. Therefore, insufficient supply of fossil fuels will cause an energy crisis. In particular, gasoline extracted from petroleum has the greatest impact. In the second half of the 20th century, there were three oil crises due to insufficient oil supply.

The other one is, As the city develops too fast, the energy that the city can produce cannot meet the needs of industry, agriculture and residents in the urban development process.
The US Energy Information Administration (EIA), a policy-neutral analytical agency within the US Department of Energy, anticipates that the “World marketed energy consumption is projected to increase by 44% from 2006 to 2030.” The EIA expects that energy demand from emerging economies-such as the BRIC countries (Brazil, Russia, India, and China)-will increase by 73% during this time frame, far outpacing the 15%increase from developed economies like Australia, France, Germany, Japan, the United Kingdom, and the United States. Large urban populations are a major driver of this trend, and cities often struggle to adequately meet demand due to a lack of supply as well as inefficient transmission and distribution systems to the end customer.This is especially the case in the cities of developing countries with dense populations, where service outages and interruptions are a daily occurrence. For example, Achim Steiner, executive director of the United Nations Environment Programme (UNEP), explains that “45% or so of people in India hooked up to a power grid suffer chronic, daily electricity outages.”

Heavy pollution from a fossil fuel power station in India

Water resource pollution and shortage

Water resource pollution

More than 80% of the world's wastewater flows-back into the environment, polluting rivers, lakes, and oceans-without being treated or reused, according to the United Nations; in some least-developed countries, the figure tops 95%. The reason why such a large amount of wastewater flows into cities and nature without treatment is:

●The amount of urban wastewater is huge and it is impossible to systematically treat and recycle all wastewater. Every day, 2 million tons of sewage and industrial and agricultural waste are discharged into the world's water (UN WWAP 2003), the equivalent of the weight of the entire human population of 6.8 billion people. The UN estimates that the amount of wastewater produced annually is about 1,500 km3, 6 times morewater than exists in all the rivers of the world. (UN WWAP 2003)

●Another reason is the stormwater runoff in the city. Because the most surface in the city is impervious surface and the vegetation which can filter the stormwater is extremely few. The landscapes used in cities, such as large industrial lawns and street trees, can have minimal filtering. So rainfall carries road salts, oil, grease, chemicals, and debris from impermeable surfaces into our waterways and back into the nature. Research indicates that when impervious area in a watershed reaches 10%, stream ecosystems begin to show evidence of degradation, and coverage more than 30% is associated with severe, practically irreversible degradation.

A typical landscape in suburban Atlanta, Georgia, USA

This widespread problem of water pollution is urban residents our health. Unsafe water kills more people each year than war and all other forms of violence combined. Most people have access to safe drinking water, but potentially harmful contaminants-from arsenic to copper to lead-have been found in the tap water of every single city around the world.

●Worldwide, infectious diseases such as waterborne diseases are the number one killer of children under five years old and more people die from unsafe water annually than from all forms of violence, including war. (WHO 2002)

●Unsafe or inadequate water, sanitation, and hygiene cause approximately 3.1% of all deaths worldwide, and 3.7% of DALYs (disability adjusted life years) worldwide. (WHO 2002)

● Unsafe water causes 4 billion cases of diarrhea each year, and results in 2.2 million deaths, mostly of children under 5 years old. This means that 15% of child deaths each year are attributable to diarrhea-a child dying every 15 seconds. In India alone, the single largest cause of ill health and death among children is diarrhea, which kills nearly half a million children each year. (WHO and UNICEF 2000)

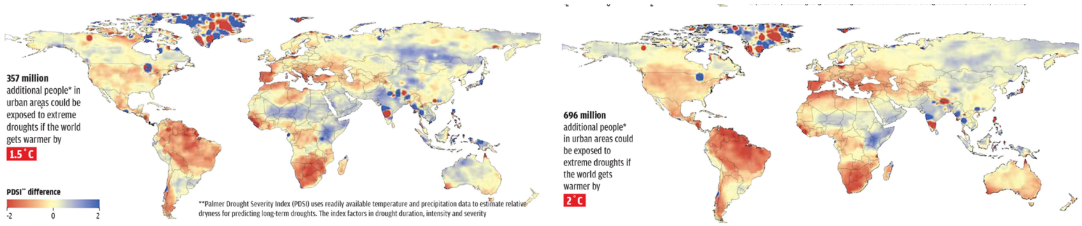
And this problem also can jeopardize the nature. Chemicals and heavy metals from industrial and municipal wastewater contaminate waterways in the urban and nature as well. These contaminants are toxic to aquatic life—most often reducing an organism's life span and ability to reproduce—and make their way up the food chain as predator eats prey. That's how tuna and other big fish accumulate high quantities of toxins, such as mercury.

Water resource shortage

The crisis at Cape Town has shown what unplanned urbanisation can do to water availability in the world's urban centres. Not only are our metropolises headed to a dry future, the scarcity will increase as people are migrating to urban areas at unprecedented rates. About 54 % of the world,or 3.9 billion people, live in urban areas and they will grow between 60 and 92 % by the end of the century, says a study published in Nature this January. As a result, the urban water demand will increase by 80% by 2050, it adds.

About 400 million urban dwellers currently face water shortage, states a 2014 study published in Global Environmental Change.Moreover, not only the population growth will aggravate the shortage of water resources in the city, but the increasing global temperature also increases the speed of water shortage. This when the average global temperature has not even risen by 1.5°C above pre-industrialisation levels. What will happen when it rises by 2°C. A study, published in Earth System Dynamics in November 2017, has made projections for those scenarios. A 1.5°C rise in the average global temperature will expose 357 million urban dwellers to extreme droughts while the figure for a 2°C rise will be 696 million. The number of city dwellers facing water shortage by 2050 could be much higher, about 1 billion, says the Nature study.

Palmer Drought Severity Index (PDSI) uses readily available temperature and precipitation data to estimate relative dryness for predicting long-term drought. The index factor duration, intensity and severity.



Since 2011, the state of California has received the lowest annual precipitation and highest annual temperature in its history. Australia is also still struggling to emerge from the millennium drought that lasted
from 1996 to 2018.

What's worse, most studies say that the situation is worsening globally. "Cities and Climate Change", a 2011 report by UN-Human Settlements Programme, says the area under extreme drought conditions is likely to increase drastically in the coming decades. From less than 1% of the total landmass now, extreme drought could affect as much as 30% of the land by 2100 due to changing precipitation patterns and increasing water demand. A 2015 study, published in the Global Environmental Change, says expanding drylands and increasing urbanisation could make nearly 0.5 million sq km of urban area drought-prone by 2030. This is nearly 300% increase from the 0.17 million sq km of urban area identified as drought-prone in 2000.

The expansion is expected to be multi-fold in China, South Asia, North Africa, West Asia and North America. A study published in February 2018 in the Environmental Research Letters, warns that by the end of the century southern European cities, especially in Spain and Portugal, could be experiencing droughts 14 times as intense as those they experienced between 1951 and 2000. In Africa, one in three people live in drought-prone conditions. This number, estimates the World Water Council, could be as high as two in three within a decade.

The environment problem in the cities:

Global climate change

Global warming is a phenomenon related to nature. Due to the continuous accumulation of greenhouse effect, the energy absorbed and emitted by the gas system is not balanced. Energy is continuously accumulated in the gas system, which causes the temperature to rise and cause global warming.
Global warming will redistribute global precipitation, melting glaciers and frozen soils, rising sea levels, etc., not only endangering the balance of natural ecosystems, but also threatening human survival. On the other hand, due to the increase in continental temperatures caused by terrestrial greenhouse gas emissions, the temperature difference with the oceans has become smaller, which has recently caused the air flow to slow down.

Temperature changes

Because people burn fossil fuels, such as oil, coal or deforestation and incinerate them, they produce a lot of carbon dioxide, that is, greenhouse gases, which are highly transparent to visible light from solar radiation and are emitted to the earth. The long-wave radiation is highly absorptive and strongly absorbs infrared rays from the ground radiation, causing the earth's temperature to rise, that is, the greenhouse effect. The more consistent conclusions about global climate change are: The global surface temperature rises during the 1 year since the 19th century or 0.2 to 0.6 °C. From the data of 119 years from 1550 to 195, the global warming trend is 0.53 °C /100 a. In general, global warming presents a large regional difference, and the warming in high latitudes is greater than in low latitudes, and terrestrial warming is more pronounced than in oceans.

Impact on precipitation

It also has an impact on the distribution of precipitation. The precipitation is unevenly distributed, and the precipitation in the continental and mid-high latitudes is greatly increased, while the precipitation in the arid regions like Africa itself lacking water is greatly reduced. Increasing the occurrence of severe weather events in some areas has seriously affected the local ecological balance and constrained its economic development.

Wind speed mitigation

According to observations in recent decades, it is found that near the land in low latitudes, the average wind speed and windy days tend to decrease. The global land and average wind speed near the surface of large areas have a downward trend, but at high latitudes and Some sea areas have an increasing trend in wind speed. Later studies have found that the average tropospheric wind speed has also declined in the past 30 years, but it is far below the downward trend of the near-surface average wind speed.

Environmental pollution

Air pollution

According to the latest data released recently by the World Health Organization (WHO), more than 80% of the world's people living in cities that monitor air quality breathe air beyond WHO limits. From 2008 to 2015, the level of global urban air pollution increased by 8%. Among them, India has the highest PM2.5 pollution index. Of the 30 most polluted cities in the world, India accounts for 16 and China for 5.

PM2.5 and PM10 are fine particles that can be absorbed by human breath in the air. They are mainly produced in social production and people's life, especially in modern society, industrial fuels, such as coal, oil use and various kinds of waste

incineration. It can be said that PM2.5 and PM10 are the basic products of industrial pollution and also the evaluation index of industrial pollution index. Although people cannot see it with the naked eye, it does great harm to human health and air quality. What is more serious is that the invisible fine particles can be transported and stayed in the atmosphere for a long distance by natural wind.

Soil pollution

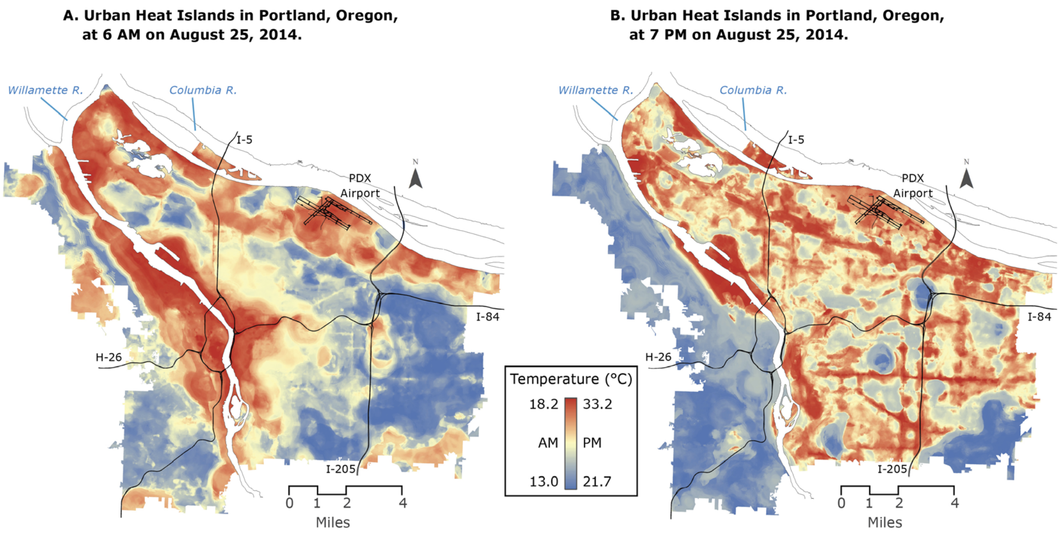
With the acceleration of human industrialization process, various industrial pollution is also overwhelming, causing varying degrees of pollution to the soil, resulting in deterioration of soil quality, affecting the growth of crops and agricultural production, What's more, it will cause irreversible harm to human body. It is estimated that about 80,000 sites in Australia are now

polluted by soil. China classifies 16% of its soil and 19% of its agricultural soil as contaminated. There are about 3 million potential pollution sites in the European Economic Area and the Western Balkans. In the United States, 1,300 sites have been listed on the country's Superfund National Key Pollution Hotspots List.

Deterioration of ecological environment

Reduction of greening area

With the rapid development of urbanization construction in our city, urban land is becoming increasingly tense, green land is constantly compressed and squeezed in the population industry cluster, hard paved road expansion and extension, which has brought huge negative ecological effects. When the conventional land greening construction tends to be saturated, the "URBAN HEAT ISLAND" effect accelerates sharply, the impact of RAINSTORMS and FLOODS, and the urban ecology deteriorates day by day.



Biodiversity is in crisis

Over the past 50 years, global biodiversity has disappeared at a faster rate than at any other historical stage due to the extensive destruction of the natural environment by human beings. Among them, the disappearance rate of natural species has reached 100 times of the normal rate of extinction.

Tropical forest is the most precious forest resource on the earth. It preserves 40% of the total biological species on the earth. The Amazon River Basin alone has an estimated 1 million species of plants and animals, including at least 30,000 species of plants (including 250 species of trees), 180 species of birds and 200 species of fish. In terms of species and genetic diversity, no other ecosystem is comparable to that of tropical forest ecosystems, such as the 1 HM tropical rain forest in the Amazon River Basin, which may include more than 20 species of trees and the same area. Temperate forests may contain only 10 to 15 species, while cold forests contain only 3 to 5 species. According to the American Newsweek on June 19, 1991, the world's tropical rainforests are cut down by about 16.2 million hectares every year. Brazil is the worst hit, with 534,000 HM of tropical rain forests destroyed and 95% of its Atlantic coastal forests disappeared. More than 60% of Congo's rainforests have been included in the deforestation plan; Madagascar will lose 30% of its rainforests by 2000; India and Sri Lanka have almost no rainforests, and Malaysia's rainforests will disappear around 2000. It is estimated that 1/2 of the world's tropical rainforests have been cut down. In the 1990s, 1/3 or 1/2 of the remaining rainforests will be severely damaged. By 2000, 2/5 of the existing forests in developing countries will disappear. With the trend of decreasing rainforests, there will be a crisis of extinction of tens of millions of species.But if simple disappearance isn't enough to get you worried, a new study in Nature finds that declining biodiversity frequently results in an increase in infectious diseases.

Many species that are lost provided buffers from pathogens, according to the study. The species left behind are the ones that are disease transmitters, though the reasons for this are not yet understood. Take the West Nile virus, for example, which is transmitted by mosquitoes and for which several species of birds act as host. When the variety of bird species is low, the population tends to include many species that harbor West Nile. In these areas, humans are more likely to contract the disease.

This pattern holds for parasites, animal infections, plant pathogens and coral diseases. The need for biodiversity even plays out at the microbial level. A rich diversity of microbes may regulate which become pathogenic in some cases, and in others high microbial diversity may protect against dangerous invasive pathogens.

Higher biodiversity could increase the potential sources for diseases, so losing this variety may seem like a good thing, the scientists say. But that is outweighed by the increase in contact between source and hosts (such as domesticated pigs and human, with swine flu) that comes when only a few species dominate a landscape.

PART 2

The low impact development method and design criteria

In this section, introducing the definition of LID, background knowledge, and why LID solves the urban problem in Chapter 1. And the design principles of LID and how to implement LID at all levels of the city to form a complete ecological network.

Introduction of Low Impact Development

Definition of Low Impact Development

Low-impact development (LID) is a term used in Canada and the United States to describe a land planning and engineering design approach to manage stormwater runoff as part of green infrastructure.

The background of LID

Since the 1960s, scholars and environmental protection departments have gradually realized that surface runoff in urbanized areas and farmland accompanied by rainfall is an important source of water environmental pollution, which is called non-point source pollution or diffuse source pollution, in order to distinguish it from traditional industrial wastewater, effluent from sewage treatment plants and municipal domestic sewage. Point source pollution of centralized emission. Since the 1970s, non-point source pollution has attracted great attention from western countries. In the 1970s, the United States promulgated the Clean Water Act and gradually implemented Best Management Practices to comprehensively control non-point source pollution. This "best management practice" devoted to the treatment of non-point source pollution mainly prevents or reduces pollutants from flowing to the surface or groundwater through surface runoff through non-structural methods or structural engineering measures, and at the same time, achieves the purpose of replenishing and recharging groundwater. Non-structural BMPs include management measures to limit impervious areas, protect natural resources, and control sources such as street cleaning and solid waste management. Structural BMPs include construction of detention ponds or filtration measures.

Tree filters can collect stormwater through an attached catch basin in Boston..

Since the 1980s, cities in European countries have gradually implemented integrated rainwater management measures to reduce rainwater flowing into combined sewage treatment networks. In the late 1980s, the Department of Environment and Resources in Prince George's County, Maryland, USA,Environmental Resources has begun to use "bioretention" technology to harness rainstorms and floods. Biological retention is a practice of water quality and quantity control. It mainly uses chemical, biological and physical properties of plants, microbes and soil to remove pollutants from surface runoff of rainwater and supplement groundwater. Bioretention facility includes sedimentation, adsorption, filtration, volatilization, ion exchange, decomposition, phytoremediation, bioremediation and storage capacity. In the early 1990s, Prince George's Department of Environment and Resources combined site design with "biological detention" and "best management practices" and gradually developed into a systematic "low impact development" theory and method of rainwater planning and management, which became the blueprint of rainwater management throughout the United States after 2000.

Tree filters can collect stormwater through an attached a curb inlet in Boston..

Advantages of LID

LID has multiple benefits, such as:

1.Recycling use the rainfall can reduce the waste of the water resource.

2.protecting animal habitats, improving management of runoff and flooding, and reducing impervious surfaces.

3.Improving groundwater quality and increases its quantity, which increases aesthetics, therefore raising community value.

4.Improving the ecological environment and adjusting temperature to create a comfortable living area.

5.Reducing pollution and improving air, water and soil quality.

LID design criteria

The three tenets of low impact development:

Enhancing Landscape Biodiversity

Nowadays, the surface in the city are already be industrialized.The pavement only have asphalt and the landscape is only made by large area of turf.But those surface not only will made our city atmosphere dull but also will eliminate local plant and soil communities necessary for natural hydrological cycling. Turf grasses kill biodiversity because the standard lawn is dependent on a regimen of chemical fertilizers and herbicides to maintain its plant monoculture.The LID technologies rely on biogeochemical rather than low-service mechanical processes to manage and treat stormwater runoff. LID promotes the use of xeriscapes, or water conserving landscapes of drought-resistant plants to maximize the delivery of ecological services in development.

conventional: large turf landscap

LID: diverse landscape

Maximizing Water Infiltration and Eliminate Runoff

Because of the rapid growth of the urban population, the demand for urban space has increased and urbanization has become serious. Unconstrained expansion of the city will undoubtedly invade the land of wetlands, forests, vegetation, and farmland. All of which constitute a watershed's carrying capacity to slow, spread, and soak stormwater, creating stable hydrological functioning. LID promotes the use of pervious surfaces which can filter and infiltrate the runoff and the use of networked plant communities to remediate pollution and peak flow of runoff after a storm. All elements in this system can reuse a part of rainwater rather than discharge them off.

conventional: impervious asphalt pavement surface parking area

LID: pervious surface pavement parking area

Managing engineer Hydrology in Distributed Networks

Conventional hard-engineered stormwater infrastructure concentrates runoff in detention facilities then dispatches polluted runoff to another site, simply moving waste problems around. Instead, LID performance is optimized when runoff is treated through a robust network with high connectivity, redundancy, and distribution. While solving the flood problem, the LID system can also filter wastewater and rainwater and recycle it to the city's life to solve certain resource shortages.


conventional: hard-engineered stormwater infrastructure


LID: rain garden

LID: enhancing impacts

Aim:To enhance the existing native facultative vegetation and soils as Green Infrastrucutre and Treatment Facilities, increase biodiversity, store and treat polluted runoff

The conservation and enhancement of existing native facultative vegetation and wetland plant communities for stormwater management is a central principle of LID design. Native plants increase biodiversity crucial for ecosystem resiliency, encourage phytoremediation, and promote healthy microbial communities. Non-native,non invasive plants can be used, but native plants are better at establishing synergies with local biotic communities. Natural adaptation to local conditions is an important process in ecosystem development. Ecosystems mature through a process of plant succession, where establishment or pioneering plant communities like native grasses and small woody shrubs evolve into more complex softwood and hardwood forests when left unattended.
Each stage in the maturation process delivers everincreasing ecological services with less energy use.

The root systems of plants naturally filter and treat stormwater, while the matrix of roots, stems and leaves attenuate and encourage infiltration. Plant leaves and branches also intercept rainfall, managing the amount of water that reaches the ground. Roots break up rock and soil, indirectly aiding in infiltration and encouraging soil tilling. These actions facilitate soil development and microbial colonization.

Plants link soils to the atmosphere. Plant species interact with fungi, bacteria, insects and other living things in soil to form unique communities. Plant communities adapt to conditions that define their metabolisms. For instance, wetland communities differ from deciduous forests based upon extremes in soil moisture, temperature regimes, rainfall, and day length. These plant communities are the foundation of ecosystem services. Understanding the interactions between plants and their soil communities provides a basis for designing ecosystem services.

The transitional areas between plant communities, called ecotones, are the most productive and biodiverse areas on Earth. One example are riparian buffers—facultative plant communities at the stream's edge connecting land and water—that facilitate diverse ecosystem services. Just like riparian buffers, LID facilities require facultative plants with the capacity to tolerate wet and dry cycles. Facultative vegetation is also highly productive, capable of controlling sediment deposition and regulating shallow water temperature necessary for important land-water enzymatic exchange and aquatic wildlife habitat.

LID principles regarding vegetation are as follows:

●Protect Pre-Development Vegetation

Protect and preserve existing native vegetation and urban forests during construction, particularly along waterbody edges. Heavy equipment should not be allowed to park on or travel across critical root zones.

●Prevent Erosion During and After Construction

Do not clearcut a site. Install erosion control blankets, lay straw or seed native grasses like buffalograss and wild rye to temporarily stabilize stockpiled topsoil.

●Restore Ecological Services

Re-establish critical ecological habitat and wetlands as appropriate for regional and local conditions.

LID: Maximizing impacts

Aim:To maximize the pervious pavement and soil area as a sponge, absorb and storage the rainwater as much as possible.

Native soils play a critical role in the storage, conveyance, and treatment of stormwater. Pores and fractures comprising soil structure act as conduits that carry water from the surface to groundwater and aquifers below.

LID requires detailed analyses of site soils, particularly at LID facility locations to determine hydric soil types an infiltration rates. Depending on the soil type and structure, 10 to 40 percent of annual precipitation can be infiltrated to replenish groundwater. Optimum LID planning places new impervious surfaces over less permeable soils, while highly permeable soils desirable for LID should be used for infiltration and treatment. Soil surveys and borings conducted by a certified professional designate soil hydrologic classes (A, B, C, or D) based on compaction, texture, depth, and other characteristics. Although a “loam” is considered to be an ideal soil for permeability, LID design employs the site’s soil profile and avoids wholesale soil amendment. Let the site dictate design. However, a small scale project like a rain garden may not need a detailed soil analysis, when the study of soil maps and a percolation test will suffice. A percolation test can be conducted to determine the soil’s infiltration rate measured in minutes per inch.

LID principles regarding soils are as follows:

●Before Construction

Develop an erosion and sediment control plan. Conduct soil borings at LID facility areas to identify soil type and the depth of groundwater, or water table. Conduct a percolation test to determine the soil’s infiltration rate.Develop a “no compaction zone” plan based on location of LID facilities and high compaction probability areas (typically soil with high percolation rates) to prevent heavy site equipment use in these areas.

- During Construction

Employ erosion and sediment control devices. Avoid compaction by implementing the “no compaction zone” plan. Avoid site work during rainfall—wet soils are more vulnerable to compaction.

- After Construction

Implement a soil enhancement regimen through the use of soil amendments. To generate microbial communities add compost, and for infiltration add sand. Manage LID facility areas by removing litter annually to prevent clogging.

LID: managing impacts

Aim:To manage all different levels' LID infrastructures connect as a network,let facilities more efficient at all levels and overall

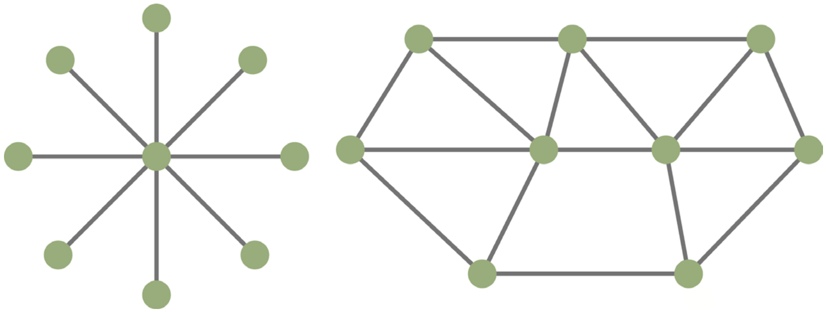
The conventional development process separates design, administration, and financing of the horizontal infrastructure from individual property development. The LID design entails holistic planning through the nestling of scales among the building, property, street, and open space.

Each development component offers intrinsic and scalable stormwater cycling and conservation technologies. Component interfaces—or “development ecotones”— are particularly opportunistic areas for creating an urban LID network. Yet, fragmentation in the development and regulatory processes present major obstacles to such integrated planning. A major obstacle includes the lack of integrated asset management, where regulatory agencies for roads, stormwater management, utilities, and landscape each work in isolation, often with contradictory mandates. Other obstacles include difficulty in funding first costs and additional maintenance costs regardless of favorable lifecycle cost assessments that will result in multiple returns on investment. Nonetheless, each component suggests within its realm a unique agency among property owners, developers, cities, and regions with potential for game-changing impacts. LID requires individuals to implement projects, but it takes a region to make it work.

LID principles regarding network are as follows:

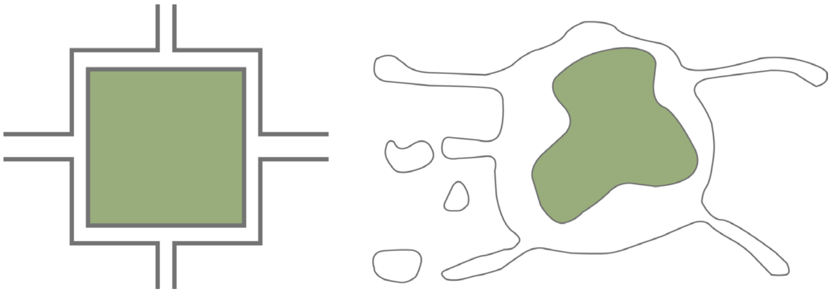
●Redundancy

To avoid systemic failure (i.e., flooding) facility redundancy is important in LID design. While some facilities may work well in isolation for first flush and small storm events, a distributed circuit of facilities creates redundancy by connecting facilities in multiple routes. The alternate routes in a network reduce the effects of gaps, increasing performance and general levels of service. Hybrid conventional and ecological engineering systems may be connected through surface facilities and underground conveyance to address sites with poor soils and for larger storm events up to a 100-year event.



●Resiliency

To maximize ecological benefits, LID design should incorporate multiple LID facilities (see “What are the LID Facilities” pp. 142-187) with different levels of service. Using an array of LID facilities that slow, spread, and soak stormwater assures full treatment capacity and resiliency in the system. Facilities that simply control flow and store stormwater should accompany more robust facilities that filter, infiltrate, and treat stormwater.To optimize resiliency, healthy ecosystems are readily adaptable to metabolic alterations brought on by external or internal disturbances. Biological diversity increases resiliency, enabling LID networks to withstand shocks or perturbations, rebuilding themselves when necessary. Design for optimum resiliency maximizes interfaces like those in natural systems avoiding the system rigidity of conventional engineering.

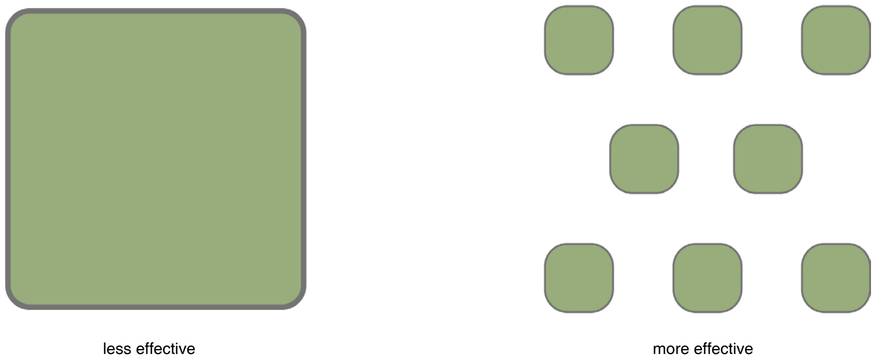


- Distribution

Distribution, or a dispersed spatial arrangement of LID facilities, optimizes the full carrying capacity of a site and avoids pitfalls associated with concentration. Water quality and quantity functioning are cumulative so that even very small facilities provide compounding benefits to the overall network. Usually, several small facilities will provide greater treatment and more diverse habitat than one large facility, while accommodating sensitive areas.

LID: From Facility to Network

The conventional development process separates design, administration, and financing of the horizontal infrastructure from individual property development. When speaking of ecological practices, Wendell Berry reminds us in The Gift of Good Land, that “a good solution in one pattern preserves the integrity of the pattern that contains it”. Recalling Berry’s adage, the LID watershed approach entails holistic planning through the nestling of scales among the building, property, street, and open space.



Each development component offers intrinsic and scalable stormwater cycling and conservation technologies. Component interfaces—or “development ecotones”—are particularly opportunistic areas for creating an urban LID network. Yet, fragmentation in the development and regulatory processes present major obstacles to such integrated planning. A major obstacle includes the lack of integrated asset management, where regulatory agencies for roads, stormwater management, utilities, and landscape each work in isolation, often with contradictory mandates. Other obstacles include difficulty in funding first costs and additional maintenance costs regardless of favorable lifecycle cost assessments that will result in multiple returns on investment. Nonetheless, each component suggests within its realm a unique agency among property owners, developers, cities, and regions with potential for game-changing impacts. LID requires individuals to implement projects, but it takes a region to make it work.

lots: LID lots infiltrate stormwater through reduction or elimination of impervious surfaces and replacement of turf grass with productive landscapes.

streets: LID streets are green streets reducing and filtering runoff as it enters public space while enhancing the quality of place.

networks: LID networks contain treatment facilities connected to regionally scaled systems of stormwater management.

Implement LID in the city

LID concepts are scalable to various sized projects and land-use types. Dividing urban development into its constituent components—building, property, street and open space—illustrates stakeholder action opportunities within each component. The goal is not just to minimize impact, but to develop regenerative and productive urban landscapes that continually renew ecosystem functioning.

Rainwater harvesting consists of up to six primary components, depending on the targeted level of water quality. These components are catchment, conveyance, filtration, storage, distribution, and purification. The amount of water collected depends on catchment size, surface texture, surface porosity, slope conditions, and annual rainfall. Regardless of the catchment surface material, a transmission loss of 10 to 70 percent should be expected due to runoff material absorption or percolation, evaporation, and inefficiencies in the collection process. The first flush of rainwater after a dry period should be diverted from the catchment system as it will be contaminated with dust, mosses, pesticides, bird droppings, etc.

Building

Buildings present ready opportunities for harvesting stormwater runoff from roofs through small-scale embedded technologies. LID facilities are one aspect of “smart building” development that optimize feedback between environment and building to achieve net energy production, or regenerative development (versus sustainable development, which is carbon neutral). LID facilities are chosen according to the level of ecological service desired.

The simplest service is groundwater recharge from roof stormwater runoff. Gutters and leaders that channel rainwater create concentrated discharges and are avoided in favor of devices that slow, spread, and soak rainwater throughout the site. A higher level of service involves vegetated or green roofs, which absorb and evaporate rainwater through a cultivated plant and soil community. Green roofs are superior building insulators, minimizing heating and cooling demands. Green walls minimize solar gain during the summer and wind loading during the winter.

Rainwater harvesting offers three basic levels of service, involving storage cisterns with options for treatment. The simplest service is rainwater reuse for outdoor landscape irrigation. A more complex harvesting service incorporates a greywater building supply with additional treatment for nonpotable water uses like toilet flushing and landscape irrigation.

Catchment&Filtration： Roof

The roof is the first part of the building that is exposed to rainwater. It can function as a catching water. It takes over the scattered rainwater and transmits it to the wall. Rainwater can naturally slide down to the wall and the ground depending on the different shapes and slopes of the roof. The quality of the rainwater can also be changed according to the different materials of the roof, and the green roof can also play a role in filtering.

LOW POTENTIAL

Asphalt/fiberglass shingle

High levels of pollution
Treatment is needed
Could not be used to irrigate edible landscapes or for potable needs.

- Harvesting Potential: Low
- Heat Island Mitigation: Low
- Initial Cost: Low
- Durability: 15-20 years

Membrane roof system

High levels of pollutants Treatment is needed
Could not be used to irrigate edible landscapes or
for potable needs.

- Harvesting Potential: Low
- Heat Island Mitigation: Low
- Initial Cost: Low-Medium
- Durability: 10-30 years

Wood shingle

May contain toxins and carcinogens.
Use products made from cedar since it is typically untreated and thus a safe harvesting alternative.

- Harvesting Potential: Moderate
- Heat Island Mitigation: Moderate
- Initial Cost: Medium
- Durability: 10-20 years

HIGH POTENTIAL

LOW POTENTIAL

Clay tile roof

May produce minor sediment
High albedo surfaces for heat island mitigation
Excellent harvesting potential

- Harvesting Potential: High
- Heat Island Mitigation: Moderate
- Initial Cost: Medium
- Durability: 50-75 years

Metal roof

Very low pollutant levels
Excellent harvesting potential

- Harvesting Potential: High
- Heat Island Mitigation: High
- Initial Cost: Medium to High
- Durability: 40-60+ years

Vegetated roof

Can treat and retain 60-100% of the stormwater
Improved air quality, heat island mitigation, and urban biodiversity

- Harvesting Potential: High
- Heat Island Mitigation: High
- Initial Cost: High
- Durability: 40+ years

HIGH POTENTIAL

Conveyance&filtration&distribution：Wall

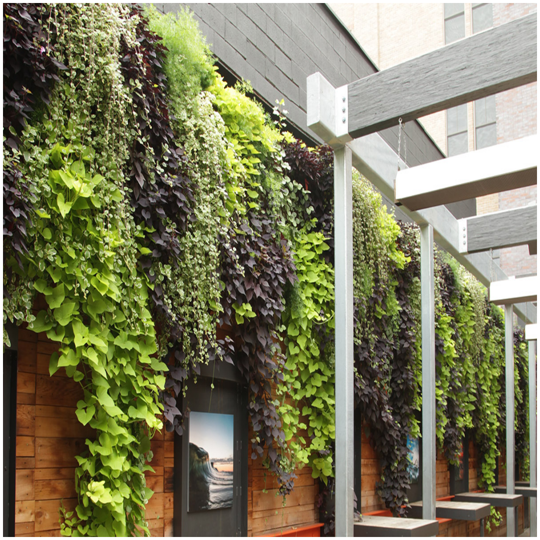
Gutters:

Disconnect/replace/eliminate gutters is the principle of LID design for walls. If you have a drainage system, it is connected to the storm drain pipe on the street, disconnect it and keep the rain water at the scene. If gutters are removed, make sure that dripping edges direct runoff to LID facilities to slow and diffuse storm water runoff. Compared to rainfall leaders, rain chains have a better attenuation ability for one to two years of storm events, however, in 10 to 100 years of storm events, foundations are needed to reduce the ability to exceed the rain chains. This illustrates the importance of redundancy in each facility working together to support the other. No facilities were quarantined.

Use the rain chains to replace the gutters, at the end of chains can add a catchment facilities to collect the rainwater as a pond.It can help to reuse the rain water or can be a landscape in the courtyard.

Vegetated screens and walls:

Vegetation walls are expensive LID facilities. However, they provide fringe benefits such as higher air quality, reduced heat island effects, building insulation and energy efficiency, aesthetic appeal, and filtration of roof stormwater runoff that can be transported or harvested.

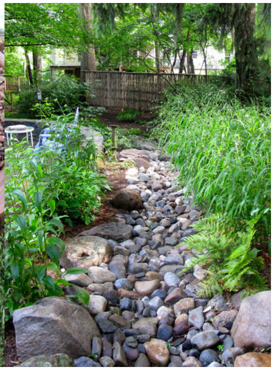


Filtration&storage&purification：Ground

Softscapes: splash block&rock swale

For traditional roofs, splash blocks and rock depressions can be used with LID facilities to transition vertical rainwater flows to help distribute horizontally. Rock depressions slow and transfer rainwater runoff, much like dry river beds, to receive and distribute concentrated runoff. Where steep slopes are to be considered, rock depressions may require geotextile lining to prevent undercutting. For larger roof areas, wide rock depressions and flow control devices such as horizontal spreader will be required.


splash block


rain swale

Below-grade storage：dry well filter&below-grade cistern

Connecting lower-grade storage devices to existing drainage systems helps keep rainwater away from collection. As with grade rainwater collection systems, rainwater must be protected from sunlight to prevent algae growth and openings need to be shielded to prevent mosquito larvae from multiplying. Metal or green roofs are best for rainwater collection. Any overflow should be transferred to the on-site LID facility.


dry well filter


below-grade cistern

Property

Property is the basic unit that divides each individual building into a drainage zone in the city. The property consists of lawn and parking lots around the building, as these semi-private public spaces are a transitional space between the building and the city. Another reason is that turf and asphalt are the biggest contributors to the elimination of plants and soil communities necessary for natural hydrological cycles. LID has been addressed for lawn and parking lot issues, illustrating the use of minimized impervious surface surfaces, combined with LID facilities and increased on-site stormwater runoff management.

Lawn

Since the primary goal of the industrial lawn is to achieve an unnatural greenness among nonnative grasses, significant quantities of chemical-based resources are required. Adapting lawns to local climate and use of native vegetation not only mitigates stormwater pollution, it also saves municipally treated potable water from being wasted on yard irrigation. Indeed, the lawn can treat and infiltrate stormwater, as well as become a productive landscape to grow food.

LID is scalable from the lot, to the block, and to the neighborhood. While their plant-based treatment networks function similarly, block and neighborhood scale configurations require cooperative arrangements among owners. LID utility easements across individual properties can ensure integrated infrastructure functioning, especially in urban areas where small-lot parcels are not large enough to manage stormwater runoff. Shared LID landscapes add a premium to property value.

Industrial lawn & LID lawn

The first problemis the over-fertilization.Suburban lawn care consumes more herbicides per acre than most farmers broadcast to grow crops. Second is about the water resource .The average lawn consumes more than 10,000 gallons of water per summer, causing water shortages in not just arid parts of the country.

LID lawn

First advantage is productive lawn. An average sized lawn of around a third of an acre could produce enough vegetables to feed a family of six.

Second advantage is nutrient cycling. The bacteria necessary for nitrogenation of soil thrives in the polyculture of a low impact lawn; in the monoculture of industrial lawns the bacteria cannot survive.

Third advantage is compost. 12.5% of refuse in landfills comes from food scraps while 12.8% comes from yard trimmings—this costly waste stream can be diverted and used for composting.

Since impervious surfaces do not allow for infiltration of stormwater, polluting substances that come into contact with hard surfaces are concentrated and channelized during a storm event, thus compounding polluted runoff dysfunctions. Pervious surfaces increase on-site runoff infiltration and prevent the transfer of pollution problems to another site. Pervious surfaces should be used at the beginning of the treatment network to slow and filter sediment before stormwater runoff reaches secondary LID facilities for treatment. Pervious paving is appropriate for parking zones and occasionally used drives, but should be avoided in high traffic areas.

Rain gardens are an excellent way to increase on-site infiltration within existing lawns. They take advantage of low lying areas as natural collection points for runoff and tolerate periods of extreme wetness and drought. In addition to aesthetic benefits, rain gardens facilitate bioremediation—the removal and breakdown of pollutants through plant processes. For parking lots, tree islands can be transformed into stormwater treatment facilities by cutting or removing curbs and sinking islands to receive stormwater runoff from impervious surfaces.

xeriscape lawns have significant economic and environmental benefits, such as increased biodiversity, food production, on-site infiltration, and low maintenance. A multispecies mix of native grasses is already adapted to an area's climate and able to exist as a stable plant community.

In the LID lawns, more LID facilities (like raingarden, pervious pavement ,xeriscape,etc.) can be used to raplace the impervious surface,Single landscape and high maintenance vegetation. Applying LID lawn to lots and to blocks. Forming the most primary ecosystem in the city.

LOTS

For urban residents, lot belongs to the semi-private space of residents, and it is also the initial way in which they can directly participate in lid. One of the easiest ways to adapt LID to an existing site is to install a rainwater garden in a low-lying area. More comprehensive measures include replacing existing lawns with native or local vegetation, and replacing drives and trails with pervious paving.

For new buildings, site planning should include minimizing impervious surfaces, protecting ecologically sensitive areas of the site, and increasing penetration through vegetation. Consider measures such as reducing lane length, limiting the re-division of existing terrain, minimizing building footprint and protecting existing vegetation.

BLOCKS

Block is consisted by a series of lots which constitute by different composition methods. Between the lots, there are some public spaces that belong to the community and not to the city. The scale and privacy of these public spaces are different from those of lots and cities. Therefore, when designing LID in these spaces, should consider which LID facilities are suitable for this spatial scale. We divide the blocks into three categories: midblock easement, green alley block, frontage block type.

● Midblock easement

When designing for LID at the block scale, several shared strategies can be implemented around an easement. The midblock easement connects individual parcels to a shared open space. This allows for conservation of existing habitat, pedestrian trails, and LID utility zones that bundle delivery of ecological services. Stormwater runoff from the house, driveway, and turf grass would enter the treatment system through a series of rain garden tributaries that extend to the shared LID easement. For redundancy and optimal networking, stormwater overflow from the street could be harbored in the midblock easement through connecting bioswales. The LID easement needs to be carefully coordinated with new and existing utility easements, which typically prohibit tree planting.

●Green alley block

The type of green alley block is already have an existing access and utility corridors, urban alleys. It can be easily retrofitted to function as a LID utility. Due to low Traffic flows, the alley could be resurfaced with pervious Paving and lined with bioswales to allow for stormwater Infiltration and treatment. As with any pervious surface, The alley should be kept clean of dirt and debris. Green alleys are Vital alternatives to overburdened streets, improving the Livability index of urban cores.

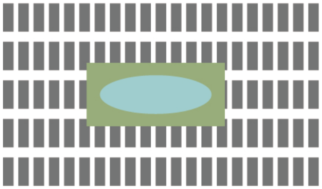
●Frontage block type

Another block configuration creates LID easements at the front of the property in a treatment network of connected bioswales. Ideally, stormwater will first pass through a network of lot-based LID facilities, and use LID frontage facilities as overflow or secondary treatment. This allows the stormwater to slow and spread before it enters the conveyance system. The LID easement also receives stormwater runoff from the street if properly sized and designed. Runoff from the street should also be filtered before it enters the connected bioswales. This can be achieved through permeable paving and filter strips. These utility landscapes can radically improve neighborhood aesthetics and functioning.

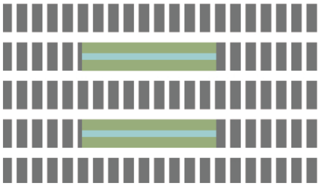
Parking lots

Parking space is another space where LID design can be done at the block level. In the parking lots, different pervious materials and LID landscape facilities can be used depending on the type, frequency of use.

The type of parking lot:



CENTER



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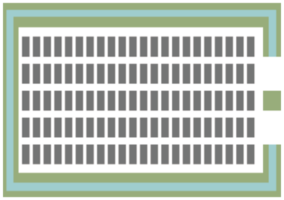
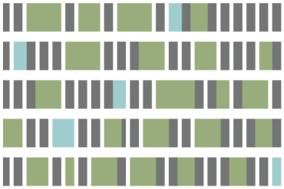
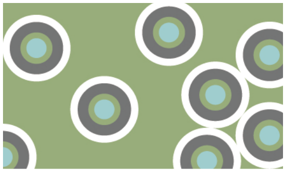


EDGES



PIXELS



PARKING GARDENS

Pixelated Parking:

Pixelated parking is an intrinsically adaptive solution, ideal for retrofits, pixel configurations propose localized replacement of impervious surfaces with absorbent landscape islands and pervious paving. Recognizing that the outer 40 percent of many commercial parking lots are only used during peak demand twice a year, the lot frontage offers an excellent public garden without sacrificing parking capacity. The pixelated parking solution reduces stormwater runoff through the addition of trees and pervious paving, eliminating the need for conventional pipe-and-pond solutions.

Water from impervious drive aisles flows to the pervious parking stalls, slowing and redistributing runoff. Through curb cuts, or flush curbs, the water is directed to vegetated islands, which are connected by a bioswale or underground oversized pipe. Peak flows eventually end in an overflow infiltration basin for groundwater recharge. If space is unavailable for an infiltration basin or other detention facility, stormwater can be detained in an underground storage facility for slow release into the municipal stormwater system.

Pixelated parking in the Chesapeake Bay,USA

Parking Gardens:

Parking garden gives new function to parking space.Beacuse conventional parking lots are simple land uses with equal effectiveness in a variety of configurations. Rather than conceive of the lot as a storage space, think of the parking lot as a stormwater garden with landscape architectural features. In the illustrated case, parking garden configurations propose a set of tangent LID landscape modules that function as a treatment network while larger green spaces at the outer areas serve as percolation parks for larger storm events. As withpixelated parking configurations, stormwater runoff begins in the drive aisle. Each parking garden is sloped toward the center allowing runoff conveyance over pervious paving into the rain garden. Rain gardens are connected to infiltration basins by underground perforated pipe to handle overflow from larger storm events. This is the most efficient configuration, as the car sits in its own treatment facility, minimizing runoff conveyance to remote facilities.

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Botanical Gardens Parking,USA

Street

The street occupies 25% of our urban landscape and is the key to LID implementation. However, since street design was specialized by civil engineers in the 1920s, two basic urban services have dominated street design standards - maximizing hourly lane flow and displacement. LID supports the return of urban services (ie, gatherings, play, business and leisure) that the street and its public access rights have provided. Unlike traditional streets, LID Street introduces facilities that provide a full range of ecological services. Remember that public access rights include streets, sidewalks, bicycle lanes, utilities, rainwater management infrastructure, and landscape systems.

Like smart buildings, streets can be designed to work ecologically, amplifying sensible use of natural resources rather than becoming another responsibility. LID streets or green streets are context sensitive and are designed to accommodate multiple modes of transportation, ensure pedestrian and bicycle safety, enhance sociality, and provide eco-based rainwater management. LID rainwater management objectives include minimizing impervious pavement and maximizing landscape space. This may require the design of new street geometries, such as the Dutch-style “shared street”, which is basically configured like a series of public gardens rather than strict traffic corridors.

When designing a green street, it is important to coordinate the utility infrastructure for easy access and management. Utilities should not be located in LID rainwater facilities to prevent damage to vegetation when utilities are needed.

Components of Streets

Which components can be used in LID design on the street?

Designing for curbs:

Perforated pre-cast curbs

Can be installed in new developments to allow water flow.
- Sediment Capture: Low
- Traffic Level: Moderate/High
- Maintenance: High

Pre-fabricated curb inserts

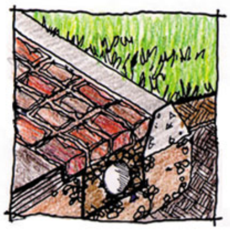
Can be used in a retrofit of an existing curb or new construction, while maintaining the curb's structural integrity.
- Sediment Capture: Low
- Traffic Level: Moderate/High
- Maintenance: High

Curb cut

Can be cut in a retrofit or new construction. Curb cuts can vary in length, allowing for greater flow control.
- Sediment Capture: Low
- Traffic Level: Moderate
- Maintenance: Moderate

Flush curb

Maximizes uniform distribution of water from the street to the treatment facility. Used with a shallow, half inch lip, water can pond, allowing sediment to settle for eventual removal by street sweepers.
- Sediment Capture: Low
- Traffic Level: Moderate/Low
- Maintenance: Low



Paving strip with sediment trench

Can filter sediment from street runoff, and serve as a tactile warning for straying automobiles.
• Sediment Capture: Moderate
• Traffic Level: Moderate/Low
• Maintenance: Low

Double flush curb with sediment trench

An aggregate trench between flush curbs captures sediment, keeping it out of the treatment facility.
• Sediment Capture: High
• Traffic Level: Low
• Maintenance: High

Designing for Urban Trees:

Streets should be designed to accommodate tree root growth—the most critical factor in implementing tree lined streets.

Healthy trees are an important part of green infrastructure and urban forestry. Shade planted along hard surfaces reduces the heat island effect and improves air quality. In addition to being a carbon sink, trees reduce stormwater runoff by interception, evapotranspiration, penetration of rainfall, and flow attenuation. Trees help to create a sense of place, reduce noise and glare, and provide a safety barrier for pedestrians, which is why the value of neighbors increases with their presence.

Utility: locate underground facilities far from the root system. Digging a trench can do irreparable damage to the roots. The adoption of tunneling or trenchless techniques to facilitate the non-destructive installation and inspection of public infrastructure.

Seeder dimensions: for a continuous seeder, the minimum width of a small street is 6 feet and the minimum width of a main street is 8 feet. For a tree well, the minimum area should be 5'x 10'. Soil: avoid soil compaction during construction. The ideal soil for the planting area is sandy loam, and the perimeter requires a structured soil beneath the impervious surface in which the mature root system will be located.

Street Types

According to different scale and functions of street, streets can be roughly divided into the following categories:

Skinny Streets:Create narrower streets to reduce runoff loading and substitute pervious paving for impervious surfaces to encourage stormwater infiltration.

Wide streets generate large stormwater runoff peak loads due to their extensive impervious surface area. Since the 1990s, many cities have revisited their street design standards, subsequently adopting narrower street profiles, some as narrow as 20 feet wide for low traffic volumes, while still accommodating emergency vehicle access.

Reducing the width of streets provides a number of benefits. While many may initially assume they are unsafe, these narrow roads, or “skinny streets” actually reduce average speeds and vehicle accident rates. Economic benefits include reduced street maintenance and resurfacing costs, while environmental benefits include reduced urban heat island effect. Soft-engineered streets provide stormwater runoff attenuation and filtering. However, such facilities handle only one to two-year storm events, requiring connection to a treatment network for larger events.

Shared Streets: Design local streets as landscapes that balance the social needs of pedestrians, transit, and stormwater management.

Shared streets, or “livable streets”, are public spaces that allow vehicles, pedestrians and bicyclists to safely share the street without the conventional mode separators like lanes, sidewalks, and curbs. Shared streets are designed as multipurpose landscapes that calm vehicular traffic. They provide LID management functions, and reclaim social functions lost to the automobile’s dominance. Instead of investing in standard traffic calming devices such as speed bumps, humps, and regulating signs, the shared street employs varied street geometries that compress the optical width of the throughway. The uncertainty and intrigue intrinsic to the spatial structure of the shared street becomes a “mental speed bump”, which naturally slows motorist speed.

While they deliver numerous social services (i.e., recreation, crime prevention, traffic calming, and conviviality), shared streets are ideal LID treatment facilities. The uniquely integral public right-of-way configurations in shared streets allow for a full range of water management functions throughout the streetscape. Since curbs are eliminated per design, parking stalls (and in some cases drive aisles) can be constructed of pervious paving, and open areas can be used as constructed wetlands to filter and infiltrate stormwater runoff. Distributed facilities should be connected with oversized or perforated pipe to create redundancy and sized according to the amount of stormwater runoff expected to enter the street. Stormwater runoff can also be harvested and stored underground for later use.

Shared streets are typically implemented in residential areas with low traffic volumes. Though superior living environments, they are an uncommon street typology in America, with the closest concept being a town square, plaza, or pedestrian promenade that artfully accommodates all modes of transportation. Due to the shared street's unique street geometries and use of vegetation in the public right-of-way, city code variances may be required.

Eco-Boulevards: Create streets with green medians that also deliver water treatment services.

The term "boulevard" originated in France and describes an elegant, wide road that uses a vegetation broker to separate the arterial passage from the slower pace of the local streets. The middle belt slows down the journey, buffering oncoming traffic and providing vegetation to shade the road. Streets facilitate walking by providing a safe, attractive and comfortable social environment. Ecological boulevards improve street types throughout the region by using middlemen for stormwater management and network connectivity.

Ecological boulevards use long strips of public roads to transform them into green infrastructure. Stormwater runoff flows through impervious roadways towards the edges of the ecological boulevards and through specified containment strategies into the interlayer of vegetation, which may include the removal of raised kerbs. The median is suppressed and converted to biological effuent, allowing drainage and penetration. To reduce the fIow, divide the median by check the dam or stump. In response to larger storm events, ecological avenues can be connected to traditional storm water systems or open space greenways for rainwater delivery. Common features of eco avenue include bike paths and wide sidewalks. When used for commuting, the bike path is located near the street, and when used for recreation, the bike path is separated by strips of vegetation . Although ecological promenades should be designed to be narrower street widths (11-foot carriageways) than traditional avenues, they are usually associated with large impermeable surface areas. Greater stormwater capacity should be used to compensate for greater runoff.

Ecological boulevards are located in developed areas with active walking activities. Through the use of narrow lanes and roadside parking, ecological boulevards should be designed to operate on low speeds. Sidewalks should be well lit and free from obstructions. One obstacle to the ecological President is the prohibition on public right of way for urban regulations on LID rainwater facilities, which need to be changed or modified. Utilities should be located outside of LID storm water facilities to prevent damage to vegetation when utilities are needed. If there is not enough system redundancy, mining LID facilities will reduce rainwater management performance. Instead, utilities can be placed under sidewalks or streets according to city regulations.

Parkways:Improve the street right-of-way akin to a greenway landscape.

Parkways integrate multiple urban functions of the existing main highway landscape, creating a unique transportation system with environmental, social and architectural functions. Combined with the services provided by pedestrian-oriented greenways and trails and highways, these pathways are adapted to different modes of transport and their inherent speeds. Parkways connect the area to local interests and optimize transportation quality of parks and green infrastructure .

In addition to the pedestrian facilities, the boulevard also contains LID handling facilities. LID facilities used on park roads provide ecological services that traditional roads do not have , such as habitat protection, protected buffer zones, and flood retention. With greater right-of-way, the park can handle storms of one to two years and larger events of 25 to 50 years. Parkway offers a unique urban landscape in a regional context that requires comprehensive government management and supervision.

Open space

Urban green space, or open space, consists of publicly regulated land areas and waterbodies that conserve and shape the urban environment. Currently, open spaces offer recreational, aesthetic, and ecological functions, however with planning, they can deliver more comprehensive ecological services. Vegetated open space at the scale of the city and region can deliver vital ecological services not feasible at the scale of the lot, block, or neighborhood. To achieve this, open space should be comprehensively planned as a green network that maintains waterbody functioning and ecosystem connectivity through the use of designed parks, greenways, and self-organizing conservation areas.

The first recognized interconnected urban open space system in North America was Boston's Emerald Necklace designed by Frederick Law Olmsted between 1878 and 1890. This green network recognized the need for a large system to mitigate urban flooding and water pollution while serving civic and recreational needs. While other plans soon followed by similarly minded cities and their landscape architects, by the 1930s growing investments in highway infrastructure redirected attention away from urban open space development. Programs and policies recommending greenways did not emerge again until 1985 when the President's Commission on Americans Outdoors emphasized the value of interconnected greenways through a proposed national greenway network to connect cities.

basis of the watershed approach to urban development . In addition to filtration and treatment , urban-scale open Spaces support the regional watershed's ability to recharge aquifers and groundwater to sustain the river's basic flow . Open space connectivity is critical to maintaining wildlife habitats and migration corridors that support urban biodiversity and some of the high-water mammal species familiar to urban areas that require more than 50 square miles per adult . Above all , a healthy open space network of a strong local genetic library can sustain the development and maturity of the ecosystem.

One of the biggest contributors to contemporary ecological dysfunction is the vastness of urban development . Urban sprawl leads to habitat loss , fragmentation , and loss of valuable ecological diversity . Perhaps the highest aspiration that cities and regions can achieve is to stop the destruction of existing habitats and plan an interrelated

greenway system to restore the damaged ecological structure . Because ecosystems often exceed legal boundaries , cumulative land-use decisions at the local level can have adverse effects on river basins at the regional level . Each pollution input at the local level has a compound effect on urban runoff . The negative effects eventually lead to unhealthy river flows characterized by flooding , altered stream morphology , elevated levels to nutrients and pollutants , excessive erosion of riverbank deposits , and loss of species diversity . Therefore , local decisions play an important role in protecting biodiversity and require a watershed approach from / to the scale of local development .

Conservation Development:

Preserve native vegetation, sensitive ecological habitat, and open space by using conservation development techniques.

While lots in conventional neighborhoods may be large, their natural landscapes are usually replaced by industrial lawns that diminish ecological functioning. Despite their low densities, sprawling subdivisions ruin viewsheds that initially attracted property investors to the site.

Conservation design deeds primary conservation areas, such as wetlands, waterbodies, floodplains, and steep slopes, to a public or quasi-public interest. Secondary conservation areas such as prime agricultural land, forested areas, critical ecological habitat areas and upland buffers should also be considered for preservation. Subsequent steps include siting houses, roads, and trails in clustered configurations without sacrificing privacy. Conservation design allows for the same

number of homes as a conventional development, with greater savings in infrastructure costs due to shorter street lengths. As numerous real estate studies have shown, increased density and shared open space also offer spatial unity and ecological integrity while creating premium market value.

Treatment Parks:

Introduce stormwater management as another
ecological service delivered by urban parks.

Public parks are typically conceived as places for passive or active recreation. When people consider sustainable development they usually think of buildings. Yet, parks can readily integrate recreation with stormwater management, resulting in improved environmental performance, greater community benefits, and reduced maintenance costs. While it is easier to implement LID facilities in new developments, opportunities are available for retrofitting existing developments as well.

An emerging trend for retrofitting existing urban infrastructure involves the incorporation of stormwater treatment parks.

Like all LID landscapes, parks should be considered as interdependent and interconnected spaces that share systems of soil, water, vegetation, and topography. A treatment park can use demonstration LID design solutions to reveal and celebrate natural processes that slow, spread and soak stormwater. Treatment parks are designed to filter stormwater from surrounding public streets, which is currently being piped and transferred to another site or treatment plant. Stormwater treatment becomes an asset instead of a liability, didactically teaching the community about ecological stewardship in managing the urban environment.

Water Harvesting Parks: Recycle stormwater runoff as irrigation for high maintenance parks, such as community gardens and sports fields.

Harvesting rainwater is not a new concept, just a forgotten one. Before the advent of centralized municipal water supply systems, communities relied on rainwater harvesting as a source for household, landscape, and agricultural water needs. Rainwater was collected from roofs and stored on site in cisterns. The proliferation of centralized, reliable water treatment and distribution systems in urban areas has displaced rainwater harvesting practices. However, a renewed interest in wise resource use has emerged in response to the rising energy cost of moving water around. Water scarcities are occurring even in traditionally water-rich regions like those in Florida and around the Great Lakes.

While it would be ecologically ideal for all parks to contain native, low maintenance vegetation that can treat urban runoff, this may not always be practical. Large areas for organized sports and local food production require significant irrigation in order to maintain vegetation. Instead of using costly potable water as the source for this irrigation, rainwater harvesting offers a sustainable alternative. Water from surrounding impervious surfaces can be collected in a treatment network, filtered and stored. For land uses involving food production, harvested stormwater runoff must be thoroughly treated. When the water is needed, a wind driven or motorized pump can be used to draw it from storage for distribution through an irrigation system.An emerging trend for retrofitting existing urban infrastructure involves the incorporation of stormwater treatment parks.

Greenways: Connect open spaces to create an urban greenway that maintains nutrient, natural resource, and habitat flows through the city.

Greenway is an indispensable connective tissue in the open space network. These approaches protect and restore nature in urban development and have the capacity to revitalize underutilized urban sectors. The ecological, economic and social services they provide ensure their dominance as important planning tools. While the open space network will be enjoyed at the local level, regional coordination is often critical for integrated design solutions developed using ecological approaches.

In addition to creating value and economic activity for adjacent properties, greenway also provides an alternative transportation system without traffic conflicts, making it an ideal choice for leisure transportation and entertainment. They also improve their health through active living and physical activity. Greenway is the key to large-scale rainwater treatment and flood control. It can be used as vegetation buffer zone and flood basin to minimize the property loss caused by flood.

In addition to using greenways as agricultural belts or track conversion tracks, its most important incarnation is the riverbank buffer zone. The riparian buffer zone is part of a larger system called the riparian corridor, which consists of flood plains, riparian and stream channels. The riverbank buffer zone is an important intersection between land and water, providing a unique habitat while regulating sediment inputs from upland land use. Riparian buffer zones are essential to maintain healthy streams and basins.

PART 3

Case study

01.Arkadien Winnenden

02.Kronsberg Ecological Community

Through the analysis of the two existing and mature LID ecological communities, it can be seen that at the community planning level, the low-impact development concept emphasizes the use of hydrology-based land use planning through the construction, roads, open space and other aspects. The intervention has enabled the community to obtain a more effective hydrological cycle. Enlarging all aspects of the community to each part of the city can sum up the low-impact development system and the specific application of low-impact development facilities and layout features combined with urban green space, water system, landscape and architectural layout.

01.Arkadien Winnenden:

Introduction:

Arkadien Winnenden is located in Winnenden, about 20 km northeast of the city of Stuttgart.
The Zipfelbach River flows from the east side of the community. The site is an abandoned factory. Up to 95% of the impervious surface and heavily polluted soil make the area's planning very important to the relationship with the river. By changing the original surface properties, repairing contaminated soil, and using the system's low-impact development facilities, it greatly promotes the retention, infiltration and purification of rainwater, creating a comfortable and pleasant microclimate environment, and restoring the natural water cycle of the site.

In the Wennendeng community, various low-impact development facilities form a complete system, and rainwater infiltration facilities such as green roofs and pervious pavements collect rainwater and merge them into open channels or grass ditch, which are then transported to sinking green spaces around the building. Or large-scale bioretention ponds in the center of the group for purification and treatment. The treated rainwater is eventually discharged into the Zipfelbach River on the east side and into the river system of the area. This approach allows stormwater runoff to be transmitted throughout the stormwater management network.

Analysis:

Building:

Stone swale: Arranged under the rainwater pipe. A considerable part of the vegetation in the plantation is also planted and maintained by the residents themselves.
This will trap some of the rainwater, and the excess rainwater will spill directly into the grass or water storage facilities.

Property:

Rain garden: A number of short-formed piles of natural form are scattered throughout the green space, which can be used to record changes in water levels and enhance the participation and interest of rainwater facilities.

Pervius pavement: In the community, the pavement are paved with pervious asphalt, and the sidewalks also use pervious bricks and recycled granite, successfully reducing the impervious surface from 95% to only 50%.

Street:

Open channel: The community mainly uses open channels to transport rainwater. The open channel section is a gentle parabolic shape paved with small stones. It is mainly placed on the side of the road and under the rainwater pipe of the residential building. The surface runoff is infiltrated through the gap of the open channel stone. The texture of the material is different from the road, which plays a role in distinguishing the type of road and indicating the direction of the road.

Open space:

Artificial Lake: Provides a beautiful landscape for the community, as well as rainwater runoff from other low-impact development facilities in the community, which is the main area for rainwater storage. Rainwater treated by artificial lakes can be used for waterscape construction, greenland irrigation and car washing in the community.

Conclusion:

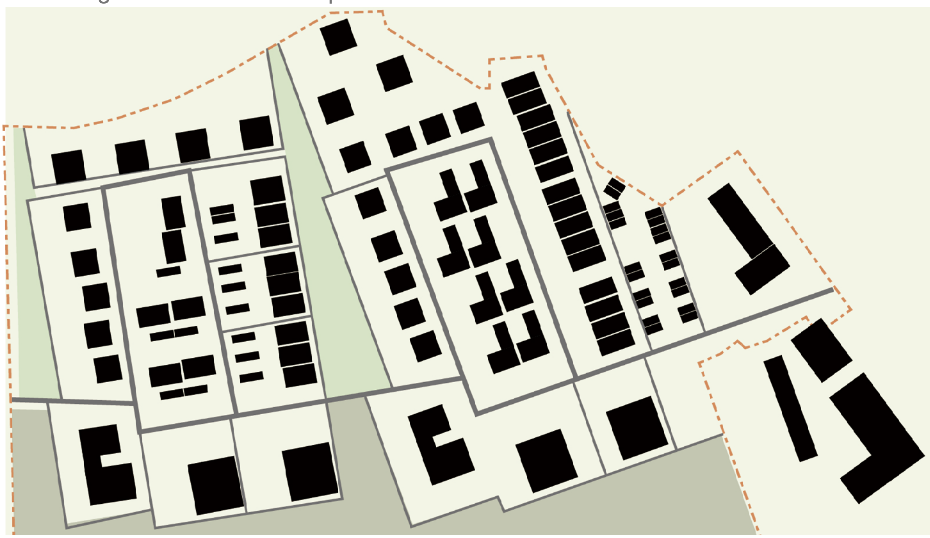
Rainwater management is carried out through a series of low-impact development facilities. The proportion of impervious surfaces in the site is reduced from 95% to 30%, and the retention capacity is about 850m3. All rainwater will be naturally purified and some will be purified by artificial equipment. 90% of the stormwater runoff is consumed within the community rather than entering the municipal pipeline, thus reducing the pressure on the construction of the municipal network.

02.Kronsberg Ecological Community:

Introduction:

The Kongsberg community is located in the southeastern part of Hannover, the capital of Sachsen, Germany, 9 km from the city centre. The planned total area is 150 hectares, providing 6,000 housing units for 15,000 residents. The community is built with high ecological standards. At present, 63 hectares have been built in the first phase. Its scale and facilities are equivalent to a complete community, including three kindergartens and one Primary school, a middle school, a church and a medical center.

In the early 1990s, housing demand in Hanover was extremely urgent. The Kongsberg area takes advantage of the new concept of housing construction. The construction of the community follows the requirements of regional planning, and works closely with Hanover's planning, environment, water, roads and other departments to develop residential buildings along the public rail transit lines to create sustainable neighborhood relationships.



Analysis:

Building:

Green roof: The building adopts the method of roof greening, and some of them adopt the form of sloping roof, which can well store rainwater and delay the ineffective loss of rainwater.

Water storage: 12~30m wide sunken lawn.It also combines local stone, vegetation and trails to create a richer landscape.

Property:

Rrain garden: In the center of the block, a rain garden is arranged, with a width of 25~35 meters. It is usually used as a space for rest. During the rainfall, the runoff from the block is collected for infiltration and purification.

Perious pavement: Increase surface water permeability and reduce runoff. Surface runoff that exceeds the amount of seepage through the permeable floor will collect into the nearby permeable zone indicating the ditch.

Street:


Grass ditch: The grass ditch is about 30~40 cm deep and is arranged along the side or sides of the main and secondary trunk roads of the community between the parking belt and the sidewalk. It can quickly collect rainwater runoff from roads and plots, and then purify and flow to water storage facilities, greatly improving the quality of living environment and water use efficiency.

Open space:

Rainwater Greenway: 12~30m wide rainwater greenway that can penetrate rainwater, control runoff and flow rate, and also serve as a large public space and linear green corridor in the community.

Large rainwater retention area: It is planted with local weeds and trees. It can be used as a park green space, and the overall landscape is full of original natural atmosphere. When it rains, it can accommodate rainwater from the community to avoid internal disasters.

Conclusion:

The Kongsberg community developed the design through low-impact systems. The community's runoff after development was maintained at 19mm, close to 14mm before development, and the rainwater was completely eliminated within the community.

At the same time, the rainwater management concept of low-impact development has also enabled community residents to have a more acute understanding of the ecological concepts promoted by the community through a series of visualized facilities, and promoted the coordination between residents and the environment.

PART 4

The LID methods in different section of city

Why the city of Prato adopts LID standards and practices?

Pollution in Prato, Italy

Air Pollution	41.67	Moderate
Drinking Water Pollution and Inaccessibility	50.00	Moderate
Dissatisfaction with Garbage Disposal	50.00	Moderate
Dirty and Untidy	50.00	Moderate
Noise and Light Pollution	50.00	Moderate
Water Pollution	50.00	Moderate
Dissatisfaction to Spend Time in the City	33.33	Low
Dissatisfaction with Green and Parks in the City	50.00	Moderate

Purity and Cleanliness in Prato, Italy

Air quality	58.33	Moderate
Drinking Water Quality and Accessibility	50.00	Moderate
Garbage Disposal Satisfaction	50.00	Moderate
Clean and Tidy	50.00	Moderate
Quiet and No Problem with Night Lights	50.00	Moderate
Water Quality	50.00	Moderate
Comfortable to Spend Time in the City	66.67	High
Quality of Green and Parks	50.00	Moderate

Air pollution data from World Health Organization

PM_{10}	29
$PM_{2.5}$	20
PM_{10} Pollution Level:	Low to Moderate

Index

Pollution Index:	52.30
Pollution Exp Scale:	87.94

Retrieved from: https://www.numbeo.com/pollution/in/Prato

LID benefits for Prato:

1.The City of Prato adopted LID standards and practices in future developments and redevelopments to encourage the following:
2.Beneficial use of rainwater and urban runoff.
3.Water quality improvement.
4.Rainwater harvesting.
5.Reduction of offsite runoff and provide increased groundwater recharge.
6.Reduction of erosion and hydrologic impacts downstream.
7.Enhancement of recreational and aesthetic values in our communities.

The sections of city

Z1 **Historical city center:** It consists of historical buildings that are extremely important to urban culture. Residential areas are mixed with commercial areas and there are more tourists.It is usually the most core part of the city.

Z2 **City center:** Compared to the historical city, the difference lies in the quality of the building and its function. It is the core of urban economic commerce, with many building layers, wide roads and high density. The functional areas of each part are clear, and there are large parking lots and central greening. The residential area is modern and of high quality.

Z3 **General urban:** It is mainly based on relatively concentrated urban residential areas, accompanied by commercial, service and green space matching the demand of residential areas. The functional partition is relatively obvious. Building density began to decrease.

Z4 **Sub-urban:** Consists of low density residential areas, adjacent to higher zones that some mixed use. Home occupations and outbuildings are allowed. Planting is naturalistic and setbacks are relatively deep. Blocks maybe large and the roads irregular to accommodate natural conditions.

Z5 **Rural:** Consists of sparsely settled lands in open or cultivated states. These include woodland, agricultural land, grassland, and irrigable desert. Typical buildings are farmhouses, agricultural buildings, cabins, and villas.

Z6 **Agriculture:** Consists of lands approximating or reverting to a wilderness condition, including lands unsuitable for settlement due to topography, hydrology, or vegetation.

Code approach

Historical city center

It consists of historical buildings that are extremely important to urban culture. Residential areas are mixed with commercial areas and there are more tourists.It is usually the most core part of the city.

	Characteristics	Request	Intervantions of LID
Building	High density, historically significant,diverse form, low height, Most of them are slope roof, no transition zone with street.	Does not affect the quality of historical buildings and the historical environment and atmosphere.	● Ground: stone swale, Underground storage 
Property	Small scale, scattered distribution.	Suitable for small scale environments and crowded block type.	● Lawn:Xeriscape lawns, rain garden  ● Parking lot: Pervious paving,center parking,band parking 
Street	Road network density is high, road surface is narrow, people, bicycle and vehicles are less diverted,green form is not uniform.	Small scale, does not affect traffic, can be connected withbuildings.	● Skinny streets  ● Shared streets  ● Eco-boulevards 
Open Space	Small and scattered, most combined with historic buildings.	Small scale, can exist in historical buildings and meet demand.	● Treatment Park 

City center

Compared to the historical city, the difference lies in the quality of the building and its function. It is the core of urban economic commerce, with many building layers, wide roads and high density. The functional areas of each part are clear, and there are large parking lots and central greening. The residential area is modern and of high quality.

	Characteristics	Request	Intervantions of LID
Building	Most of the high-rise buildings with flat roofs have high building density and high quality. There is a small square and green space between the street as a transitional space.	Cooperate with different structure and materials, to meet the needs of different hight of building and large water storage.	Roof: Green roof; Ground: Underground storage
Property	The scale is large, the function is concentrated, and the form is single. There are different needs in different time.	It can improve the urban environment and meet the different needs of these spaces at different time.	Lawn:Xeriscape lawns; Parking lot: Pervious paving,band parking
Street	Road network density is high, road surface is narrow, people, bicycle and vehicles are less diverted,green form is not uniform.	Small scale, does not affect traffic, can be connected with buildings	Skinny streets; Shared streets; Eco-boulevards
Open Space	Mostly city center parks, squares, etc.	Can meet the needs of beautifying the city.	Treatment Park

General city

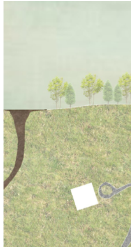
It is mainly based on relatively concentrated urban residential areas, accompanied by commercial, service and green space matching the demand of residential areas. The functional partition is relatively obvious. Building density began to decrease.

	Characteristics	Request	Intervantions of LID
Building	High density, historically significant,diverse form, low height, Most of them are slope roof, no transition zone with street.	Does not affect the quality of historical buildings and the historical environment and atmosphere.	• Roof: Green roof • Wall: Green wall • Ground: Underground storage and rain chain
Property	Small scale, scattered distribution.	Suitable for small scale environments and crowded block type.	• Lawn:Xeriscape lawns, rain garden • Parking lot: Pervious paving,band parking, edge parking
Street	Road network density is high, road surface is narrow, people, bicycle and vehicles are less diverted,green form is not uniform.	Small scale, does not affect traffic, can be connected withbuildings.	• Skinny streets • Shared streets • Eco-boulevards • Parkways
Open Space	Small and scattered, most combined with historic buildings.	Small scale, can exist in historical buildings and meet demand.	• Treatment Park

Sub-urban

It consists of low density residential areas, adjacent to higher zones that some mixed use. Home occupations and outbuildings are allowed. Planting is naturalistic and setbacks are relatively deep. Blocks maybe large and the roads irregular to accommodate natural conditions.

	Characteristics	Request	Intervantions of LID
Building	The building placement isdeep and variable front and side yard setbacks,typical height is 1- to 2-story with some 3-story.	Roof rainwater can be collected and treated for secondary use.	● Roof: Green roof ● Wall: Green wall ● Ground: Underground storage
Property	With both a front and a back yard,It will most likely be relatively small — at least when compared to the yards you'll find in rural settings.	Add some LID intervention.	● Lawn:Xeriscape lawns, rain garden ● Parking lot: Pervious paving,pixels parking
Street	Thoroughfare Types are roads, streets, avenues, bikeways.	Improve the existing situation	● Shared streets ● Eco-boulevards ● Parkways
Open Space	Civic Space Types are parks, greens, greenways, playgrounds.	Make best use of the good open space, to do something to improve the quaity.	● Treatment Park ● Conservation development ● Water harvesting parks



Rural

It consists of sparsely settled lands in open or cultivated states. These include woodland, agriculturalland, grassland, and irrigable desert. Typical buildings are farmhouses, agricultural buildings, cabins, and villas.

	Characteristics	Request	Intervantions of LID
Building	Building Placement is variable setbacks,typical height is 1- to 2-story.	Roof rainwater can be collected and treated for secondary use.	● Roof: Green roof ● Wall: Green wall ● Ground: Rain chain
Property	There are plenty of small towns in rural areas where houses have large yards.	Add some LID intervention.	● Lawn:Xeriscape lawns
Street	Thoroughfare Types are roads, bikeways.	Improve the existing situation	● Shared streets
Open Space	Civic Space Types are parks, greenways.	Make best use of the good open space, to do something to improve the quaity.	● Water harvesting parks ● Greenways

Agriculture

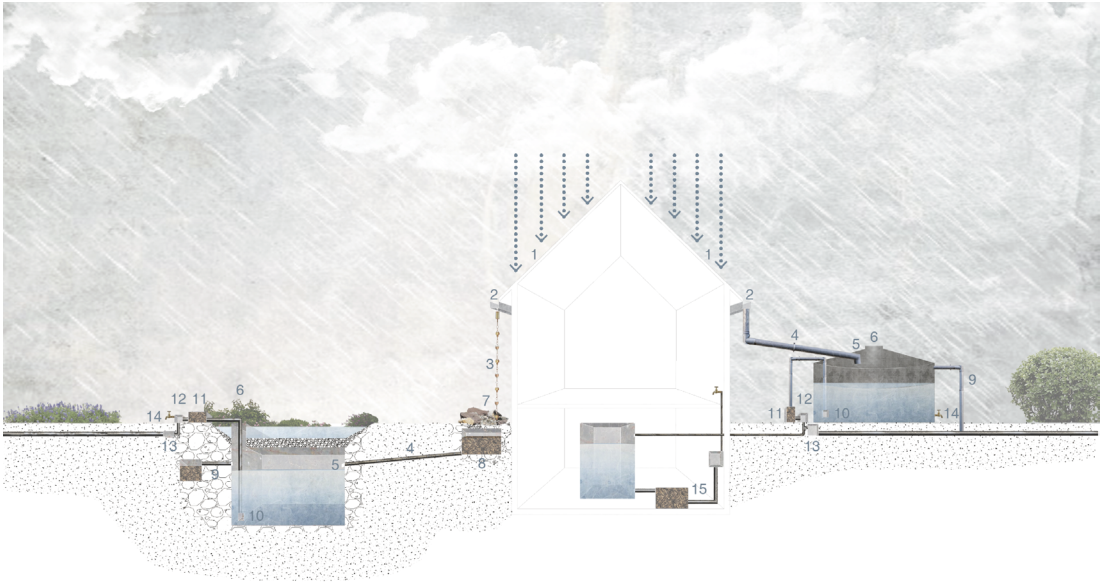
It consists of lands approximating or reverting to a wilderness condition, including lands unsuitable for settlement due to topography, hydrology, or vegetation.

	Characteristics	Request	Intervantions of LID
Building	Not applicable	No	
Property	Not applicable	No	
Street	Thoroughfare Types are rural roads, highways, parkways, bikeways.	Improve the existing situation	• Shared streets
Open Space	Civic Space Types are parks, greenways.	Make best use of the good open space, to do something to improve the quaity.	• Water harvesting parks • Greenways

LID intervantion system in each layer:

How the LID intervantions work in each different layer and how they treat the rainwater as a network so that it can be recycled and reused.

Building:

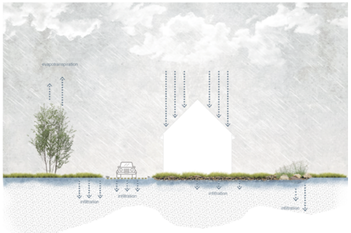


1. runoff collection surface
2. gutter with leaf screen if located adjacent to a tree
3. rain chains
4. pipe to cistern or tank
5. rainwater inlet
6. access for service or maintenance
7. stone swale
8. debris and sediment interceptor, first-flush device
9. cistern or tank overflow, connects to an irrigation system or infiltration trench for recharge
10. landscape irrigation supply filter
11. optional sand filter
12. irrigation and pressure pump
13. water supply line to irrigation system
14. hose bib
15. optional greywater or potable water connections with filtration system

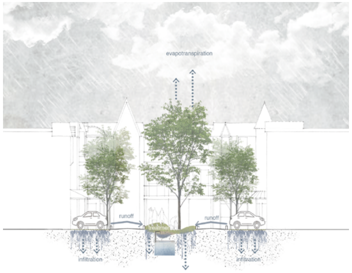
LID intervantion system in each layer:

How the LID intervantions work in each different layer and how they treat the rainwater as a network so that it can be recycled and reused.

Property:

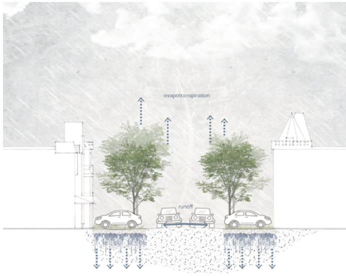


Lot



Block type1: midblock easement

Block type2: green alley block

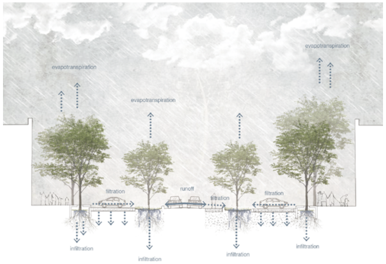


Block type3: frontage block type

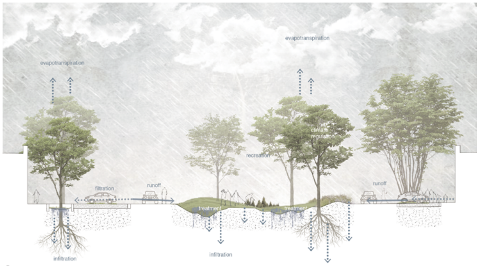
LID intervantion system in each layer:

How the LID intervantions work in each different layer and how they treat the rainwater as a network so that it can be recycled and reused.

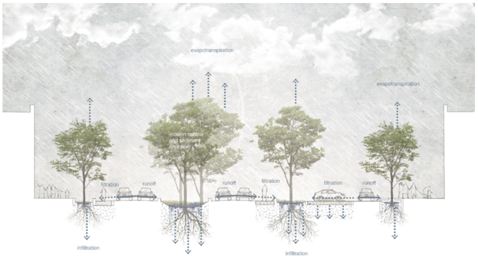
Street::



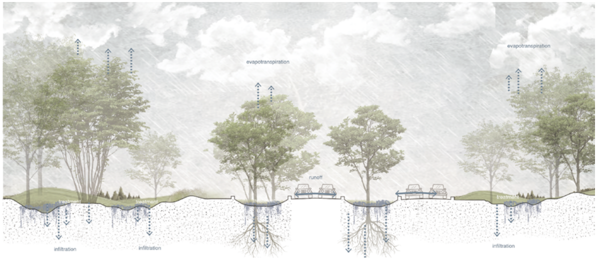
Skinny streets



Shared streets



Eco-boulevards

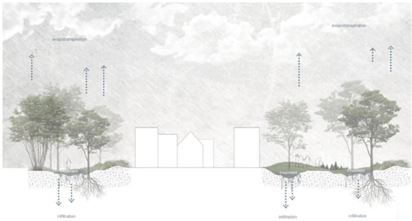


Parkways

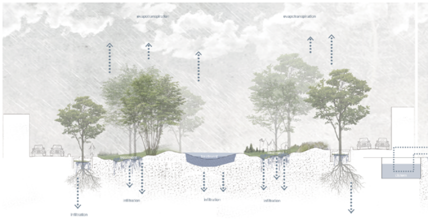
LID intervantion system in each layer:

How the LID intervantions work in each different layer and how they treat the rainwater as a network so that it can be recycled and reused.

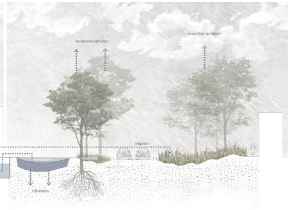
Open space:



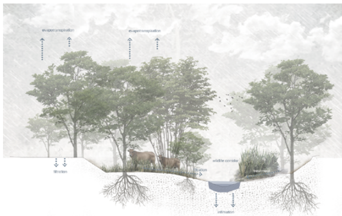
Conservation development



Treatment Park



Water harvesting parks



Greenways

PART 5

vision

Vision

Legend:

Building:

TO REGULATE rainwater flow, improve heat island effect, purify urban air and optimize ecological environment.

Plant herbaceous vegetation on the roof or high vine plants on the exterior walls of buildings.

Install a metal chain at the bottom of the cornice to drain rainwater and protect the building from rain.

TO REDUCE the exploitation of groundwater and the pressure of urban drainage system, improve the utilization rate of water resources.

Collecting and utilizing the rainfall runoff collected by the roof of building and stored in a cistern or tank on the ground, where the foundation of building is not allowed to dig.

Collecting and utilizing the rainfall runoff collected by the hardened surface of buildings such as roofs and roads, squares, etc. and stored in large underground reservoirs.

Property:

TO REDUCE the city flood peak flow, purify rainwater, reduce pollution and improve microclimate.

Artificially excavated shallow green land is used to collect and absorb rainwater from the ground. The rainwater is purified by the combined action of plants and sand, and it gradually infiltrates into the soil, conserves groundwater, or replenishes the city with landscape water and toilet water.

TO INCREASE urban surface rain permeability, improve urba green coverage and reduce urban noise.

Rearrange the existing parking area in the city,use the pervious material on the surface and insert landscape greening at meanwhile.

Street:

TO CONNECT building, property and open space to build a sustainable and integrated ecological rainwater system.

- Substitute pervious pavement in narrow street of residential area.
- Employ the pervious pavement and remove the height difference between the sidewalk and the driveway, and set up some elements(paving, rain gutters) to assist the separation between people and vehicles.
- Insert green belt which with LID intervention to separate opposite traffic in urban main road.
- Creat greenway landscape beside the highway of the city.

Open space:

TO INCREASE biodiversity and improve urban water storage capacity.

- Plant more native vegetion in low density area, such as sensitive ecological habitat and open space.
- Remanage the existing park in the city and apply the LID intervention.
- Create recycle system to store stormwater for irrigation.
- Insert a buffer belt between the ditch and high permenant agricultural area.

PART 6

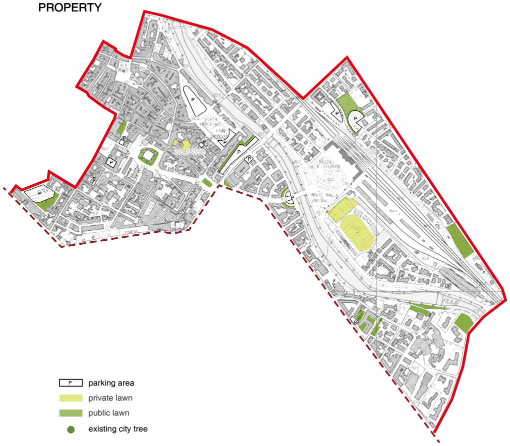
Concept plan for each city transept zone

Historical city center:

Existing situation:

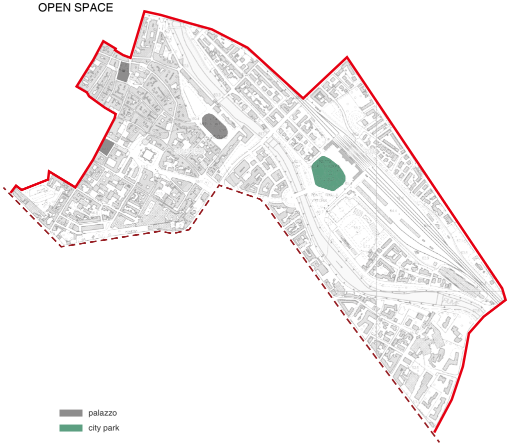
BUILDING

PROPERTY

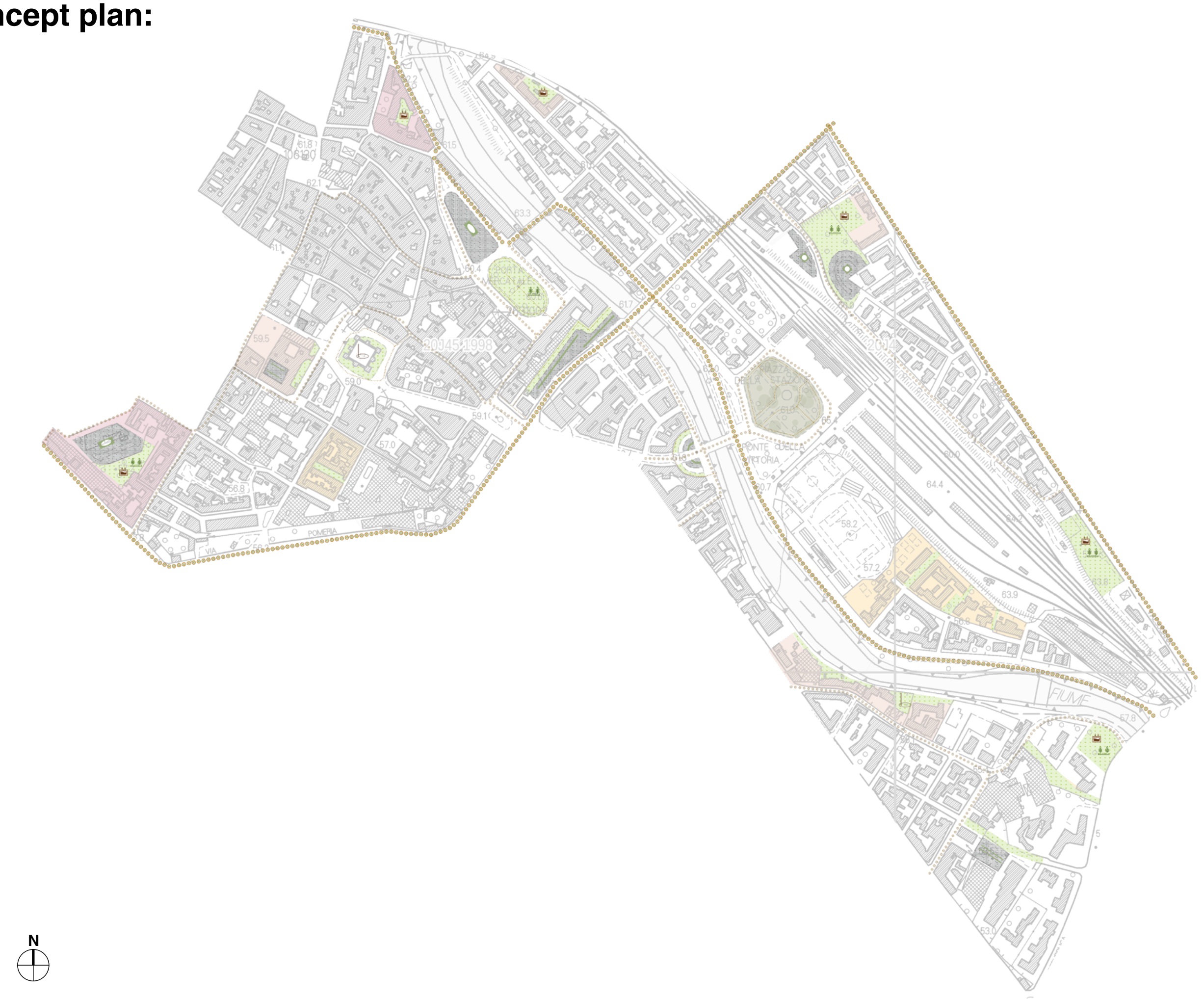


STREET

OPEN SPACE



Concept plan:



Building

Rock swale
-for ancient buildings and buildings that can be directly connected to green spaces and river，can transition vertical stormwater flow in tandem with LID facilities to aid in horizontal network distribution. At sime time, beautify urban ecological environment.

Underground storage------ under the lawn
-for groups with central green spaces or large lawn, place rainwater collection facilities below the permeable surface to collect rainwater. Facilitates can out of sight rainwater harvesting. Like on-grade rainwater harvesting systems.

Property

Lawn

Xeriscape lawns
-for all lawns in the city xeriscape lawns have significant economic and environmental benefits, such as increased biodiversity, food production, on-site infiltration, and low maintenance. A multi species mix of native grasses is already adapted to an area's climate and able to exist as a stable plant community.

Rain garden
-for all lawns in the city enhanced urban ecologies. By implementing a biodiverse treatment train across the property, stormwater can be filtered, infiltrated, and treated to improve water quality.

Parking lot

Pervious paving
-for all parking areas in the city pervious surfaces increase on-site runoff infiltration and prevent the transfer of pollution problems to another site. Pervious surfaces should be used at the beginning of the treatment network to slow and filter sediment before stormwater runoff reaches secondary LID facilities for treatment.

center parking------parking spaces for areas of landscape value or historical monumental value in the city.

band parking-------for general parking spaces, there are no special requirements for the size and location of the parking space.

Block type

Midblock easement
-the midblock easement connects individual parcels to a central shared open space. The LID facilities usually placed in the central space to receive the stormwater runoff from the house, driveway, and turf grass into the treatment system or storage facilities.

Green alley
-have existing access and utility corridors, urban alleys can be easily retrofitted to function as a LID utility. Due to low traffic flows, the alley could be resurfaced with pervious paving and lined with bioswales to allow for stormwater infiltration and treatment. As with any pervious surface, the alley should be kept clean of dirt and debris. Green alleys are vital alternatives to overburdened streets, improving the livability index of urban cores.

Frontage block
-lawns connection between the street and the block. The LID easement also receives stormwater runoff from the street if properly sized and designed. Runoff from the street should also be filtered before it enters the connected bioswales. This can be achieved through permeable paving and filter strips.

Street

Skinny streets
-create narrower streets to reduce runoff loading and substitute pervious paving for impervious surfaces to encourage stormwater infiltration in residential area.

Shared streets
-design local streets as landscapes that balance the social needs of pedestrians, transit, and stormwater management in residential areas with low traffic volumes.

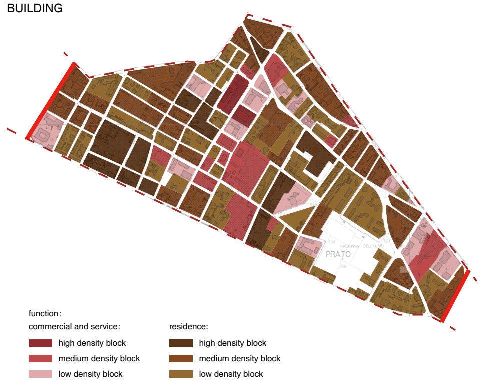
Eco-boulevards
-create streets with green medians that also deliver water treatment services to separate arterial throughways from the slower pace of local streets.

Open space

Treatment Park
-use demonstration LID design solutions to reveal and celebrate natural processes that slow, spread and soak stormwater in public open space.

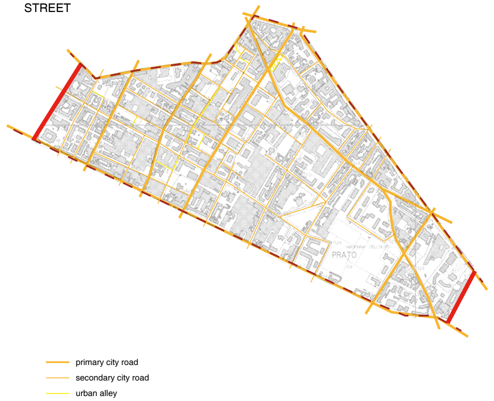
City center:
Existing situation:

BUILDING



PROPERTY

STREET



OPEN SPACE

Concept plan:

Building

Green roof
-suitable for flat roof buildings, can be used in commercial complexes in the city centre

Underground storage ------ under the building
-for the building has good condition of basement, with water storage conditions, place rainwater collection facilities below the permeable surface to collect rainwater.Facilitates can out of sight rainwater harvesting. Like on-grade rainwater harvesting systems.

Underground storage------ under the lawn
-for groups with central green spaces or large lawn, place rainwater collection facilities below the permeable surface to collect rainwater. Facilitates can out of sight rainwater harvesting. Like on-grade rainwater harvesting systems.

Property

Lawn

Xeriscape lawns
-for all lawns in the city xeriscape lawns have significant economic and environmental benefits, such as increased biodiversity, food production, on-site infiltration, and low maintenance. A multi species mix of native grasses is already adapted to an area's climate and able to exist as a stable plant community.

Parking lot

Pervious paving
-for all parking areas in the city pervious surfaces increase on-site runoff infiltration and prevent the transfer of pollution problems to another site. Pervious surfaces should be used at the beginning of the treatment network to slow and filter sediment before stormwater runoff reaches secondary LID facilities for treatment.

band parking-------for general parking spaces, there are no special requirements for the size and location of the parking space.

Block type

Midblock easement
-the midblock easement connects individual parcels to a central shared open space. The LID facilities usually placed in the central space to receive the stormwater runoff from the house, driveway, and turf grass into the treatment system or storage facilities.

Green alley
-have existing access and utility corridors, urban alleys can be easily retrofitted to function as a LID utility. Due to low traffic flows, the alley could be resurfaced with pervious paving and lined with bioswales to allow for stormwater infiltration and treatment. As with any pervious surface, the alley should be kept clean of dirt and debris. Green alleys are vital alternatives to overburdened streets, improving the livability index of urban cores.

Frontage block
-lawns connection between the street and the block. The LID easement also receives stormwater runoff from the street if properly sized and designed. Runoff from the street should also be filtered before it enters the connected bioswales. This can be achieved through permeable paving and filter strips.

Street

Skinny streets
-create narrower streets to reduce runoff loading and substitute pervious paving for impervious surfaces to encourage stormwater infiltration in residential area.

Shared streets
-design local streets as landscapes that balance the social needs of pedestrians, transit, and stormwater management in residential areas with low traffic volumes.

Eco-boulevards
-create streets with green medians that also deliver water treatment services to separate arterial throughways from the slower pace of local streets.

Open space

Treatment Park
-use demonstration LID design solutions to reveal and celebrate natural processes that slow, spread and soak stormwater in public open space.

General city:
Existing situation:

Concept plan:

Building

Green roof
-suitable for flat roof buildings, can be used in commercial complexes in the city centre

Green wall
-suitable for low-rise independent buildings away from high-density plots. They offer collateral benefits such as higher air quality, reduced heat island effect, building insulation and energy efficiency, aesthetic appeal, and filtration of roof stormwater runoff that can be conveyed or harvested.

Rain chain
-for residential buildings of 2 floors and below, Compared to rain leaders, rain chains have better attenuation capacity for one to two-year storm events.

Underground storage ------ under the building
-for the building has good condition of basement, with water storage conditions, place rainwater collection facilities below the permeable surface to collect rainwater.Facilitates can out of sight rainwater harvesting. Like on-grade rainwater harvesting systems.

Underground storage------ under the lawn
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Property

Lawn

Xeriscape lawns
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Rain garden
-for all lawns in the city enhanced urban ecologies. By implementing a biodiverse treatment train across the property, stormwater can be filtered, infiltrated, and treated to improve water quality.

Parking lot

Pervious paving
-for all parking areas in the city pervious surfaces increase on-site runoff infiltration and prevent the transfer of pollution problems to another site. Pervious surfaces should be used at the beginning of the treatment network to slow and filter sediment before stormwater runoff reaches secondary LID facilities for treatment.

band parking-------for general parking spaces, there are no special requirements for the size and location of the parking space.

edges parking-------for the parking area which have a large area of lawn or green space, to separate these two function, and to protect the green spce.

Block type

Midblock easement
-the midblock easement connects individual parcels to a central shared open space. The LID facilities usually placed in the central space to receive the stormwater runoff from the house, driveway, and turf grass into the treatment system or storage facilities.

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Street

Skinny streets
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Shared streets
-design local streets as landscapes that balance the social needs of pedestrians, transit, and stormwater management in residential areas with low traffic volumes.

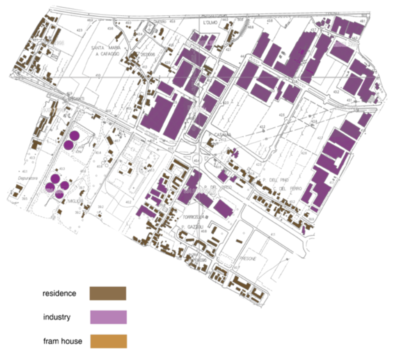
Eco-boulevards
-create streets with green medians that also deliver water treatment services to separate arterial throughways from the slower pace of local streets.

Open space

Treatment Park
-use demonstration LID design solutions to reveal and celebrate natural processes that slow, spread and soak stormwater in public open space.

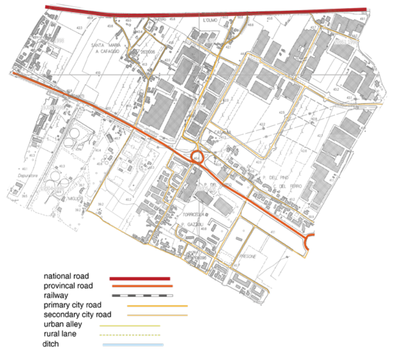
Sub-urban:
Existing situation:

BUILDING



PROPERTY

STREET



OPEN SPACE

Concept plan:

Building

Green roof
-suitable for flat roof buildings, can be used in commercial complexes in the city centre

Green wall
-suitable for low-rise independent buildings away from high-density plots. They offer collateral benefits such as higher air quality, reduced heat island effect, building insulation and energy efficiency, aesthetic appeal, and filtration of roof stormwater runoff that can be conveyed or harvested.

Underground storage------ under the lawn
-for groups with central green spaces or large lawn, place rainwater collection facilities below the permeable surface to collect rainwater. Facilitates can out of sight rainwater harvesting. Like on-grade rainwater harvesting systems.

Property

Lawn

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Rain garden
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Parking lot

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band parking-------for general parking spaces, there are no special requirements for the size and location of the parking space.

pixels parking-------for oversize centralized parking lots, commercial centers or large service areas

Street

Shared streets
-design local streets as landscapes that balance the social needs of pedestrians, transit, and stormwater management in residential areas with low traffic volumes.

Eco-boulevards
-create streets with green medians that also deliver water treatment services to separate arterial throughways from the slower pace of local streets.

Parkways
-improve the arterial highway with LID treatment facilities akin to a greenway landscape.

Open space

Conservation development
-preserve native vegetation, sensitive ecological habitat, and open space by using conservation development techniques in low density area.

Treatment Park
-use demonstration LID design solutions to reveal and celebrate natural processes that slow, spread and soak stormwater in public open space.

Water harvesting parks
-recycle stormwater runoff as irrigation for high maintenance parks, such as community gardens and sports fields.

Rural:
Existing situation:

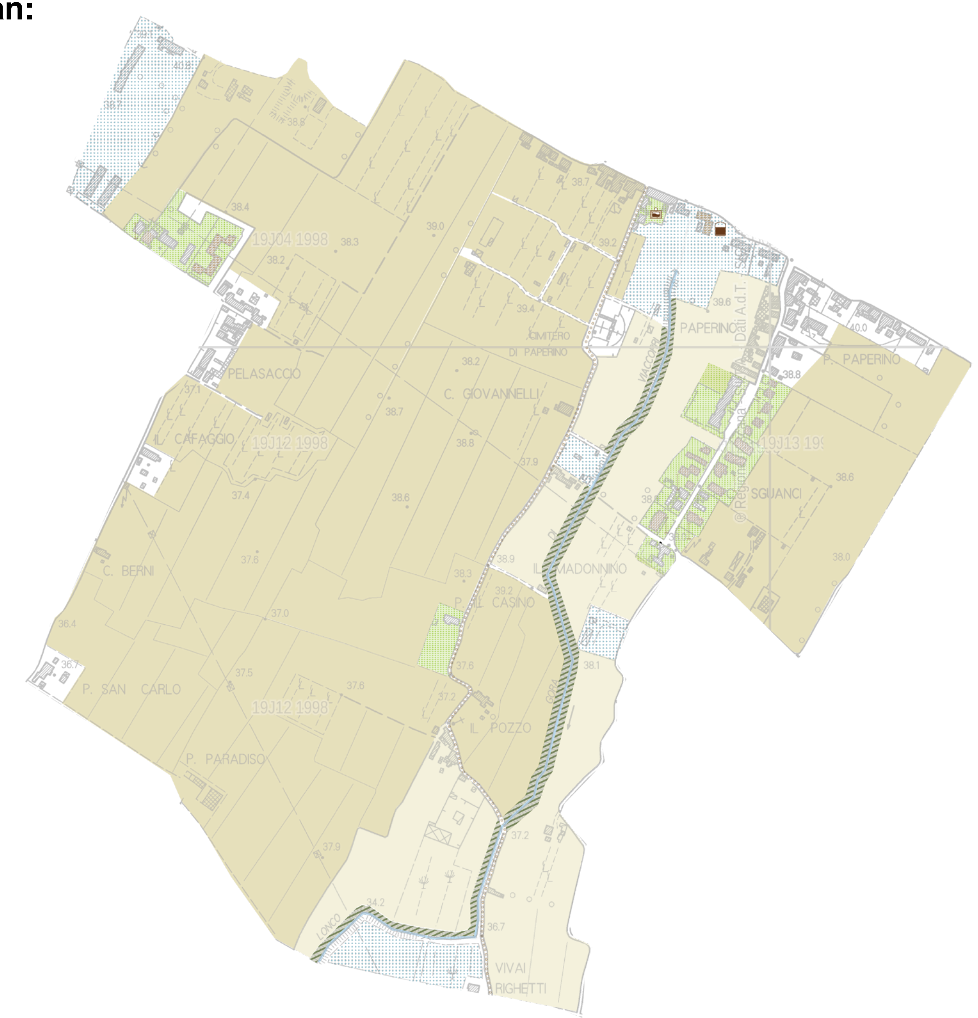
BUILDING

PROPERTY

STREET

OPEN SPACE

Concept plan:



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Street

Shared streets
-design local streets as landscapes that balance the social needs of pedestrians, transit, and stormwater management in residential areas with low traffic volumes.

Open space

Water harvesting parks
-recycle stormwater runoff as irrigation for high maintenance parks, such as community gardens and sports fields.

Greenways
-use vegetated buffers as an agricultural belt or an important ecotones between land and water.

Existing element

high permanent agricultural area

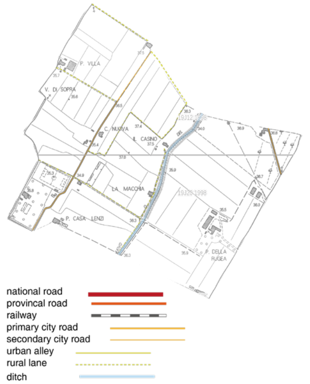
low permanent agricultural area

Agriculture:
Existing situation:

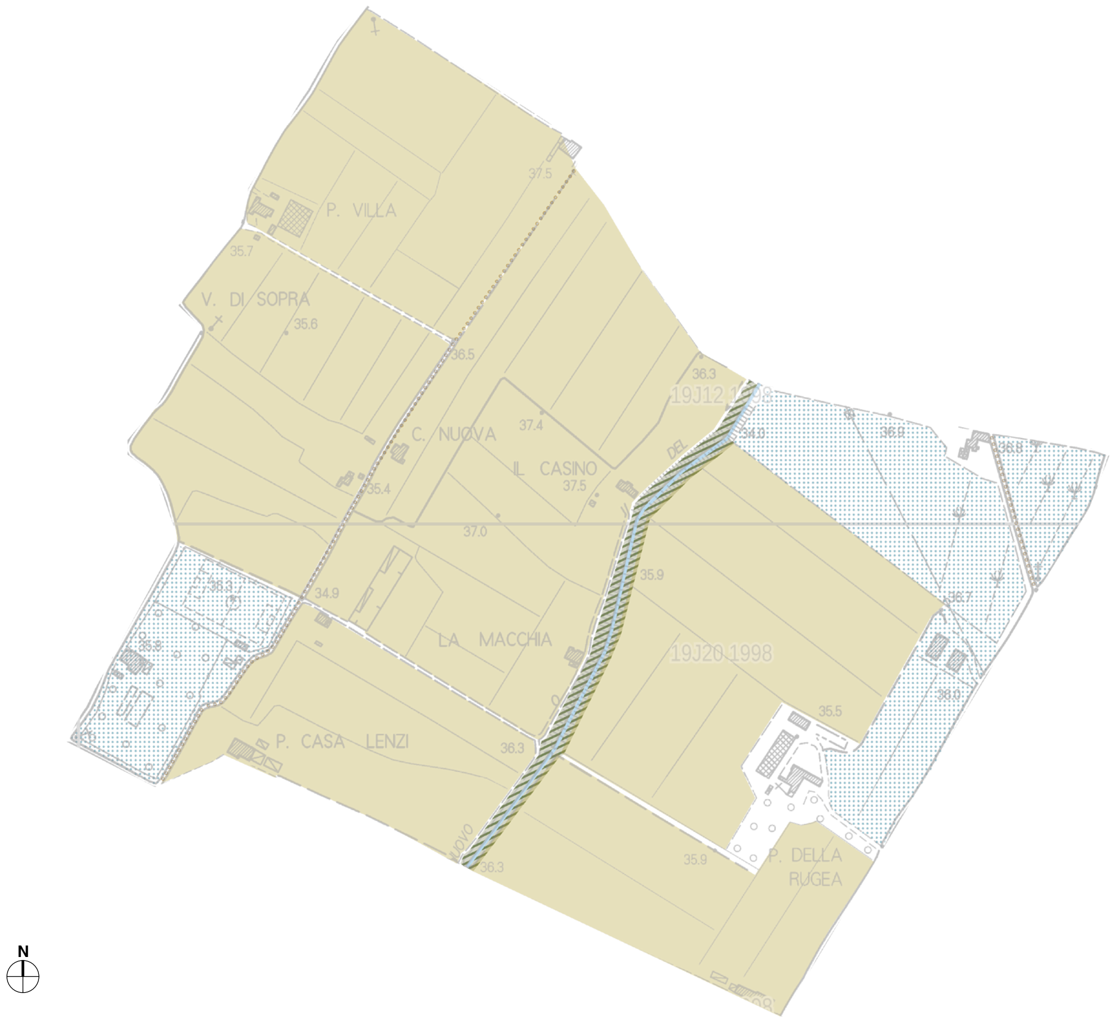
BUILDING

PROPERTY

STREET



OPEN SPACE



Street

Shared streets
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Open space

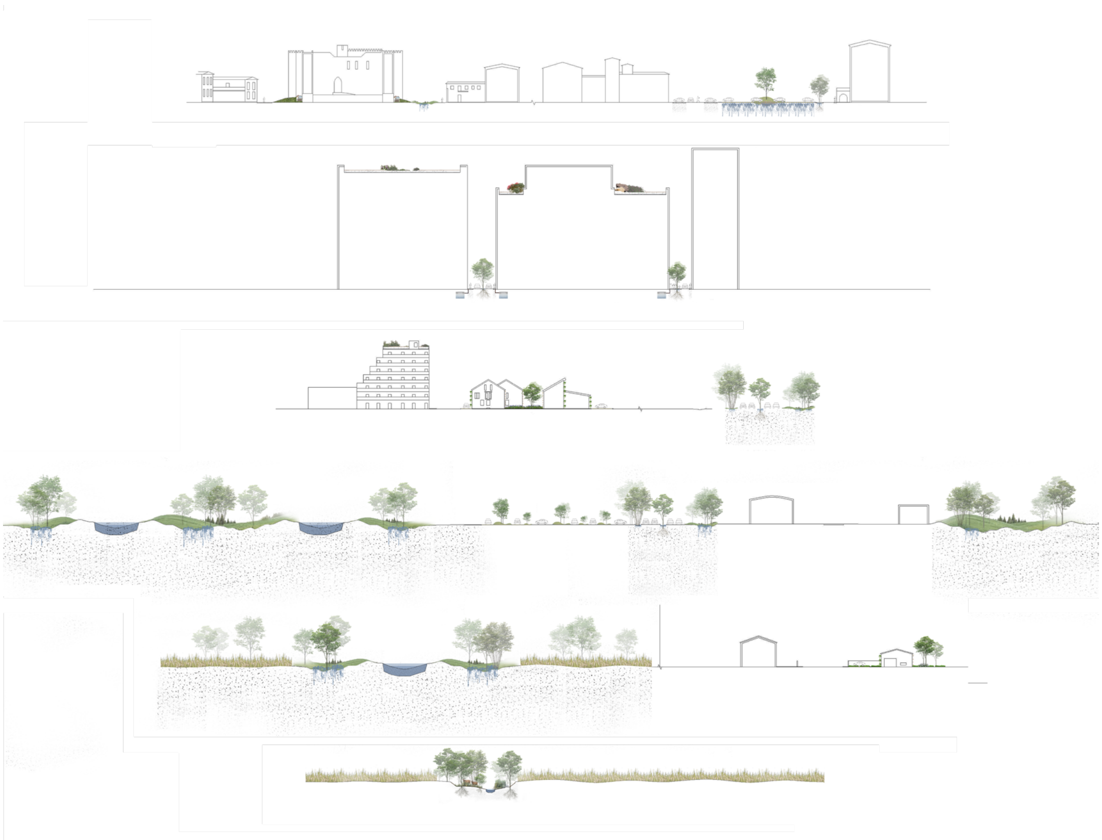
Water harvesting parks
-recycle stormwater runoff as irrigation for high maintenance parks, such as community gardens and sports fields.

Greenways
-use vegetated buffers as an agricultural belt or an important ecotones between land and water.

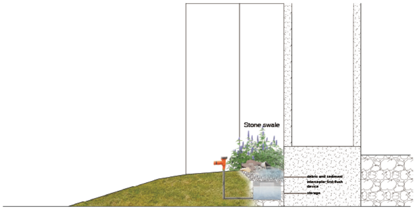
Existing element

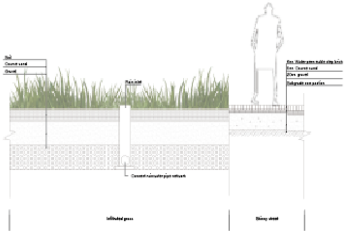
high permanent agricultural area

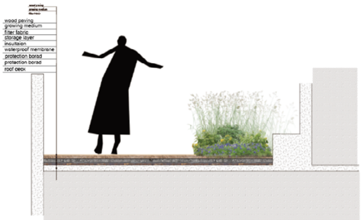
Sections:

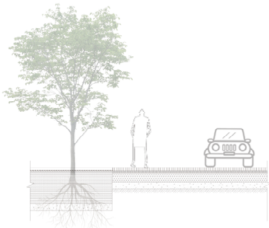


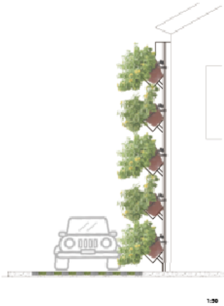
Details:


Stone swale




wood paving
growing medium
filter fabric
storage layer
insulation
waterproof membrane
protection borad
protection borad
roof deck

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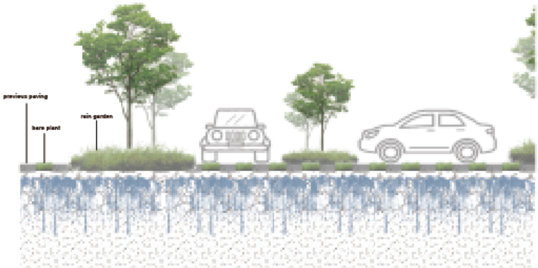
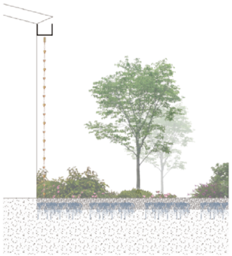

previous paving
bare plant
rain garden



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Xing Hongtao.Landscape Design of Colleges and Universities Based on Low Impact Concept:A Case Study of the Shared Training Base from Jiangsu Vocational Institute of Architectural Technology,2018.

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LID intervantion system in each layer:

How the LID intervantions work in each different layer and how they treat the rainwater as a network so that it can be recycled and reused.

Property:

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