Droppeparken; where the city's rhythm meets nature's cycle

A design proposal to raise awareness on stormwater in Gothenburg

Anahid Babadi

Independent project . 30 credits
Swedish University of Agricultural Sciences, SLU
Landscape Architecture- Master's Programme
Alnarp 2020

Droppeparken; where the city's rhythm meets nature's cycle
A design proposal to raise awareness on stormwater in Gothenburg

Anahid Babadi

Supervisor: Karl Lövrie, SLU, Department of Landscape Architecture, Planning and Management
Examiner: Lisa Babette Diedrich, SLU, Department of Landscape Architecture, Planning and Management
Co-examiner: Stefan Lindberg, SLU, Department of Landscape Architecture, Planning and Management

Credits: 30
Project Level: A2E
Course title: Independent Project in Landscape Architecture
Course code: EX0846
Programme Landscape Architecture – Master´s Programme

Place of publication: Alnarp
Year of publication: 2020
Cover picture: Anahid Babadi

Keywords: *Stormwater management*, *Landscape Narrative*, *Research by Design*, *Pedagogical Design*, *LID approach*, *Storytelling by Design*,

SLU, Swedish University of Agricultural Sciences
Faculty of Landscape Architecture, Horticulture and Crop Production Science
Department of Landscape Architecture, Planning and Management

Abstract

We live in a time of disruption as a consequence of climate change. Our cities are facing increasingly extreme weather events such as drought, more frequent rainfall and flooding. Therefore, in order to address these challenges, urban planning and landscape design can be utilized to find sustainable solutions and at the same time create attractive urban environments. With this vulnerability in mind, waterside cities such as Gothenburg need to be open to adopting new sustainable stormwater practices that use blue-green infrastructure.

In recent years, sustainable stormwater management and strategies to achieve this such as Low Impact Development (LID) have been practiced in many urban projects. Hence, the technical aspects of this approach are very well developed. However, from a social perspective less attention has been given to how these systems can potentially increase the quality of life between buildings. The integration of open storm water systems in public spaces is an area that has a great potential for research. In addition, communication with the public about an open stormwater design can be a challenge if the aim is not understood correctly. Pedagogical design can be used as a tool to overcome this challenge and better inform citizens about extreme weather events.

Through the application of research-by-design and the investigation of open stormwater projects in northern Europe, this project aims to explore the potential for designing a similar system for the Eriksberg area of Gothenburg.

An important outcome of this project is to demonstrate that storytelling in design can be used as a pedagogical tool to raise awareness of environmental issues. The design proposal introduces elements in the design area that narrate the story of a falling raindrop. These elements integrate the technical solutions of stormwater management with the visual and acoustic characteristics of water to create a multisensory experience. This emphasises the role of water to represent the identity of the place. The design presents a story that highlights the identity of the place and potentially helps visitors to understand the designer's intention. This will possibly encourage active participation of inhabitants.

Finally, it is crucial to have a multidisciplinary perspective when working with stormwater projects. In addition, investment in prototyping and innovative test beds offer new possibilities for waterside cities that explore social and artistic potential.

Acknowledgment

I want to thank my supervisor Karl Lövrie for being the critical eye of my thesis work. I appreciate your encouragement and constructive feedbacks through the whole process.

Further, I want to thank my colleague, Anna-Karin Olsson for the valuable discussions we had about this work.

All my teachers at Swedish University of Agricultural Sciences deserve a great thank you because this work is the result of the inputs and inspirations that I got during my studies.

I am also grateful to all colleagues at COWI landscape group for letting me be a part of their warm atmosphere.

A warm thanks goes to Dennis Hopkins for proofreading part of my thesis. Any errors that remain are, of course, mine.

Thank you Pegah for inspiring me to get the job done.

Last but not least, I want to direct my gratitude to my family and my dear Pooya for always believing in me and support me during this work.

Thank you all!

Figure 1: River Göta Älv in the middle of Gothenburg; one of the main elements of the city

01: Introduction

Life is full of surprises. And so is the essence of it, water. This thesis aims to draw the attention towards the notion of sustainable stormwater management and the new opportunities it brings to human societies. Today's world is facing many environmental challenges which are the results of human's interventions in nature and exploiting it to their benefit. Interfering with nature confront us with irreparable consequences among which climate change became our everyday challenge. Consequently, we witness extreme weather which causes frequent and severe rainfalls in some regions, more likely in cities by the water. The severe rainfall events make water-cities more vulnerable to challenges such as flooding and sea level rise. Therefore, this issue and searching to find a sustainable solution to deal with it, demands a special attention in cities by the water.

Ecological stormwater management reduces runoff, improves ecosystem habitats, diminishes the costs of rainwater harvesting and prevents from occasional flooding caused by severe rains and the additional pressure from sea level rise. From the social perspective, considering stormwater management through the lens of landscape architecture, makes room for the water as a natural element in people's everyday lives. Bringing water to the surface instead of dealing with it underground helps rising awareness about this issue in addition to using the aesthetic capacity in creating liveable urban spaces. It is also of great significance to present these challenges and be able to communicate about them with the public audience.

The population who live by the water are facing emergency water challenges. Hence it is important to focus on possible learning experiences in those cities.

Personal statement

My interest in the challenges and opportunities that water brings to urban life is the initial point of this thesis. I believe one actual challenge in human societies is to make a balance between natural elements and the urban development projects and water is a crucial element to consider.

Great part of my passion for water and water related issues comes from being a resident of the river city, Gothenburg. Firstly, as an involved citizen I would like to live in a city that promotes sustainable city design, emphasising on identity, while is open to creative solution for making a vibrant city. Secondly, as a landscape architect the interactions between water and human always fascinate me. The fact that the first human civilisations and the primary settlements formed around the water is a good evidence to the long history of coexisting with water. Being close to water meant possibility to grow food, access to travel and in brief prosperity. We used to understand the water and direct it for our purposes. In Indus valley, for instance, the city of Mohanjo Daro, located in the region that we currently known as Pakistan, was an example of utilizing well-planned drainage system. The changes in our planet caused by overexploiting resources influenced our relation to water as a factor that should be pushed aside in order to save our homes and cities against flooding and drowning.

I believe in today's modern cities, by taking advantage of technologies that promote blue and green infrastructure, it became easier to revive human's primary connection to water. In a world that all are in search for authenticity and the roots and identities, it would be a significant privilege for human societies to learn unifying natural and built elements.

However, the sustainable solutions regarding water challenges would not be completely understood unless we can communicate with the average citizens. Part of the missing link between human and water could be restored through effective communication. That is the other focal point that I would like to address in this work with the intention to promote scientific storytelling in urban projects.

Line between water and land - Design for uncertainty

Our comfort lies in control; to control the situation and environment that surrounded us. Therefore, we tend to keep a limit to control our safety; a line, a border to unknown. So is the line between land and water.
My aim with this thesis is to give a perspective towards the future without defined lines. In the status quo, land and water are intertwined. There is an urge to update our strategies to respond to this new condition. There is no line. The changing trends in climate make it uncertain to reach the forecasts. Hence a spot has the potential to be both land and water. To embrace the water rather than pushing it out is the basis that this work seeks to present with a design proposal.

The illustration on this page is inspired by an artwork that I saw at Nordic watercolour museum in Sweden by Gunilla Hansson. I recreated her worked based on my interpretation, for me it contained a meaning of borderlessness and passing a threshold. Moving between different phases and the state of change that happens when you pass a threshold and at the same time you still carry some characters from previous state. (öar eller sjöar)

Narrative for communication; the role of storytelling as a problem-solving tool

Listening to stories has not only been our long-lasting hobby but also the survival of human species on this planet intertwined with these stories. We are in control of the planet for our ability to believe in fictional stories. Through creating a shared entities, stories relate us together and make a sense of cooperation in order to save that entity. Storytelling is a powerful medium yet not much used when it comes to communicating science. I believe a story can be told through design and form the place characteristics. Nourished storytelling immerses the audience in the experience. I would like to experiment the potential that exist in landscape architecture field to use narratives as medium. I hope the findings from this thesis will lead to creating public spaces with enhanced qualities using the potentials of nature especially water.

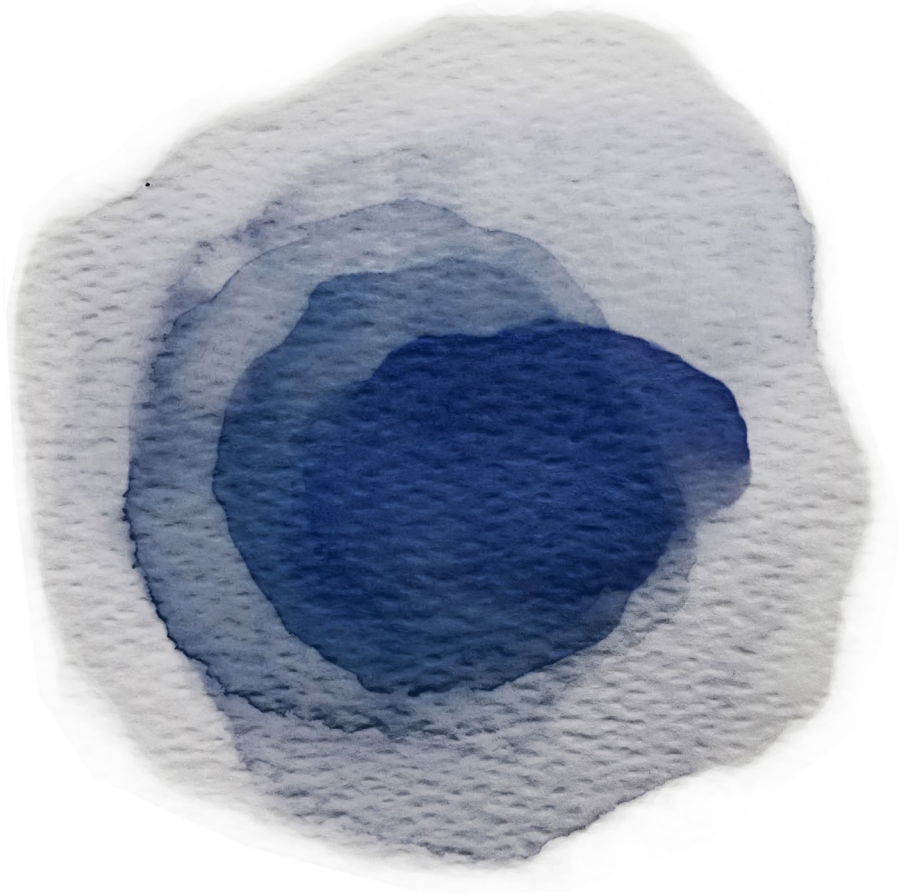


Figure 2 : Author's recreation of Gunilla Hansson's "öar eller sjöar"

Aim & Research question

The purpose of this thesis is to investigate possibilities to raise awareness about stormwater and enhance social aspect of it in people's everyday life.
Through a design proposal the aim is introduce an open stormwater system in Eriksberg, Gothenburg. As it was also stated in personal statement, my intention is to give a perspective towards the future without defined lines. Furthermore it tests communication tool to start a dialogue with non-technical audience.

Through reviewing literature and observations from the design examples, the thesis addresses the following questions:

How to create an open stormwater system in order to enhance the qualities of the urban environment?

What are the possibilities for sustainable stormwater management in Eriksberg?

Can design be used as a tool for scientific storytelling to address urban challenges?

Method

This work is an example of practice-based research which by definition is an investigation to obtain knowledge with the help of practice and its outcomes.[1] It applies research by design method in order to answer the research questions. The term research by design implies on the ways that bridges research and design and leads to generation of new knowledge through designing process.[2] I switched back and forth between the primary questions and case studies to eventually define research questions.

I investigated the ongoing project concerning water management and the potentials for Gothenburg in this regard. After reviewing project descriptions, I noticed interesting potentials regarding connection to water in a harbour development area, Eriksberg, and therefore desired to choose it as the pilot area for my design. Simultaneously, I started reviewing literature on climate programs and texts on water sustainability approach.

Since the outcome of this project is a design proposal for Gothenburg, I decided to focus on finding projects in northern Europe that in a way envisioned strategies to take care of stormwater in urban areas. My intention was to learn from similar experiences in this work. Therefore, I started the next step by examining case studies of sustainable rainwater management in Sweden, Denmark and Netherlands. Besides my personal observations during visiting projects, I interviewed people in charge of designing those projects at private firms and municipalities. A series of interviews were organised regarding reference projects with the municipality of Rotterdam, Gothenburg municipality, De Urbanisten firm in Rotterdam and Ramböll in Copenhagen.

Visiting the case studies helped me to narrow down my literature review. Adding that to the lessons I learned from the north European examples and given the status quo in Eriksberg, I delivered my design manifesto as an opening to the design proposal.

The attempt during the design process is to introduce storytelling as a method of communication through design. A narrative that is originated by scientific fact and demonstrated by design.

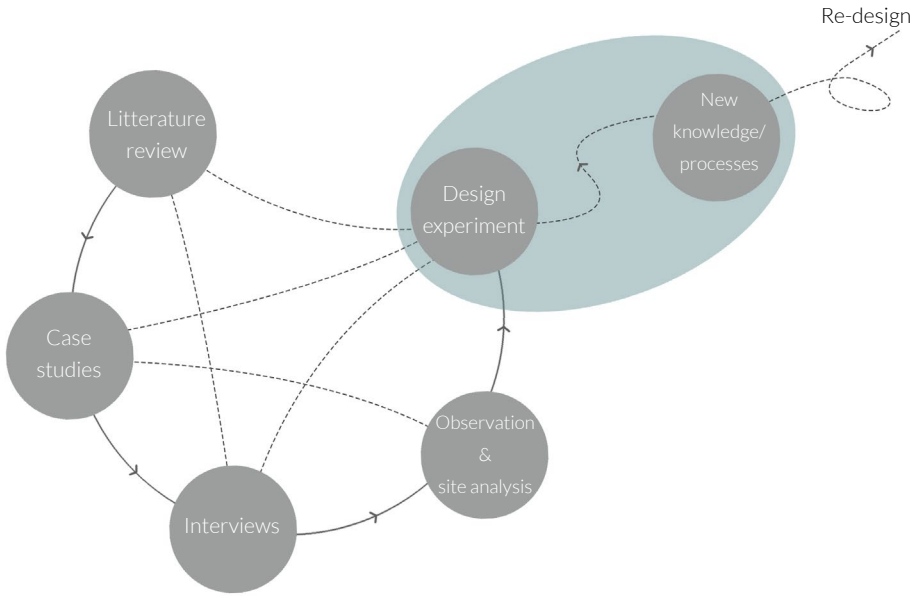


Figure 3: Research by design method - Design experiment is the starting point for forming new knowledge and processes and eventually a new design Illustration by auther.

Disposition

This thesis is built up in six sections. The first section introduces the necessity to focus on dealing with stormwater in the urban environment. Following, it describes my personal interest in this issue and its relation to narratives. It also contains aim and research questions as well as methodologies applied in this work. Furthermore, the second section deals with the technical information of the thesis and the tools to implement those theories and explaining the role of water in human life from environmental psychology perspective and the characteristics of the water like sound and visual effects. In the end of this part there are some lessons learned from reviewing this background information. Following, the third section describes case studies and sums up with the lessons learned from these empirical findings. Section four contains introducing the attributes of Eriksberg and analysis of the site that leads to the fifth part of the work which is my design manifesto and a design proposal for sustainable water management in Eriksberg. Consequently, the design is presented in the format of a narrative in this part. Finally, the conclusions from the findings and discussions on creating water sensitive urban spaces are included in the last section.

Delimitations

As a part of sustainable development goals, access to clean water has always been an important issue. However, stormwater management has been recently come to attention due to the climate change and higher frequency of flooding. Therefore, there is no accurate data that indicates the volume of water we are planning for in the future scenarios. The nature of uncertainty in investigations is another cause to the lack of accurate data.
The selection of case studies has been done considering the framework of this thesis which is to learn from the examples in northern Europe. The choice of case studies is made with respect to author's understanding of problem and possible inspirational examples that could help the design process.
The interviews were conducted in English which was not the native language of interviewer and interviewees. Therefore, there has been a risk for misunderstanding. In addition, the materials regarding case studies and partly theoretical framework was translated from Swedish, Dutch and Danish to English. This might affect the level of understanding of the literature. The results of this thesis are not based on the input from the habitants, which could have brought another dimension to the work.

02: Background aspects

To trace the concept of sustainable stormwater management, strategies applied in the field and reviewing implementation of these strategies will be discussed. This thesis starts with addresseing ecological aspects of sustainable urban water management. It then introduces the characteristics of water in urban environment following by the role of narratives in landscape design. The link between these aspects is in order to add a new perspective when designing with stormwater.

Following some important terms that has been used in the thesis are clarified:

What is a cloudburst?
A sudden, very heavy rainfall in a brief duration. According to Swedish Meteorological and Hydrological Institute (SMHI) cloudburst is a minimum of 50 mm rain during an hour or minimum of 1mm during a minute.[3]

What is stormwater?
Stormwater is rain, snow and hail that flows from roads, parking lots and roofs. Under natural conditions, most of the water penetrates into the ground before it reaches out to watercourses. In a densely populated cities with paved and hard surfaces, water flows on the ground via ditches or sewage pipes to the sewage treatment plant or directly to the nearest watercourse.[4]

What is surface runoff?
Overflowing of water caused by excessive stormwater or other precipitation causes. It carries the contaminants across from roads and other sources of pollutants and deposit them in the watercourses.

Stormwater management

The main purpose of a stormwater system is to take care of precipitation, rain and snow. Some systems primarily remove the water from the ground, while others purify it and slow down the flow. The stormwater solutions that lead, cleans or delays the water on the surface usually are called open stormwater solutions. Examples of such solutions are ditches, gutters and detention or retention ponds.

The stormwater system usually leads to a stream. In some parts of the city the stormwater system can be connected to the wastewater system; which is called the combined system. For combined systems, the recipient is the city sewage treatment system. The stormwater system usually consists of a combination of different parts that are visible, open and parts that are below ground. Open water solutions can create more values in a city than just leading and cleaning of stormwater. Surfaces used for stormwater management can through greenery can contribute to ecosystem services by enhancing biodiversity, local climate control, aesthetic values, air purification, and noise reduction.

The surface can also be planned and used for various purposes such as for recreation, learning and play. Stormwater can be considered as a resource for increasing both social and ecological values in the city. [5]

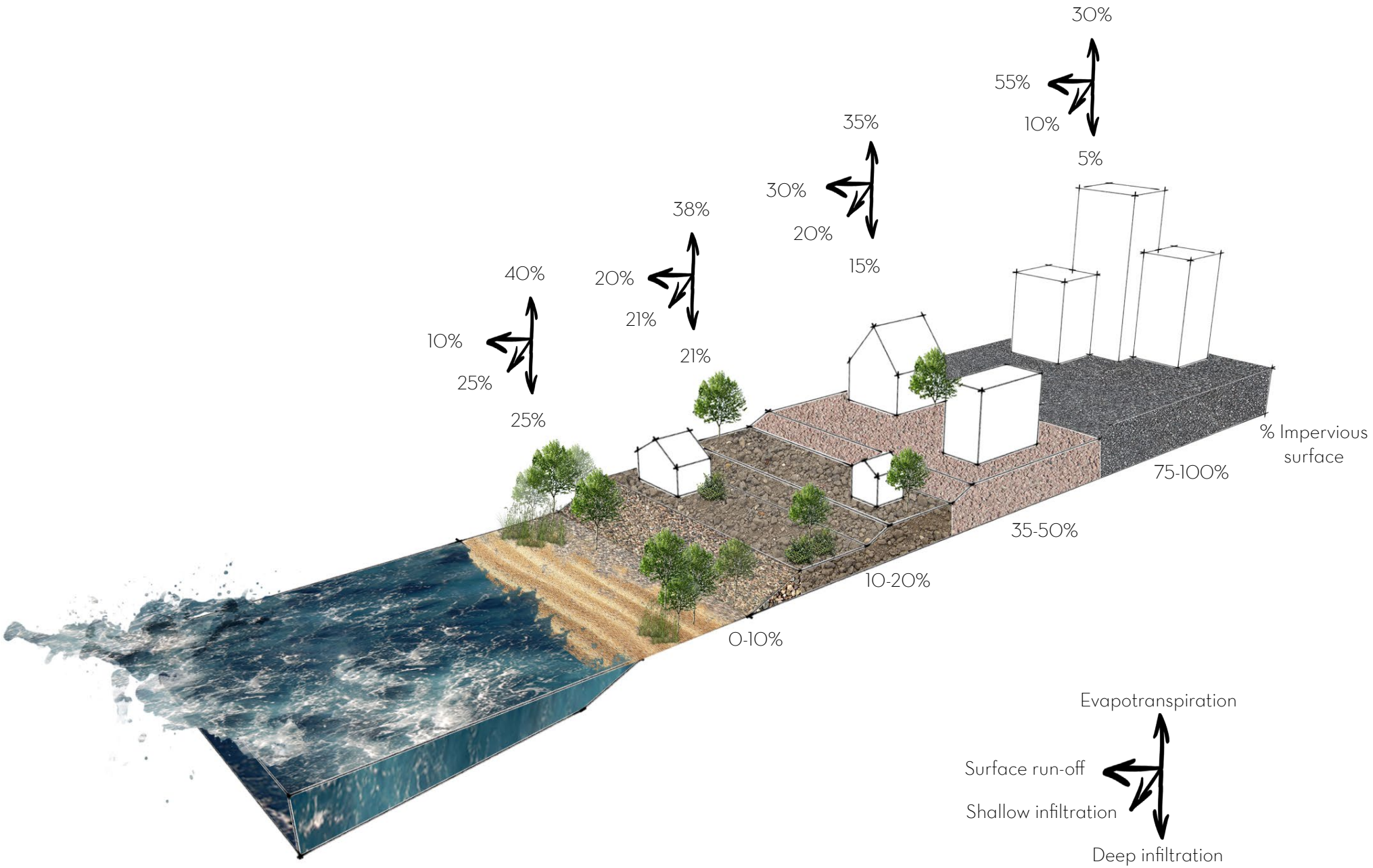


Figure 4 : Author's recreation of rainwater balance and water infiltration in different environments, inspired from the book "Rain gardens"

Sustainable approach to stormwater management

Sustainable stormwater management aims to reduce runoff by treating the stormwater close to its source. The treatment is done through natural processes and the goal is to return the water to its natural cycle.[6,7]

There are other terms that interchangeably used to address sustainable stormwater management. Following indicating the terms, LID (Low Impact Development) is briefly explained. Furthermore, some of the techniques for sustainable stormwater management are pointed out. There are several techniques to implement sustainable stormwater approach among which rain garden, green roof, retention ponds and bioswales are described here. It is important to notice that these are among many other techniques, which are used for this appproach.

that the described techniques are just a part of many that are used for this approach. Here we just touched the ones that are applicable to the context of this thesis.

Terms used for sustainable stormwater management worldwide

LID – Low Impact Development (USA): Describes planning and design approaches for stormwater runoff management with sustainable stormwater management practices.
GI – Green Infrastructure (USA): Similar to LID, describes stormwater management approaches and practices to reduce or eliminate runoff through onsite infiltration, evaporation, and/or reuse of rainwater (compare U.S. EPA 2008).
SUDS– Sustainable Urban Drainage Systems (UK): Describes measures for sustainable stormwater management.
BMP–Best Management Practices (Europe): Describes measures for sustainable stormwater management.
DRWM - Decentralised Rainwater/Stormwater Management (Germany): Describes measures and techniques.
IURWM – Integrated Urban Resource Water Management (global): Describes an integrated approach to manage urban water (not only stormwater).
WSUD – Water Sensitive Urban Design (particularly Australia): Describes an approach that aims to integrate sustainable water management, particularly decentralised stormwater management, into urban design." [7]

LID (Low Impact Development) applies to an approach which is in favour of transition toward soft engineering by managing stormwater run-offs through vegetated treatment. It offers more extensive ecological benefits in managing stormwater. The conventional methods used to manage stormwater, known as “pipe-and-pond” infrastructure, focuses on drain runoffs and direct them through pipes and finally it dispatches in another place. The drawbacks with this method, besides transferring pollution, is that it leads to “urban stream syndrome” . This impairment refers to ecological degradation of streams in urban watershed that would cause loss of species diversity, change in stream geomorphology and higher water temperatures as some examples.[8]

In contrast, LID is based on sustaining the site’s hydrological regime in order to deliver enhanced landscape biodiversity while achieving maximum water infiltration and minimum run off. Moreover, LID’s techniques convey the run off through a network of treatment facilities in the landscape.
In order to maximise the ecological benefits of LID approach a set of design principles is recommended. These principles are redundancy, resiliency, distribution that enable the LID network to effectively slow, spread, and soak runoff. [8]

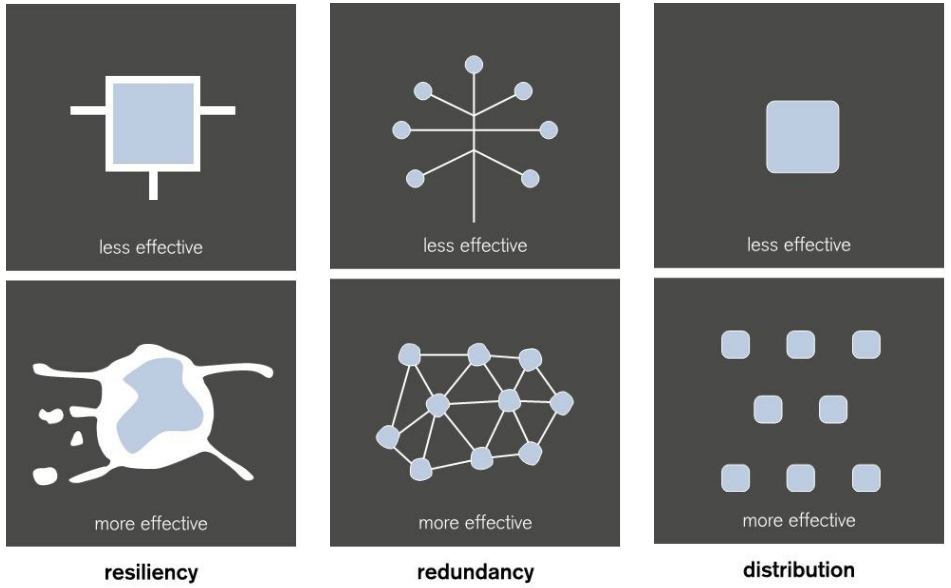


Figure 5 : LID’s principles. From Low Impacr Development a design manual for urban areas [8]

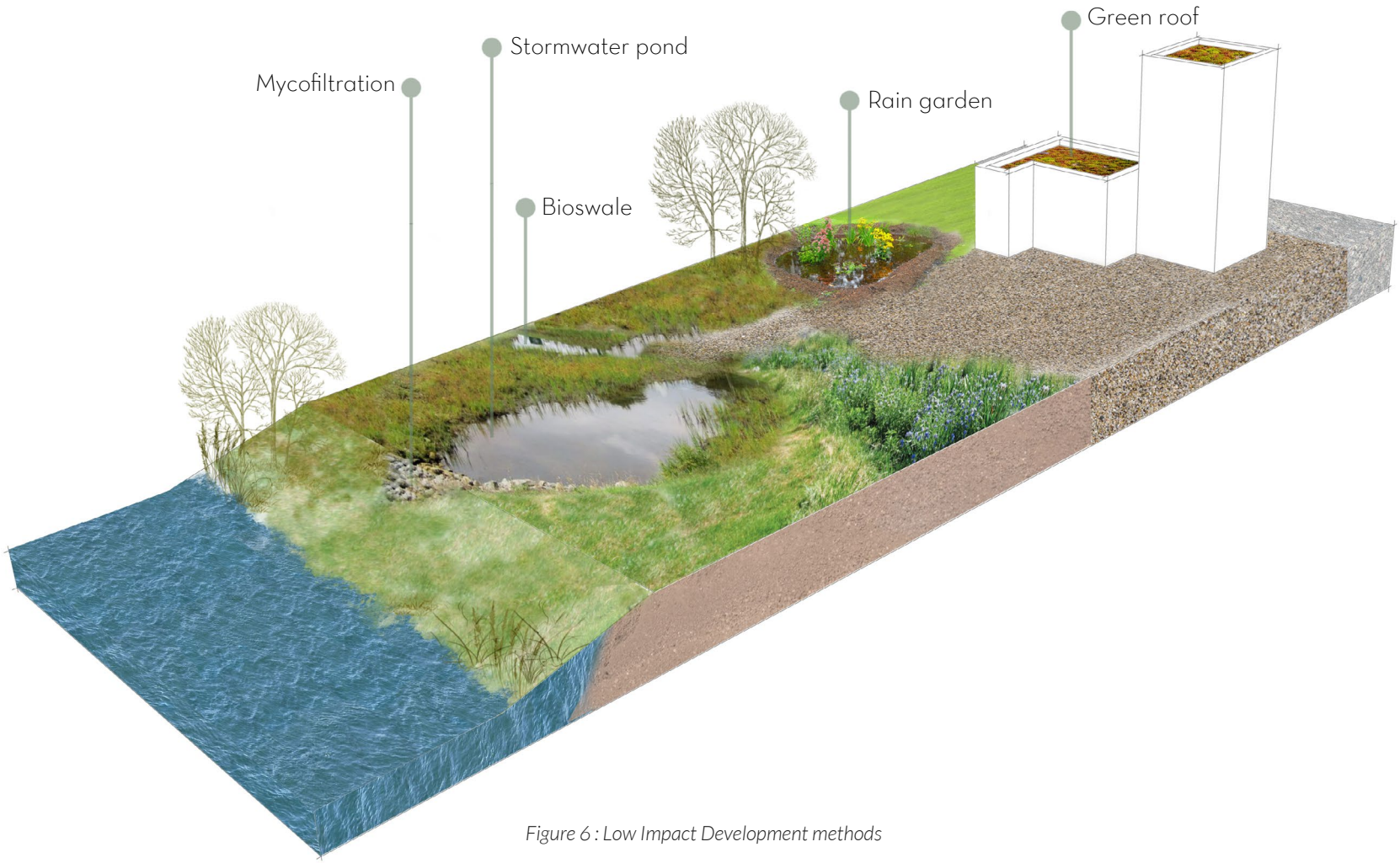


Figure 6 : Low Impact Development methods

Dunnett and Clayden, in their book Rain Gardens, give a holistic description of what a rain garden consists of. In technical terms it applies to a designed depression to take the excess rain and run offs from the urban environment. However, they also include all the possible features that help "capture, channel and divert" snow and rain water.[9] According to this definition, rain garden is a design concept that includes all the components involved the story of a raindrop, such as diverse planting, which help to efficiently use these drops in the landscape.

Higher level of complexity and diversity of planting in the rain gardens, provides a richer biodiversity in the urban environment. This is especially of great importance since our connection to water in cities is limited to fountains or city ponds. Rain gardens can offer a refuge to nature among the built environment.

In the book *Creating rain gardens*, the authors indicate the reasons to plant a rain garden in practical, personal and cultural level. Firstly, it is designing with nature while promoting efficient use of natural resources. On a personal level they explain the dynamic that waterscapes offer to a place and the visual appeal in a water features, especially for children. Finally, rain gardens create a new relationship between human and manmade environment. It is a daily reminder that reminds us of our relation to water in the environment.[10]

Planting rain gardens is also a pedagogical tool to demonstrate water cycle for children as well as adults. It brings opportunities to understand different phases of capturing the water and how to use it for other purposes. In addition to creating a playful experience it establishes a new connection to water that would help a mindful use of this valuable resource for future generations.[9]

Figure 7 : Photo published by Nigel Dunnet - Sheffield 'Grey to Green' project

Vegetated roofs have a significant impact on urban water and heat balance. They contribute to ecosystem services by sustaining the temperature and preventing from forming heat island effect through evapotranspiration. The term evapotranspiration applies to the combined effect from evaporation and transpiration. In Sweden, local disposal of stormwater has been one of the main arguments for the use of green roofs. By reducing runoff peak flow (The maximum rate of discharge during the period of runoff caused by a storm) and reducing the total drainage, green roofs play an important role in stormwater management. The thickness of the structure is the most crucial factor for reduction of stormwater, as well as the choice of plants. Succulents have rather small evaporation rate and high durability in the stressed environment. Hence, they are often desired species for urban green roofs. However, in order to maximize contribution to lowering the city's temperature, species with high evapotranspiration are preferred. Currently a good plant list with suitable plants that maintain both high evaporation rate and long-term survival is not available. Nevertheless, by employing smart planning it is possible to place the plants according to water needs and in this way create both climate-efficient systems variations of plants and high survival. [11]

According to Lindholm et al. it has been experienced that plantings varied species with different shapes and habitus provides high evaporation in green roof environments.[12]
There are different types of green roofs to recreate the natural vegetation systems among which low growing succulents, herbaceous roofs, turf, biotope roof, roofs with edible planting and trees are commonly proposed by green roof market in Nordic countries. [11]
From the stormwater management perspective herbaceous plants or shrubby species are more effective alternatives due to their enhanced capacity to uptake water in comparison to succulents.[13]
According to data from investigations on the effects of green roofs on stormwater runoff, there is a decrease in the annual runoff by 30–86% as well as reduction of the peak flow rate by 22–93%. [11]
Finally, it is also important to emphasis on the biodiversity that green roofs provide for the built environment. By mimicking the natural habitats, they make it possible for flora and fauna and other species to thrive in the urban environment.

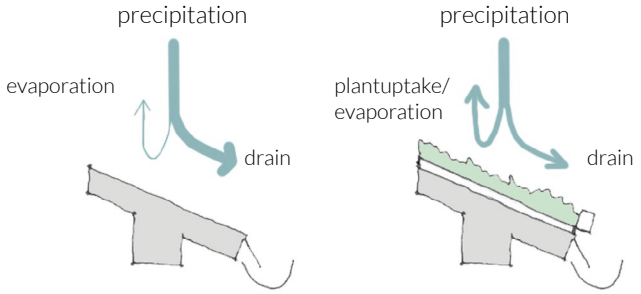


Figure 8 : Green roof contribute to reduce percipitation outflow
Source: Veg Tech's catalogue.
www.vegtech.se/upload/files/PDF/VegTech_katalog_olikataklosningar.pdf

Stormwater ponds are another technique to manage stormwater. They categorise into retention and detention ponds. The retention or wet ponds are designed with additional capacity to permanently hold body of water and mitigate surface runoff during rainfall events.[14]

The water remains in the pond for a period of time and therefore through sedimentation, the possibility to remove pollutants from it. Constructed wetlands and rain gardens are examples of bioretention techniques.

Detention ponds or dry ponds, on the other hand, are vegetated areas that capture and retain runoff in between rain events. The water will be drained when the risk of flooding passed by to make available capacity for the next storm event.[15]

Eventually stormwater ponds can comprise both characteristics of retention and detention ponds.

Figure 9 : Stormwater detention pond in Brown Deer, Wisconsin. photo by Aaron Volkening, flicker

Bioswales

Bioswales are vegetated slope which create a shallow basin for rainwater to flow in. With the same function as rain gardens their construction consists of a layer of soil and grass in combination with planting. Water is treated in bioswale through sedimentation and plant uptake.[15]

Primarily, its function is to deviate and slow down the waterflow. However, if the construction involves the use of porous material such as macadam an infiltration function will be added to the process which results in an increase in the water quality.

One of the advantages of using bioswale in the cold climate is to provide capacity for snow, which later can divert water during the snowmelt period.[16]

Figure 10 : Bioswale. source:https://integritylandworks.com/can-you-have-a-rain-garden-without-rain/

Natural habitats are subject to damage either by human activity or natural disasters. Similar to human activity, the stress, disease and exhaustion caused by those damages weakens their immune system. Mycorestoration refers to use of fungi in order to repair or restore immune systems of organisms. One way to practice Mycorestoration in habitats known as Mycofilteration.[17] Mycofiltration refers to a technology that improves water quality by using cultivated network of fungi mycelium in a man-made ecosystem. This ecological approach first invented by the American mycologist, Paul Stamens, due to his finding about Stropharia rugoso-annulata mushroom quality in reducing bacteria from the run offs.[18]

Mycelium is the vegetated structure of fungi that could be found in soil or other organic structures. The Mycelium in the mushrooms act as a membrane to filter microorganisms, pollutants and silt.[19] In a study conducted in 2013, Paul Stamens and his research team identified fungal species and different substrate combinations that are capable of removing bacteria from Urban Stormwater while demonstrate resiliency in excessive heat, cold, saturation, or dehydration. Among the 6 fungal species tested in this study, Stropharia strain from Fungi Perfecti demonstrated a distinctive resilience in harsh conditions while removing E. coli bacteria from stormwater, and therefore identified as an ideal candidate for mycofiltration. The second viable candidate might be Irpex, however it failed during the experiments to show the constant removal of E. coli. The findings from this study suggest a significant capacity of fungal species for mycofiltration in extreme environments. It also indicated their capability to bacteria reduction through removing E. coli and free-floating bacteria. It concludes that specific fungal strains could be used in stormwater treatment applications for pathogen management.[20]

Figure 11 : Stropharia rugoso-annulata

Source: http://tcpermaculture.com/site/category/questions-from-readers/

Water is the only classic element that could be experienced through all our senses. Our eye defines the colour and reflection of water, our ears enjoy the sound of waves crashing on the rocks, a satisfaction of a glass of water is the ultimate joy for a thirsty person and we all have experienced the joy from the smell of the sea and relaxation when the water climbs our ankles. Though pure water is colourless, odourless and tasteless.

Kaplan and Kaplan (1989) in their book, *The experience of nature, a psychological perspective* wrote about Attention Restoration Theory (ART). The theory suggests that exposure to natural environment develops the ability to focus and concentrate. They consider water as a highly praised element in the landscape. The magnetic characteristic of water and the fact that it defines through contact with the surrounding environment makes it interesting to examine human-water interaction. [21]

The relationship humans have with water is an immemorial one. Human relationship to water started from the early ages. This can be seen how children react to water in fountain squares. Kaplans state that water is the natural feature that attracts human the most. [21]
Based on that Hydén (2009) also emphasize on the special characteristics that water offers to the outdoor environment. [22] Zoe Ryan explains in her book Building with Water (2010), that the urban spaces that are formed around a water element such as fountains became a gathering places and meeting points during time.[23]
Water has the capacity to create serenity in the space. It makes people relaxed just by looking at the reflection of the water or listening to its sound while in nature or urban environment. [24]

Dunnett and Clayton (2007) indicate that the capacity for interaction, which is the result of bringing water into a landscape is less likely to happen through any other elements. [9] Water invites the visitors to be a part of its story. The latter also express that water as a natural feature creates a coherent design, and would promote the connection to other elements in the place that leads to more possibilities for public interactions and play. Establishing alternative designs to include water in the space compared to the traditional fountains and ponds, could offer new sets of functions to the environment. Existance of water in the public space makes opportunity to take a pause and stay in the place. Therefore, it might cause more presence in the space and a higher degree of interaction and involvement. In addition, going further from a traditional type adds to the ecological features of public spaces through promoting biodiversity in the urban ecosystem.

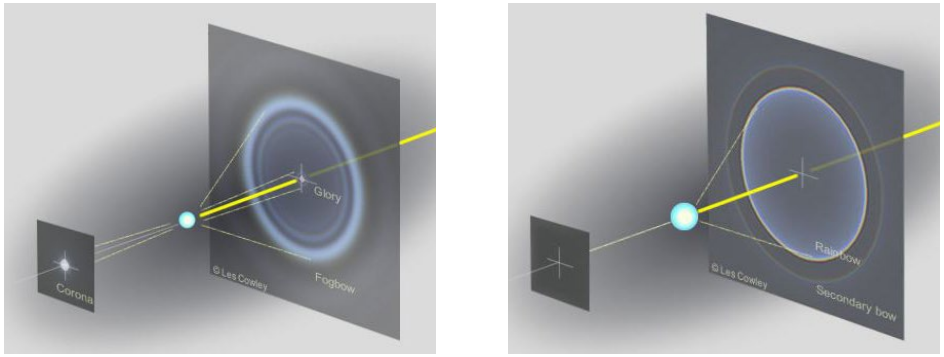
John Motloch in his book *Introduction to landscape design*, refers to Norman Booth description of visual effects of water:

"...all the visible characteristics of water are directly dependent on exterior factors that bear on and reflect it. Water must depend on its environmental context for its particular qualities. change the forces in the environmental setting and you also alter the characteristics of water in that setting." [25]

To a great extent our visual perception of water is the result of its reflective quality and the interaction between water and light. The light reflects off surfaces based on how smooth the surface is. There are two types of reflections. Specular reflection happens when surface is shiny and smooth, and therefore the reflection will be closed to a perfect mirror. A rough and tensioned surface causes light to spread in many directions and is refered to as diffuse reflection. Still water reflects the light and forms a mirror image while tension on the water surface forms an unclear image.

Water in the form of mist and fog also interacts with light. The light beam scatters and diffracts by encountering drop surface and the result is formation of oscillating ringed pattern. The size of a droplet is an important factor in experiencing the reflected light. Mist droplets are 10-1000 times smaller than rain droplets. Therefore, they diffract light and result in a fogbow, while raindrops form a sharp rainbow. [26]

Figure 12 : two types of reflection



Small droplets *Large droplets*

Figure 13 : Compare light scattering by small and large droplets

Figure 14 : Diffuse reflection, ripples on the water surface create tenstion and minimize visibility.

Figure 15 : Specular reflection, Chehel Sotoun (Fourty Columns in persian) The pavilion has 20 columns which, when reflected in the water are appeared to be 40
Source: https://apochi.com/attractions/isfahan/chehel-sotoun-palace/

Water structures in public spaces are mostly desired for their visual attractiveness rather than the effect they create in urban soundscape. [27] Historically the sound of water was an essential element in landscape architecture. Examples are water features in Persian gardens or garden ornaments like suikinkutsu. However, during mid-20th century up to now, landscape architects faced critiques regarding the failure to incorporate sound in design. In addition to its potential for masking urban noise pollution water sounds generate a stress reduction effect when is used in the environment. [28] The sound of water has interesting psychological benefits on human brain. Different sounds can have meditative or stimulating effects. [29]

Canadian composer, Raymond Murray Schafer, introduced the term soundscapefor the first time in his book *The turning of the world* in 1977. The term applies to "the sounds that arise from a particular environment". [30] Later in the book *The soundscape: our sonic environment and the tuning of the world* (1993) he indicates three categories within a soundscape: keynotes, signals and sound marks.

Keynote sounds are the subtle surrounding sounds that are not always audible but imply a feeling of being surrounded. Sound signals are the "foreground" sounds that are listened to consciously. Inspired by Kevin Lynch's landmark, a sound mark is a unique sound in an environment. Maja Nikolajew, in a report inspired by her doctoral thesis, explains different sounds of water based on this categorisation. [31] According to Nikolajew sound of diffused rushing waves or sprinkling scattered drops on a large surface of water are examples of keynote sounds. Sound signals are sound of a water jet that pours down with a constant rhythm or when merged drops splash on a body of water slowly and continually with a constant rate. The example of sound marks is a splashing sound of water or falling water drops on a water surface.

The multisensory effects of water and possibilities to control the sound of water through combining it by other natural elements is a reason to benefit from it in landscape design.
For instance, by using plants with wider leaves that can amplify the sound of water, the masking effect of water would benefit the design. However, some water sounds are preferable to others. For example, rippling and purling water because of its fluctuating character and low strength is preferred over sources with a high flow rate that are closer to white noise. Therefore, it is discussed that the experience that the water sound creates in the environment is complementary to the sound pressure level in order to create a successful masking effect.[27,28]

Figure 16 : Suikinkutsu in a Japanese garden.
Source: https://sharing-kyoto.com/see_Ohashi_Family_Garden/story

Narrative landascape

Potteiger and Purinton (1998), in their book *landscape narratives design practices for telling stories*, define the term landscape narrative as the interplay that develops between landscape and narrative. Through narratives we can interpret the sequence of events in a place. The role of landscape in these narratives is not only the backdrop for the stories, but also all the changes in the landscape provoke its own stories.
Potteiger and Purington also point out the interplay between the landscape and storytelling whether explicit or implicit could be used in design practices. [32]

The concept of landscape perception has been defined as an interaction between humans and landscape. [33] Since landscape is a product of human's intervention in nature, understanding this as a part of environmental perception can result in the outcomes that could affect both humans and the landscape.

Anne Geelmuyden in an article on European landscape convention points out the inextricable connection of landscape to a physical area but most importantly in people's minds. The character that a landscape acquires is a product of personal, cultural and experiential circumstances. that is how the story of a landscape forms in people's minds. [34]

Consequently, the narratives of a place carries a great potential in establishing the people's relation to the place. The idea of employing landscape narrative has been examined in a few landscape practices. Examples as such could be Eden botanic garden and Stourhead garden in the UK. [35]

Although the scientific research into landscape narrative is still in its early stages there has been evidence on it's potential to form pedagogical experience through landscape design. One alternative to evaluate the effectiveness and efficacy of landscape narrative in educational landscape is to use augmented and virtual reality environments in order to understand the human perception and behaviour. [36]

The term Genius loci or spirit of the place has been used synonymously to refer to place identity, image or soul of a place within different research areas such as sociology, environmental psychology, urban planning.

Christian Norberg, in his book *Genius loci towards a phenomenology of architecture* states:

"Since ancient times the genius loci, or 'spirit of place', has been recognized as the concrete reality man has to face and come to terms with in his daily life. Architecture means to visualize the genius loci, and the task of the architect is to create meaningful places, whereby he helps man to dwell". [37]

To identify with a place is to cultivate a sense of belonging to it, which is the core element of formation of successful neighbourhoods and cities. The interaction that happens between human and place is dependent on this sense of belonging. What is understood in the text of Norberg as genius loci is referred to the spirit that exist in each place, and in order to bring a place to life that spirit should be realized and cultivated. In today's urban design however the belief that there is a certain soul to a place is replaced with the hunt to find the lost connection to the nature and revitalize the natural landscape or the natural element of the place.

The increasing grey and hard surfaces in the cities that can be a dominant cause of stress and diminished mental health urges to integrate natural characters in designing urban environment. Therefore it is crucial to recognize how to integrate nature in tune with the identity of the place or in other words the specific needs and requirements that each place demands. The role of landscape architect is to identify these identity characters and to facilitate narration of the landscape.

Lessons learned 1

1. The sustainable strategies of stormwater management aiming to mitigate the effect of severe rainfalls and prevent possible flooding.

2. Rain gardens, bioswales, green roofs and stormwater ponds are Low Impact Development (LID) methods that care of stormwater on the ground and at the same time create green urban life. It would be beneficial to evaluate the effectiveness of each strategy based on the scale of projects.

3. Mycofiltration is an effective method to capture pollutants from water. Introducing fungi in combination with plants in the urban area contains pedagogical value. Using this method in combination with LID strategies would possibly be beneficial to stormwater projects.

4. Landscape is the product of man's intervention in nature. It is not only defined within specific boundaries, but also by people's minds and their experience as well as cultural background.

5. Landscape design is to awaken the spirit of a place.

6. Sounds of water would benefit urban spaces not only for its masking effect, but through its therapeutic values. It is also important to consider inherent characterise of the water sound and the experience that it creates in the environment. Some sounds like rippling and purling water are preferred compared to sources with a high flow rate that resemble white noise.

7. Different types of reflection can be exploited when combining light with other design elements.

03: Case studies

Case studies help realising how places that are faced with similar challenges around the world learn from the opportunity of living with water. This study has been conducted in 3 cities in northern Europe. Rotterdam, Copenhagen and Malmö are places that to the best of my knowledge, introduced design practices with water. Thus this thesis can benefit from the viewpoints of the projects in these cities and learn from the experiences for designing a waterscape in Gothenburg.

I would say if there were no time and money restrictions, I would have investigated more places, simply to get a broader knowledge on this subject. Nonetheless that could be an extension to this project in the future.
Among the projects I visited in Rotterdam, I chose Benthemplein water square, Rain (a) way garden, Westersingel sculpture route and Museumpark. I believe these projects approach sustainable water management from different aspects. Benthemplein water square and Rain (a) way garden are modern projects and recently built while Museumpark is an urban park that has known as a blue-green pathway that connected several museums in the city from 1927. Moreover, each of these projects integrated water management in a unique way from social, aesthetical and technological perspective.

The place that in Copenhagen attracted my attention on the subject was Tåsinge plad that is the first climate adapted urban space in Copenhagen [38] . Following my meeting and an interview with urban water management department at Ramböll I got the information about Sankt Annae square. I thought conducting a comparison between these two places could help the foundation of this work.

The Hyllie water park in Malmö is a project that introduces waterparks not only with a recreational design goal, but also considers the environmental aspects of design with water
Visiting, studying and understanding these places would lead to a series of criteria that are the requisites for the design proposal. The cases are explained in detail in the following sections.

The pictures are taken by the author, if not mentioned otherwise.


Copenhagen
Malmö
Rotterdam

Rotterdam

Rotterdam is a delta city and amongst the cities that their population density and economic value are vulnerable to climate change. Locating on the delta of the rivers Rhine and Meuse and via the Nieuwe Waterweg (New Waterway), the city has opened to the North sea. Most part of Rotterdam, including the main port is located in outer-dike areas. The inner-dike of Rotterdam is mostly below the sea level and therefore the consequence of flooding in this area would be disastrous.

The inner dike areas adapted a system of canals and lakes, outlets and waterways, sewers and pumping stations to keep the water levels in the polders stable. Through more robust strategies such as Maeslant storm surge barrier and dikes the lower-lying polders are well protected from high water levels in the river Meuse.

Rotterdam is an example that adapts to the natural circumstances during centuries by dams, dikes and land reclamation and have brought the dangers and risk of flooding under control. Not only the climate is changing, but also the city. The city of Rotterdam aims to be 100% climate proof by 2025. Therefore, Rotterdam municipality sets out climate adaptation strategy that will be discussed in continue.[39]

The following section is the summary of interview with Eveline Bronsdijk, sustainability advisor at Rotterdam municipality.

Q: What makes it necessary to work with stormwater projects in Rotterdam?

A big part of the Netherlands is already artificially made, they stole the land from the water with dikes for example, the average height of Rotterdam is 3-7 meters below the sea level. Basically, when you look at the underground map of Rotterdam is much busier than the ground because of all the pipes and sewage system of the old engineering. When you look at water management in the Netherlands, they do have increasing heavy rainfall, so we need to increase the capacity of water storage in terms of heavy rainfall. Rotterdam climate proof is the umbrella above all the strategies in stormwater management.

Q: Could you explain about some of these projects that are executed by the municipality?

The projects we discuss here are part of the Rotterdam climate proof program, The first project is Benthemplein water square, which is a part of European subsidies. The process of building Benthemplein water square was preceded by the stakeholders around the square; there is a children's theatre for 6-12, a high school, a church and a gym. The square consists of 3 basins. The biggest one with the basketball field is definitely the most male/boyish, but the two other smaller basins were designed for the wishes of girls who prefer to sit in smaller groups. The second square became so popular that the stakeholders didn't allow the municipality to change it. The city made a decision to design a water square as a practice of various strategies that could be done to take care of stormwater in the city. The square can hold 1.7 million liters of water. There is a pumping system in Benthemplein square. The water stored in Benthemplein square would be pumped out in 48 hours so there will not be the risk of existing stagnant water in the place and consequential pollution. Part of the Idea behind it is to look at the solutions with multiple approaches. The square was flat before the design. The main function in one of the basins is skateboarding. Sometimes it is used by the theatre as the open performing stage. There is a sport function in the Benthemplein that was something that the stockholders specially requested. That is the purpose with the basketball field. It is also an open space for other inventive activities.

Another project is Westersingle, which is a street from the central station to all the galleries and museums and that is why they put statues in the Westersingle park. When you look at Westersingel for example there is some extra lane with artworks, there have been changes to that channel, so it is actually allowed to be flooded. The average citizen doesn't know that this actually is a strategy of water storage, also there is a garage at the end of the street that is being used as a storage for water underground.
There is a project called RDM innovation lab, which is a testing zone for future projects, and basically how we work in Rotterdam.
Rain (a) way garden is another project that absorbs extra water and (detain) contains extra water. it is an artistic way, so it is not the most practical. It used to be a parking space and this is also part of interference of the citizens, they reclaimed the parking space and designed the garden.

Q: What are the measures that you considered when working with these projects? How do you connect it to the rest of the city?

When you look at the measurements we take for water management you don't want to make people frightened and make a disaster. you want to keep the city safe and educate the citizens that water management is important without scaring them. The inventions that we made like Westersingel and also the roof of the garage at the central station has got extra space to store water underneath. and it is not visible. These are all strategies to make the city safe, it's all based on the fact that we don't have the space underground to expand the sewage system, so Benthemplein and similar projects are nice ways to inform people about the ways we try to keep the street from flooding. Even if we talk about the green roofs, it might be understood as a green strategy, but it is actually part of the blue solution. We had the program from 2008 to 2014 for green roofs and we had made an integral approach because sometimes some certain rooftops should not necessarily be used to store extra water. The integration plan was made by De urbanisten. People were buying tickets to visit rooftops. It applies that you experience street life at a different level. 14.5 km flat space in Rotterdam. which has high potentials to be used. At some points this connection should be made to have streets at another level. Green roofs in combination with wind and solar energy would help sustainable buildings. When you add a social

function to them, it increases the worth of the building. In all these projects active participation is needed to find solutions, there is a common risk in experiencing new strategies and everyone should take a roll.

Q: What are the most important aspects to consider when working with such projects?

So basically, when you look at it in general in these projects, participation from the citizens is the solution for the water management. The simplest way is to encourage them to add some green to their gardens. What we try to do internationally, with 100 resilient cities is to exchange the knowledge with the cities that have similar problems.
We organised an event in 2013, a workshop with New Orleans, Mexico City, Bangkok and Rome, in Rotterdam. We arranged field trips in Rotterdam and they came up with inspiration for their own cities. This is a smart way to share information because when you connect countries and cities there are always political layers and it is easier to cross the political barriers through collaboration.

Rotterdam climate adaptation strategies

Rotterdam municipality pursuing strategies to create a climate-proof city. The basis for the climate adaptation strategies is to maintain the robust system of canals, dikes and polders and at the same time focus on building more resilient city that is less vulnerable. Starting with a resilient and robust system, Rotterdam municipality aims to integrate climate change adaptation measures to other projects and linking them to other activities in the city. It is also important to mention that the municipality is not the only responsible stakeholder in executing these strategies. Collaboration between other sectors is also an important factor in implementation of climate adaptation strategies. The result will bring a multifaced opportunities to the city among which is the added value for the environment, society, economy and ecology. Making city climate proof provides the opportunity to present Rotterdam as an attractive city. By cooperating greenery that mitigate the effects of extreme rainfalls, the city enhances the living environment for the citizens. It also strengthens biodiversity and ecosystem services. Focusing on the adaptation measures motivate the citizens to get involved and make them eager to participate in this process. The opportunities that this collaboration and attractiveness brings to the city makes Rotterdam economically thrive as a world port city. [40]

Designed by DE URBANISTEN studio in Rotterdam and as a part of adaptation strategies of Rotterdam municipality, Benthemplein water square was inaugurated in Agniesebuurt district in 2013. The place catches 1.7 million litres of rainwater in its three basins.[41]The deepest basin is a basketball field situated in the middle and the other two basins function as a stage and skateboarding. The process of design executed with direct participation of the stakeholders. 30 people from the church, children's theatre, high school and the gym around the square as well as people in the neighbourhood participated in 3 workshops to pointed out their preferences for the square.

The water square functions with the separate sewage system. The underground infrastructure flushes the first run off in the events of heavy rainfall due to the pollution risk. This water is pumped directly into the sewage system. After that the basins retain and infiltrate the following runoffs. The water stored in Benthemplein square would be pumped out in 48 hours so there will not be the risk for existing stagnant water in the place and consequential pollution.

The aesthetic approach was also considered in deciding colours scheme of the square. The area that water flows in such as gutters are made out of stainless steels that are shiny and reflective, while the area that stores the water is coloured in different shades of blue. According to De urbanisten the intent is to make a loose weather map and make people aware of the areas that will be flooded by time. [40]The area adjacent to the basins is designed for green spaces which highlights the blue green strategies adapted in the water square. As the world's first full-scale water square, it precisely represents ecological and social and artistic perspectives towards stormwater management.

Figure 17 : Benthemplein water square (a)

(b)

(c)

(d)

(e)

Another project in ZOHO district, close to Benthemplein square, is an artistic demonstration called Rain (a) way. With an interest in rainwater, Designer Fien Dekker used nature as an inspiration to design tiles to brought back the natural cycle of rain water in urban space. The project replaced a parking area and is composed of different tile designs with different levels of permeability, ornamental grass and seasonal flowers. “Ebb tiles” are made out of water proof concrete, and therefore it directs the rainwater into the vegetated area through the patterns on it. “Flood tiles” has the capacity to filter the water and allows rainwater to permeate into the ground with different rates. The goal of this project is to make water visible in the city, while using it in an efficient way to serve the front garden of a building. It also minimizes the amount of concrete pavement by disconnecting drainpipes from sewers and suggesting an open water management solution. [42] Rain (a) way garden is a clear proof that when aesthetic approaches intertwine with ecological goals, the result would not only serve the built environment, but also performs as a pedagogical tool to communicate about a certain subject.

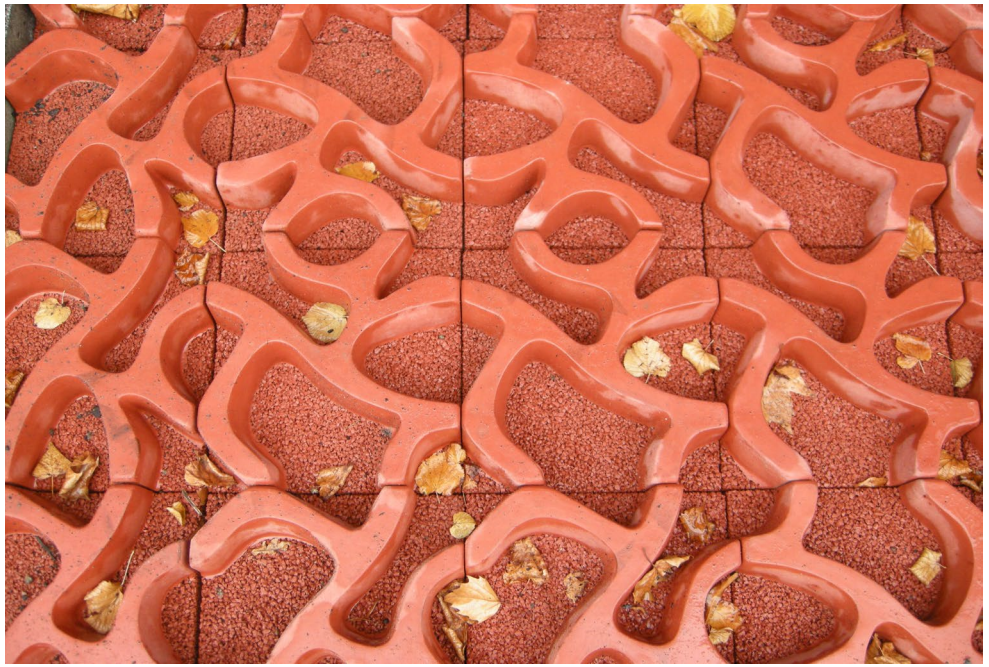


Figure 18 : Tiles in Rain (A) Way project (a)

(b)

(c)

As one of the most popular outdoor spaces in Rotterdam, museumpark is a green area surrounded by museum district. It is a so-called depression amidst the urban expansion. The park is designed by city architect W.G. witteveen in 1927 and got its current image between 1988-1994 by French landscape architect, Yves Brunier.[43]

Moving through the park, one experiences changing with the soft and hard surfaces and different presence of water as well as other natural elements. Entering the place from the street side, there is a series of planted honey locust trees in the white shells carpet. It offers a place to stay and also acts as a green and white corridor to access the next space, which is an asphalted area, coloured in stripes, for sports and other activities with some water features. From there one can enter the museum buildings by passing through the rain gardens designed in front of them. The reservoir in from of the museum building acts as a natural wetland. The reservoir divides into some creeks, springs towards a forest area and form some islands. It pictures a colony of raingarden decorated with stones and seasonal flowers.

As a part of strategies to manage flooding, an underground parking designed by Paul de Ruitier that functions as another reservoir to store rain water up to 10,000 m^3 within a half hour of heavy rainfall and mitigate the pressure on the sewage system by one-quarter. [44]

Diverse approaches in managing water in museempark which implemented through different time periods helps to understand a versatile perspective in dealing with this subject.[45]

Figure 19 : Museum park (a)

(b)

(c)

(d)

Source: http://ttnotes.com/museumpark.html

Locating between Rotterdam central station to all the galleries and museums, Westersingle canal conveys through the central part of the city. Formed from a polder in the 19th century, the Canal lays out today with green beds and planted trees on the sides.[43]
It is designed lower than the street level. The reason is to avoid the street from flooding. Sculptures from different parts of Rotterdam are gathered and placed in waterside sidewalk along with the other urban furniture. When the sidewalk is flooded, the floating sculptures make a dramatic scene in the street. However, it is not a well presented strategy for public, and therefore the average citizen does not know that flooded canal is a part of strategies for water storage. The green belt next to the waterside helps water to permeate slowly into the ground. These are all mitigation strategies due to the lack of space underground to take care of water. Using these strategies in combination with the sculpture rout adds an artistic perspective to the place, while improving flora and fauna. It is a subtle approach to make the city safe and not frighten the citizens in the time of disasters.

Figure 20 : Westersingel canal (a)

(b)

Source: https://www.100resilientcities.org/wp-content/uploads/2014/09/c. Rotterdam_presentation_Arnoud_Molenaar.pdf (c)

Copenhagen

The summary of Copenhagen cloudburst management is explained as follow:

Copenhagen has experienced a major rainfall event in 2010 and 2011 that caused extensive damage. Therefore, one of the primary challenges is facing more and heavier downpours in Copenhagen. To tackle this challenge a set of measures were suggested in Copenhagen climate adaptation plan in 2011 to achieve a green-blue city that mitigates the effects of climate change.

This was followed by cloudburst management plan in 2012, which specifically outlines the methods, priorities, and measures recommended for the area of climate adaptation including extreme rainfall. According to cloudburst management plan the biggest socio-economic savings on damage costs of flooding is to invest in a combination of measures able to handle extreme rainfall events and reduce the impact on the drainage system on all other precipitation days. In order to achieve this outcome, the document has two recommendations; first to drain stormwater out to sea and secondly storing it. The water from extensive rainfalls should be drained to sea/harbours in bigger quantity and partly to the existing freshwater basins and lakes in Copenhagen. However, the environmental effects of this action is not studied in this document. Secondly, slowing down the speed of water and surface runoff is another important action to reduce damage and increase the drainage capacity by leading the stormwater to areas that can be stored.

Following this method of implementing adaptive measures in Copenhagen, the city plans to increase the investment on blue-green infrastructure. By incorporating adaptive measures into the local master plans and urban development projects thereby promoting the blue and green infrastructure of the city. [46] In the following part, two examples of implementation of blue-green infrastructure is explained in two projects.

As a part of cloudburst program in Copenhagen, Tåsinge Plads is located in Copenhagen's first climate change adapted neighbourhood. Inspired by the idea of Copenhagen as a fortress, it is designed to contain 7,000 square meters of rainwater.[47]

It has become a popular public space in Skt. Kjeld's Quarter in Østerbro which with its lush planting area makes draining of rainwater possible, while encourages play and activities. It also supports learning about stormwater management for the citizens.

By using topography and creating height difference there is a dry peak at one end and a humid low point at the other, which allows water to flow to the lowest point and released into the sewage system. The rain garden makes a desirable condition for Danish flora and fauna to grow in the city.

The site is furnished with illuminating sculptures: water drops and rain umbrellas. Water drops are containers for rainwaters and through manual pumps discharge the water into rain garden. They also reflect the sky and bring a possibility to play, movement and climbing. The rain umbrellas have a capacity to hold water and release it into the sewage system as well as providing shelter for the rain. Thus, the presence of water in the square is also clarified here and presents a playful functionally which has been aimed in the square. [48]

Figure 21 : Tåsinge square (a)

(b)

(c)

(d)

Locating between Nyhavn and Frederiksstaden neighbourhoods in central Copenhagen, Sankt Sankt Annae Square (Sankt Annæ Plads) was another project in the cloudburst program. The square was renovated between 2012-2016 with the vision of improving urban life and pedestrian traffic while protecting the area from flooding in the event of extreme rainfalls. The collected water then leads to the harbour both on the surface and through special pipes.

Since this area is one of the special places in the centre of Copenhagen which is characterized by urban spaces from different time spans and with different histories, the goal was to make a cohesive design. The passage ends at the national centre of dramatic art of Copenhagen by the harbour. The main idea was to enhance symmetrical green elements and use them to infiltrate water in order to avoid flooding in the street level. The project is also combined with an underground parking garage which leave the space on the ground for a better urban life. [49]

By using plants and other soft materials such as cobblestones the possibility to form a shallow and almost imperceptible basin for stormwater will be encouraged. In this way, water takes a sharp turn into the square rather than running down the street. There are new surface drains on either side and also the area of grass that runs down the centre of the square has been lowered to absorb more water quickly. All spaces have been designed with a concave profile for the function of carrying water.[50]

Figure 22 : Proposal skiss from Sankt annae square
Source: https://www.academia.edu/25050800/A_case_study_of_Infrastructure_-_the_Sankt_Ann%C3%A6_Project_Copenhagen

Malmö

In the recent decades Malmö municipality adapted detention measures in managing stormwater. This is primary due to combined sewer system with limited capacity in the city centre. As the city grows and wastewater from an increasing number of development areas is to pass through the city on its way to sewer treatment plant, it is necessary to take powerful measures to reduce stormwater flows, so that residents, especially in the older western parts of Malmö will not be affected by frequent flooding in the ground floors.

The land in Malmö consists mostly of dense moraine clay that is not
suitable for infiltration or percolation. Therefore, these processes are never expected. Thus, stormwater detention must occur through surface diversion in a slow system. Due to the flat terrain in Malmö many development projects must execute some kind of soil modelling to create waterways for stormwater to flow without the risk of nearby properties being damaged in cloudburst events. Modelling is also needed in many cases to get the runoff patterns in the landscape. In recent years, the trend in both Malmö and Sweden regarding stormwater management has been slowly shifted towards environmental and quality aspects. This has led to the focus today to the same extent on purification of stormwater.

Work on preventive measures, that is, to ensure that the pollutants do not even end up the stormwater, is the most important task. It is not a sustainable strategy in the long run to build purification ponds in order to prevent pollution to reach the watercourses. The contaminants that accumulate in the stormwater ponds must be taken care of as well. However, the advantage of stormwater ponds is that we know where the pollutants exist right now. In a national and international perspective, Malmö is at the forefront when it comes to stormwater management. This is especially due to the good cooperation that exists between departments already in the early phases of planning process.

Malmö's way of working with the stormwater issues in the planning process is studied both in Sweden and abroad. In order to protect against future climate change, good planning is essential and Malmö municipality aims to continue avoiding development in areas that will be problematic to cope with during cloudburst or sea level rise. In the future comprehensive plans, waterways and runoff patterns should be included and buildings are kept away from areas facing flooding risk.[51]

Hyllie water park

Close to Hyllie station, Hyllie water park was inaugurated in 2015 which functions as green lungs of Hyllie district. [52] It serves as a pedagogical park with water as the main theme that makes it possible for school children and the general public to explore water in a new way. Water in combination with greenery creates room for both sensory and experimental experiences. Hyllie water park is a collaborative project among actors VA SYD , Malmö municipality, street department and C Wingren Landscape have jointly developed the concept. Students from three schools participated in decorating concrete wall with ceramic. The path is designed with different water stations that give various experiences of water in different phases and forms. It ends to a pond that is a lush platform to stay and enjoy the surroundings. The whole project is built around the water tower in Hyllie, which is one of the VA SYD's three operating water towers. It is also Malmö's newest water tower and a popular landmark. The water tower is illuminated in different colours in the evening and night depending on the period or holidays during the year, but usually it glows blue.

Entering the water park, one will pass through a waterfall and water drops would form a rainbow under a reflection of sun on sunny days. Walking through the park, there is a surface with pumps and fountains that sprays water unpredictably from different places as the children pump. The water from the fountain flows down the canal. There are moving obstacles along the channel that can be angled in different directions and thus control water flows. The water flows down into the sluice area where the water level is regulated in different sections. Water pipes in three different sizes have been transformed into seating areas where the children can challenge each other in "guessing the sounds". Thirteen different sounds connected to water are played in the two largest tubes. In addition, there is a water workshop that consists of various technical water tools such as screw pump and connecting vessels that give children the possibility to control the water level. The way to the pond is passing through a grove which provides a great place for play in nature.
Through designing the water stations integrated with nature, Hyllie water park makes a creative platform for visitors especially for children to understand water characteristics and opportunities. It is a very good example of a pedagogical design. [52]

(a)

(b)

(c)

(d)

Figure 23 : Water features at Hyllie water park

Source of all pictures: www.kretseum.se/hyllievattenpark

Lessons learned 2

1. Inclusive spaces does not mean all spaces for everybody

Designing inclusive spaces should be interpreted as variety of use and functions for different groups rather than searching to find a function that attracts all. Spaces could be divided into sub-spaces designed specific target groups. Distribution of activities in one space would invite different target groups. Consequently, it would also be a source of inspiration that creates a dialogue between people with different choices and priorities. It is also important to notice if the design is aimed for a specific group in the society (defined by age, gender, education, etc.) or the aim is to create a place and observe how it attracts people with different interests. The latter would be a more accurate measurement to start an inclusive design. Through the observations it is possible to analyse which feathers are more desirable for a certain group. It is an implausible claim that all places are for everybody. In the example we reviewed in Benthemplein square, one of the small basins were more used by boys for skateboarding, while the other was chosen mostly by girls due to its scale and the possibility for sitting in smaller groups. The art of the landscape architect is to recognize the gaps between spaces desired by different groups and connect them in a way that it represents as a whole.

2. Flexible and multifunctional spaces

The notion of rain garden which is the philosophy behind most of the discussed examples is creating a multi-functional landscape that would contribute to multiple advantages in the environment and possibly human wellbeing. The flexibility of place and the capacity to be used by different target groups and during various events and times of the year is a key to design successful places. It also allows creative uses by making possible interaction between the designers and users of the place.

3. Design for Human scale

Human-centric design is the basis for formation of our urban spaces. Our impressions of a space is defined based on our relation to that space and how we see ourselves in it. That is how a space and a place could be differed. A place is a space that we found some connection to. Places usually carry a sense of belonging while spaces are more general and lack a specific identification. When designing a place, the proportion of spaces should be adapted to human needs and convenience. The size of water functions in Hyllie water park, for instance, brings the possibility for user interaction. In other words, how a person perceive her/

himself in the place is a positive experience. The same is true in some other examples such as Taasinge square, museum park and Rain (a) way garden. In Benthemplein square, in contrary, the biggest basin is designed to be too large compared to the size of a person. One can easily experience the depth of a basketball field is dominating the space. In comparison to the two other small basins in the square it is less popular to use. This shows an importance of considering human experience in relation to the size of a place.

4. Art as a mediator, use art as a tool for Placemaking

Art in any form is a tool that introduces a new way of seeing and experiencing a phenomenon: how we can see an object or concept through the eyes of the artist and reinterpret it. Therefore, art is a powerful tool to form people's experience in a place and helping to explore a place with new eyes. Art could be used as a mediator to draw attention in a place or a specific issue. In the example of Westersingel sculpture route, the sculptures raised much attention of the residents when the route was flooded in a heavy rain event. In other cases, like Rain (a) way garden the design of tiles adds to the aesthetic value of the place and invites the user to stop by for a moment and ask "what is happening in this place? "Either way using different forms of art creates a moment of contemplation and could help to understand new connections.

5. Involve a sensory experience, sensory design, a multisensory design practice

A sensory design aims for an experience to include all the senses. Usually it is our vision that forms the big part of our experience. Creating a multisensory design practice which involves other human senses like hearing, taste, smell and touch would add to the depth of the experience and forming a stronger memory of a place. In Hyllie water park using sound and light in relation to water highlights the water characteristics and opens a new way of perceiving this element. In the Rain (a) way garden the sound of water in the tiles would engage the viewer and also invites people to come and touch the water stored in the tiles.

6. Community design, Involving stakeholders

Using multiple perspectives in design by active participation of citizens and stakeholders creates a strong foundation in the first step of urban projects. It creates a sense of belonging for the citizens that they are involved in decision making process and makes it clearer for authorities how to design based on the feedbacks they recieve. An enhanced sense of responsibility is realized when users participate in a project

both during design process and after the project is executed. It would result in safer spaces and more engaged community.

7. Narrative as design tool

Following a designs storyline stablishes a connection between a place and visitor and opens space for reflection on the design. This eventually can enhance the sense of place. Hyllie water park narrates a design through walking in a path and the functions that are placed along the way. Rain (a) way project narrates detailed movement of rain on the tiles and its permeation to the planted. The connection between three basins of the square is not clearly perceived. Therefore, I assume that it was not designer's intention to do so. The rest of the case studies are narrating stories through intertwining natural and built elements and the way water flows in this story.

8. Water city lab a place for ongoing trial and error.

A testing ground to see how a vision works in reality and how the citizens respond to the emerging urban projects is essential in every city. Since all urban projects are place specific and are being evaluated based on the use of citizens it would be a great advantage to test them prior to invest on a big project. Allotting a space to create pilot projects is an urban investment, while making citizens updated about the future projects. Urban design is an ongoing process meaning designers always learn from what made a place desirable or empty of people, and what is a positive feature in one design might not work in another place. Therefore, pilot projects could be useful to help reach a better understanding in the subject with less investment.

9. Raising awareness and make a pedagogical design

Following the previous lesson, providing a ground for active learning would also help to be more conscious on the ongoing problems in cities. Public spaces in cities could be platforms for citizen's interactions. Landscape architects could communicate through design on how they tackle a problem in a city and how and the design idea brings new possibilities for a place. Public spaces could be the platform for this active dialogue between the stakeholders in cities.

Figure 24 : View towards Eriksberg's crane

Design area

The selection of the area is made based on the measures derived from my design manifesto. I was looking for a place that is part of the new development projects in north of Gothenburg due to the fact that sustainability measures are taken into account on the building projects, while it is clearly overlooked in the spaces between buildings. The historical value that a place offers plays a significant role in forming a public memory and my goal was to create a collective memory in connection to water as the identity character of Gothenburg.

Hence, Dockparken (also called Docktorget) in Västra Eriksberg, was selected as a design area first due to the numbers of development plans that city of Gothenburg is performing around that area and secondly because of the Eriksbergs crane that acts as a landmark and carries decades of history for the city.

Furthermore, while investigating the area, I noticed two other built projects that had been executed with the thought of involving water element in design. First, the reservoir in Propellergatan which is in a few meters distance from the alternative design area and acts as a container in the times of rainfall. The second is the pocket park in Sannegardshamnen that by using vegetation and constructed slopes direct water into the drainage area. My attempt is to examine the further creative design ideas inspired by these two examples, nearby the study area.

Dockparken is a playground and beach volleyball next to a parking area located in between water and a street. Since my main focus is to integrate art in landscape design as an essential element for thriving urban environment, I thought this area has the potential to manifest as a vivid public space that embraces the identity of Gothenburg.

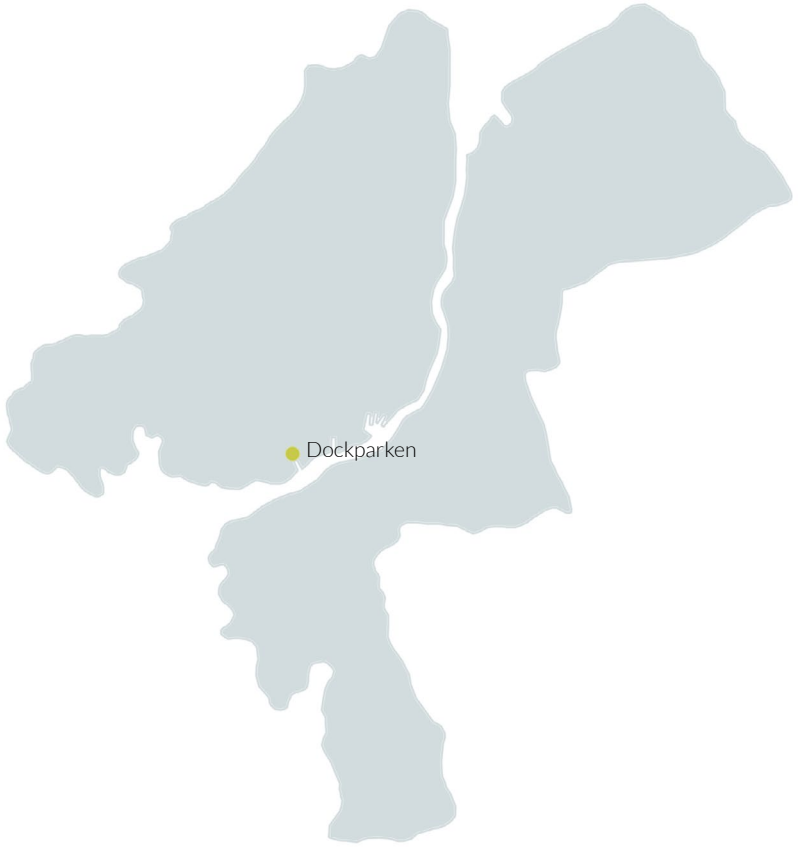


Figure 25 : Public space design in Sannegårdshamnen.
UsingVegetation and sloped surfaces to direct rain water
Source www.norconsult.se

Figure 26 : Resevoir at Propellergatan, close to Eriksbergsdockan

At the present moment the design area is consist of areas with play equipments for young children and the main part of the area functions as beach volleyball. Existing proposal for Dockparken aims to invite other target groups and therefore there will be an additional playground for older children. Since the aim is to gather more residents in this place for activities and events, there is an asphalted area for food trucks. Also, two areas assigned for playing pétanque is proposed in the future plan. There is proposal for new trees to be planted and some sitting areas are also added to the place.

Overall, I can say that besides the new play equipments, there is not a major change in this proposal and therefore the goal of attracting residents to use this place might be difficult to achieve due to lack of diverse functions for different age groups.

It also seems disconnected to its surroundings and importantly the canal. I think vicinity to the canal is a very powerful character that should be used in designing this place.

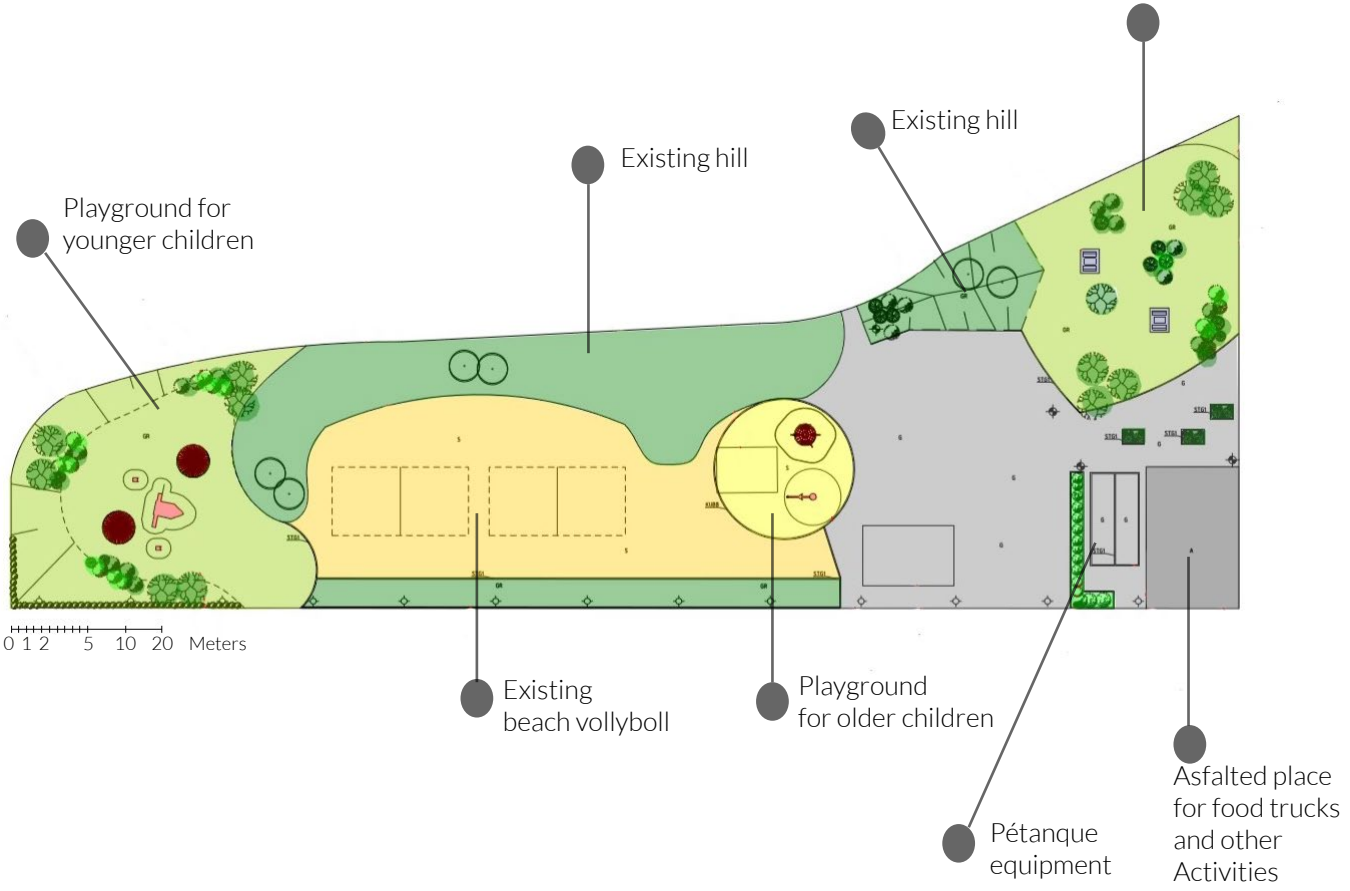
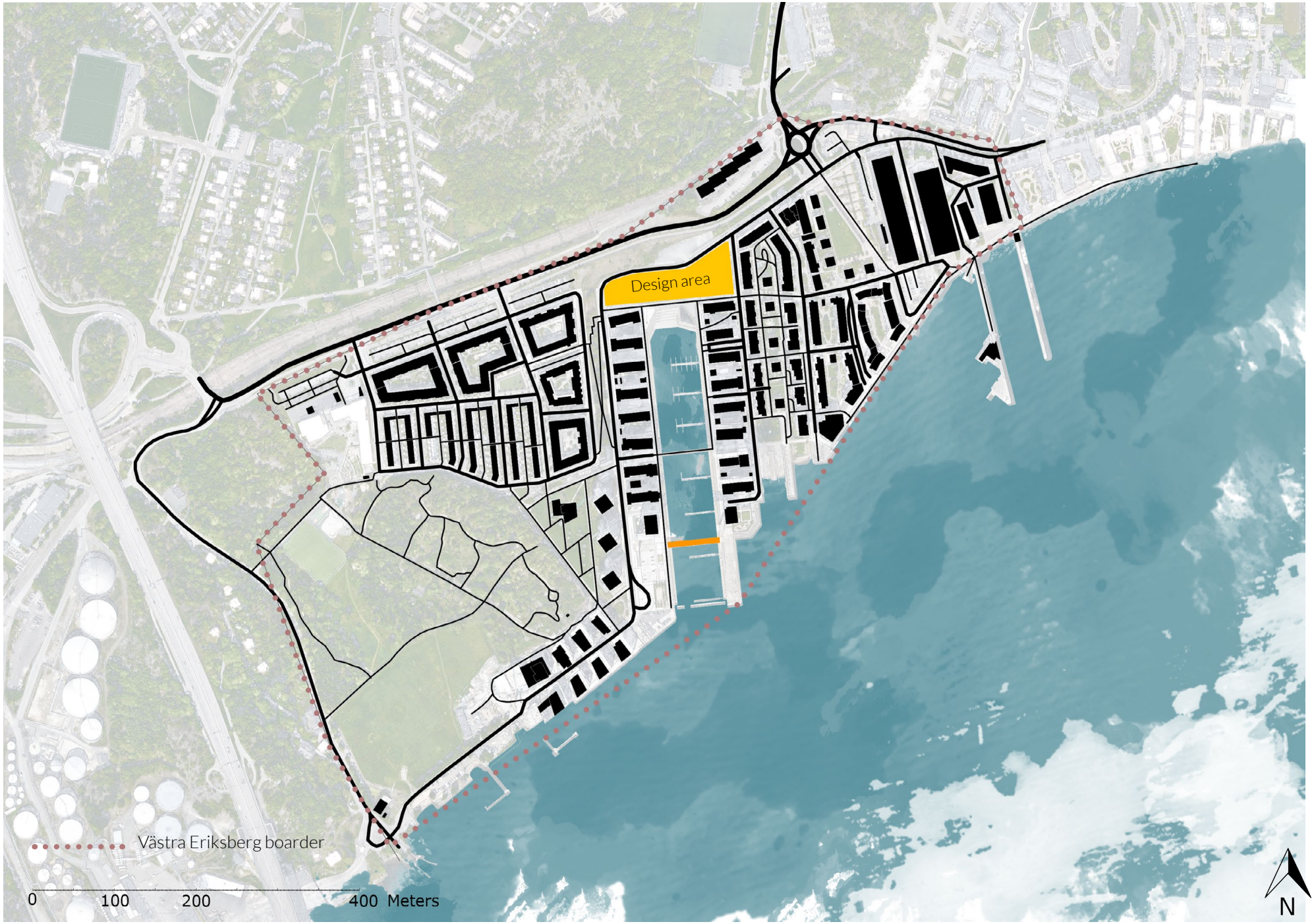


Figure 27 : Views from Dockparken


Design area
Västra Eriksberg boarder
0
100
200
400 Meters
N

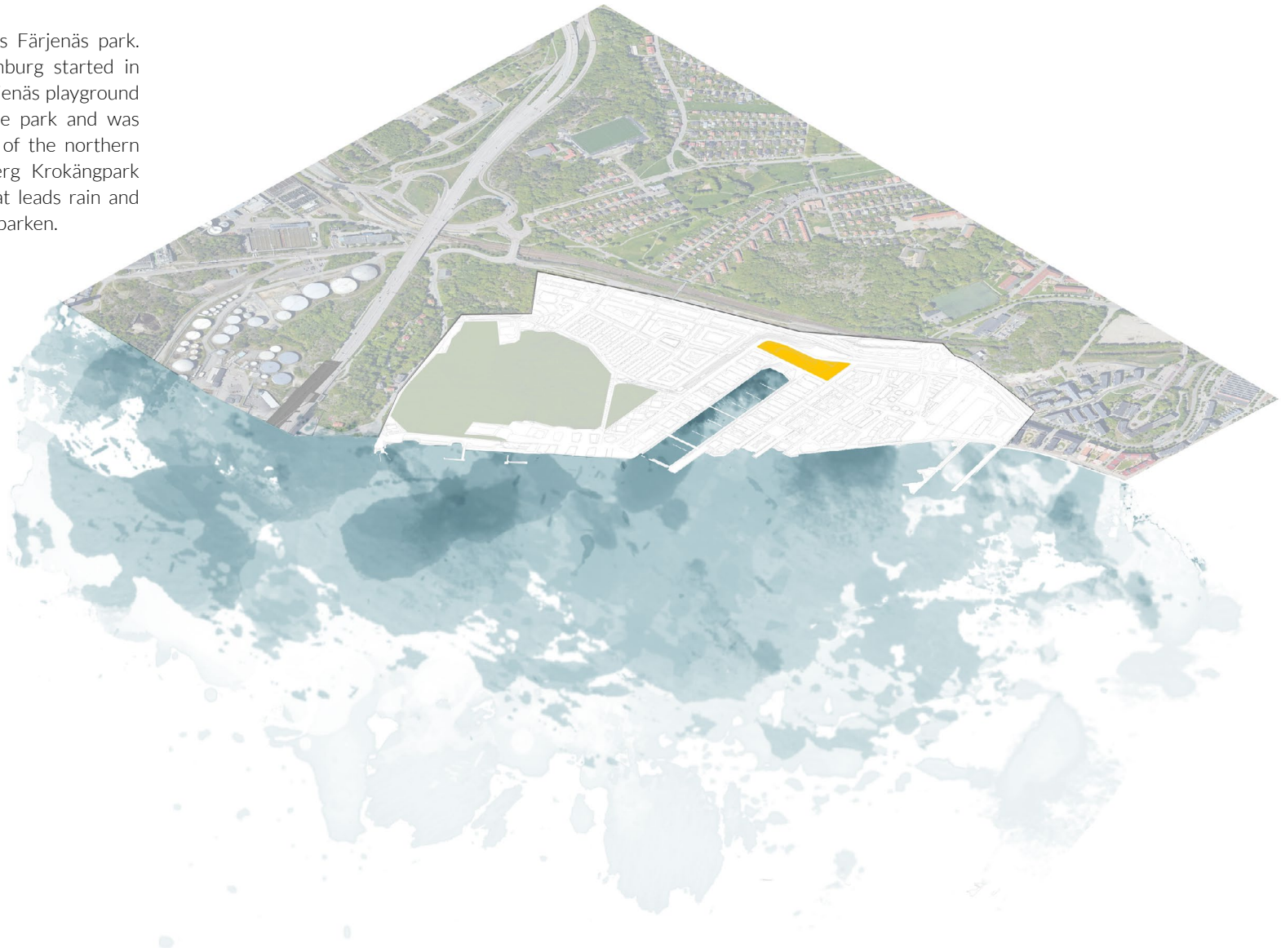
Land use

The area mainly consists of residential mid-rise building with local businesses on the ground floor. There are cultural-historical buildings on the east edge of the area such as Hotell Villan, Eriksberg Mekaniska Verkstad which was a ship building company and the “Blue building” that was a engine workshop which today hosts a hotel and conference facility.

- Design area
- Public buildings
- Residential
- Commercial buildings
- Other buildings

Green Space

The natural green space is Färjenäs park. The foundation of Gothenburg started in this place in 1603. The Färjenäs playground is located in margin of the park and was inaugurated in 2013. Out of the northern borders of Västra Eriksberg Krokängpark is another natural area that leads rain and melted snow towards Dockparken.

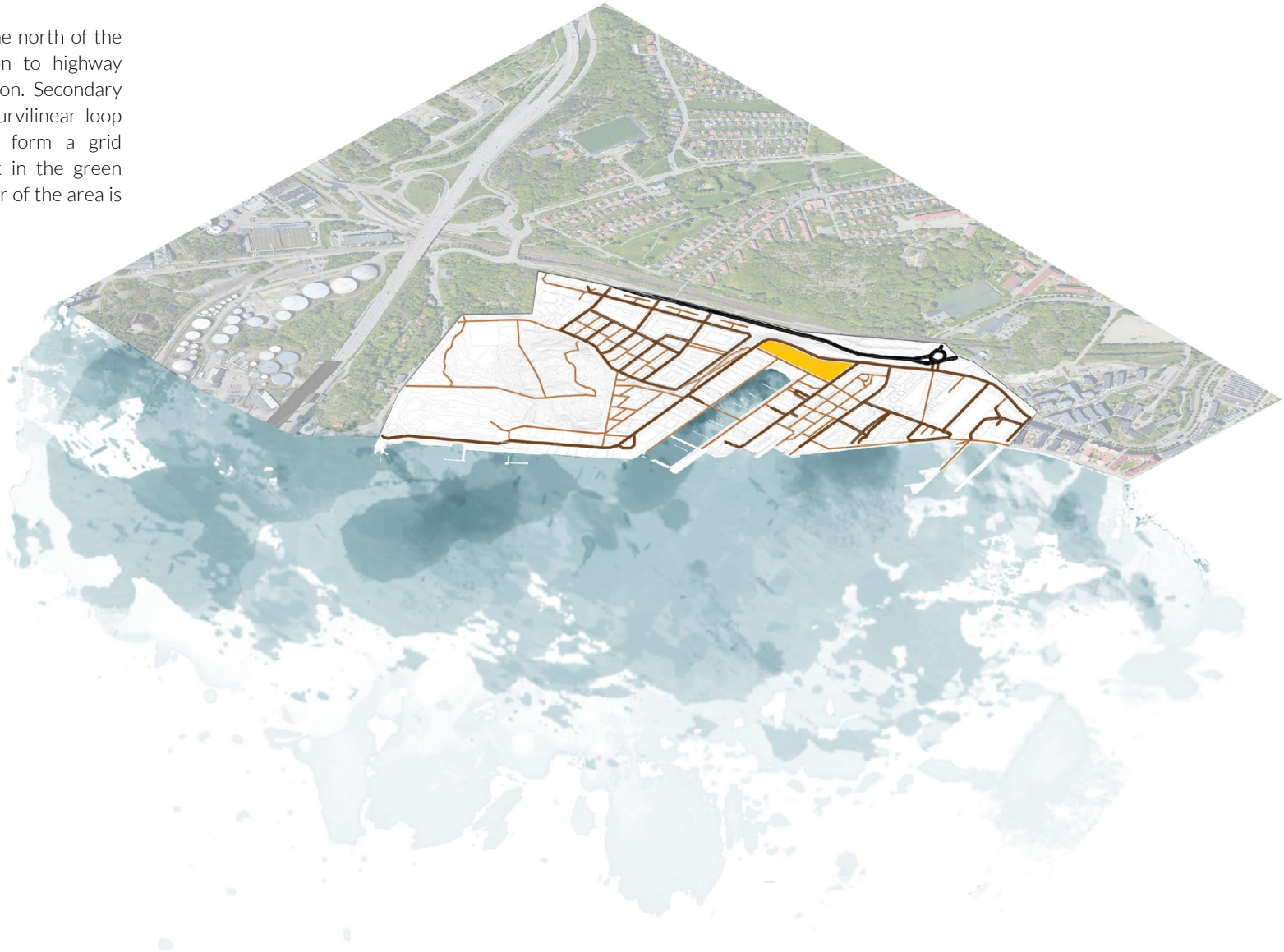


Design area

Green space

Street network

Road Västra Eriksberg in the north of the area due to its connection to highway counts as arterial connection. Secondary streets or collectors has curvilinear loop pattern and local streets form a grid pattern. The local network in the green space on the western border of the area is rather organic.



Design area

Arterial path

Collefctor path

Local path

Open space

In the east side of area there is a water basin which holds rain water. There are two activity, skateboard areas on two sides of the canal. The one on the east is located next to a pocket park and the one on the west side is close to a sloping lawn surrounded by flower beds which allows slow infiltration in the rain events. There is another pocket park/lawn area in the north that holds water in the rain events.

Design area

Open space

Lessona learned 3

1. Västra Eriskberg mainly consists of residential buildings and local businesses. Promoting the function of spaces between buildings enhances the qualities of urban environment and provides the opportunity for the residents to stay outside.

2. The area benefits from Färjenäsparken on the west. Krokängsparken is on the northern side and outside the border of Västra Eriksberg. The two areas are disconnected by Västra Eriksbergsgatan road and therefore no strong connection is seen between Krokängsparken and the study area.

3. The only significant barrier is Västra Eriksgberggatan on the northern border of the study area. The streets are accessible for pedestrian. However, the cycle paths are shared with the pedestrian and cars.

4. Besides two places in the southern part of the study area, which are allocated for skateboarding, there is not a specific function in the open spaces. The pocket parks are a good addition to the area in order to provide places to stay. The open space on south western part of the canal is a good example of combination of green and blue strategies.

5. Overally, the area has a great potential to improve public spaces that express the identity of the place. Apart from the crane that is the remained identity from old times, there is no specific element that highlights the character of Västra Eriksberg.

6. Dockparken has a focal location in the neighbourhood and with the vicinity to the canal has the potential to offer new activities to the residents.

On average there are 152 rainy days in Gothenburg during a year. The fact that it rains more than 1/3 of the year brings an immense possibility for the city development projects that consider designing with water.
Although the strategies for development of Gothenburg are known as “RiverCity Gothenburg Vision” the connection between the river and the city is not taken into account in designing public spaces. However, this is going to change as many ongoing projects aim to emphasis on this charachter as Gothenburg will celebrate its 400 years anniversary in 2021.
One of these projects known as “Rain Gothenburg” funded by municipality of Gothenburg to invest on involving stormwater in urban projects. The goal with this project is to manage the extreme rainfalls and use the rain as an opportunity for creating unique experiences and represents the identity of the city close to water.

As a part of this project, in December 2018 the first rain playground, Renströmspark, was inaugurated.

Figure 28 : A wall painting at sjöfartsmuseet in Gothenburg

Figure 29 : A word cloud by Mia Wahlström as a part of her research on the sould of Gothenburg city. The could is made from the citizens answer to what they think Gothenburg is identified with. The sea is the most dominant identity character in city.

Renströmspark is the first water playground in Gothenburg as a part of Rain Gothenburg project which is planned for the 400th anniversary of Gothenburg in 2021. The goal with this project is to integrate water in urban design.I met Emma Johansson, project leader of Renströmsparken. In this part I summarised the points we discussed in the meeting.

The vision for the Rain Gothenburg project is to create unique places which are interesting to be at when it rains. Renströmspark is a city park which is easily accessible from the city centre and placed in the vicinity of a natural pond, Näckrosdammen. Prior to transformation of the playground there was a dialogue between the municipality and citizens on the features that people expected from a rain playground as well as the desired activities that could take place there. At this stage the decision on the place was not made yet and further when the Renströmspark was selected as the project's location the dialogue continued through emails between municipality and citizens. The issues were addressed by citizens were regarding the characteristics are more pleasant when thinking about rain theme in a playground. Among the suggestions that park and nature department received, was designing water paddles, which was rather an easy solution and at the same time favourable to kids. Ideas on creating something that can collect water and some kind of interaction with water, visual experience and showing other features of water like sound, feeling were other points addressed through citizen's participation.

The park and nature department also considered this place to be used through the whole year. It is more likely that in architectural visualizations to show happy people in sunny weather while in reality it could be dark, grey and rainy. The role of a landscape architect is to design a place that is still inviting in the latter situation.

The design process was performed with collaboration of landscape architects at 02landscape and two artists, Thomas Nordström and Annika Oskarsson.

The design criteria were to bring fantasy and innovation into creating the place as well as making a robust design. It should be easy to maintain and be understood as a meeting place for everyone and not just as a playground.

Based on the designers' analysis the entrance should be more inviting. Thus, they designed a new entrance which makes the space open and attractive. The previous entrance opens towards a historic sculpture and opens to the view to the pond. The proposal was to divide up hard surfaces with cobblestones. The sculpture stays at place to represent cultural and historical value of the place.

The spaces on the playground are divided based on three functions:
1. Rain movement (Climbing equipment)
2. Raindrops on a glass (Water paddles)
3. Collecting the rain (Hosta leaves)

These functions are executed in the place through art installations. The climbing equipment “Spön I backen” is made of steel construction with rubber plates. The safety of the children while playing in this area was discussed through the process and the measures were considered in design.

The idea behind designing hosta leaves where that water will be collected on the leaves and there also designed places under the leaves for people to sit on. The collected water will flow through the pipes towards the sand area by the pond. Differences in height of the leaves provide experiencing sound of water.
Regarding the water paddles there are laws from environmental department that the water should not be collected in one place for too long time due to hygiene concerns.
There is no detention function considered at Renströmsparken. There was an idea of a rain garden from the beginning, but the clay structure of the soil and maintenance of plants made it difficult to realize that idea. The commission was to make the waterplay function more visible in the city. The materials that are used for design was already existing at the place.

In designing for rain water management many factors are involved such as the cloudburst surfaces, the quantity of water. When dealing with such issues in Gothenburg, there is also a local obstacle like the soil type which doesn’t let the direct flow of water into plant beds and new solutions are required to solve this problem.

The most important thing when working with stormwater management project is to collaborate with different experts to address not only technical aspects of stormwater but also aesthetic, social, cultural and environmental benefits of it. Moreover, it is crucial to consider the local characteristics of the place as well as seasonal changes to make the place accessible al year round,

Also, to involve people in the process from the early stages and inform them about the important aspects of designing for stormwater is another aspect to consider in stormwater projects.

Figure 30 : Renströmspark (a)

(b)

(c)

(d)

In the following section, I introduce some examples that inspired me to carry on with design proposal in this work. Among them there is one project that is done by a landscape architect firm and the rest are artistic projects.

The way that these project created sensory experiences drew my attention. It was also very interesting to review the projects that applied a unique and different approach. The first high speed photography by Harold Edgerton is a great example as such. Tanner fountain was actually the first project that motivated me to study landscape architecture. The different approach towards a fountain design was very refreshing and unique.
The rain room was an exhibition that I visited in Modern Museum of Art in New York. The perception towards experiencing rain was a fascinating approach. To experience being surrounded by rain and at the same time not experiencing in directly. Lastly the Waterlicht project was an inspiring example with the goal of envisioning the future of water on the planet. With a very subtle material, light and air, the artist pictures the future scenario of sea level rise and the necessity to take action on this issue.

Following, the projects are briefly explained.

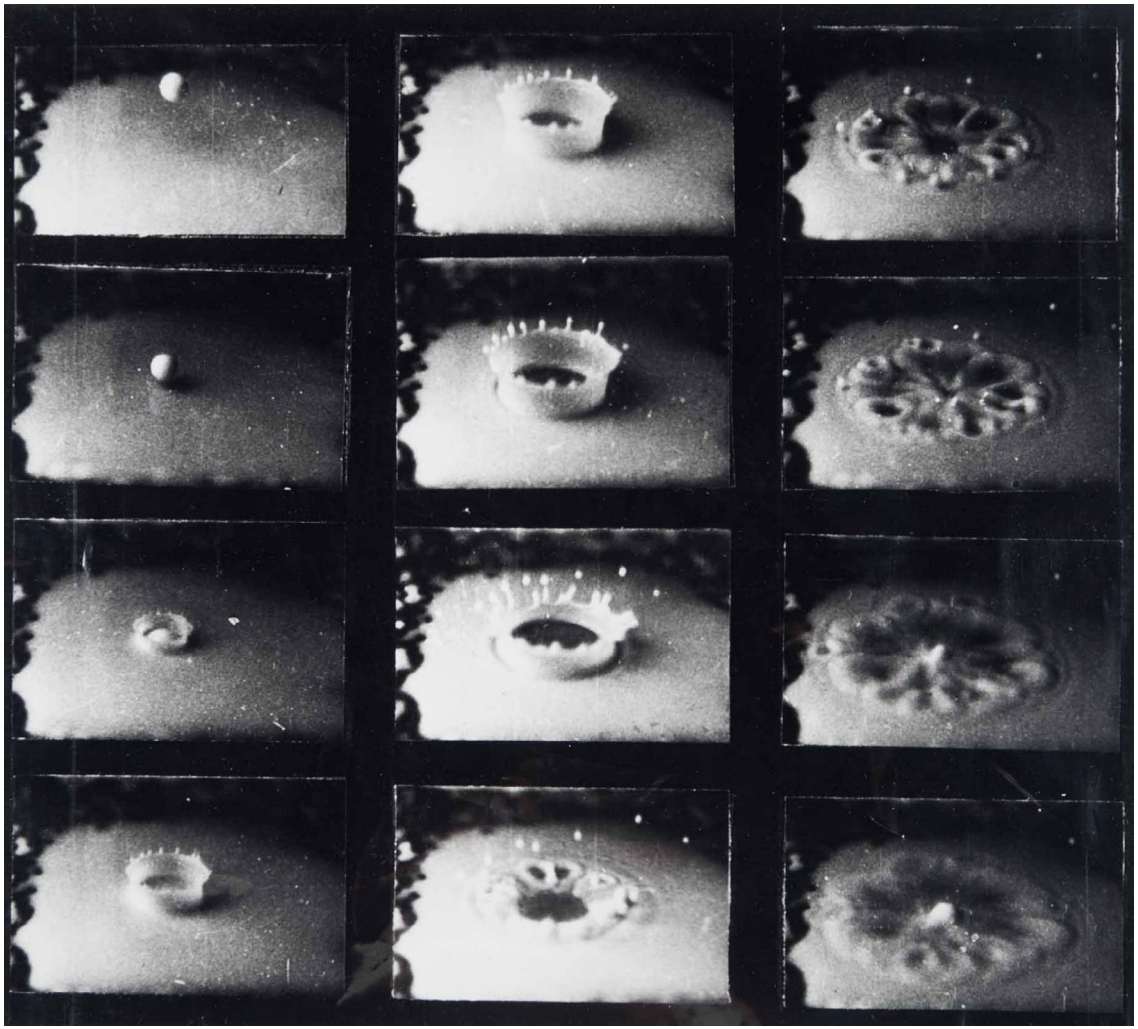


Figure31 : Milk Drop Series, (1933)High speed photography - Harol Edgarton
Source: www.csw.org/news-detail-thompson-gallery-exhibitions-detail?pk=863079

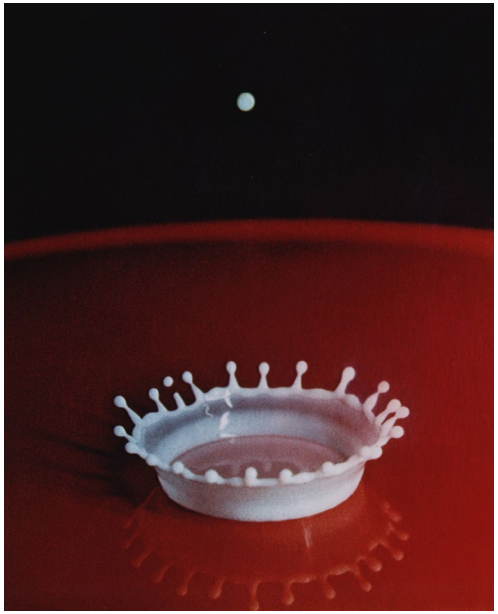


Figure 32 : Milk Drop Coronet, 1957

Figure 33 : Dye Drop Into Milk, 1960

Source: www.csw.org/news-detail-thompson-gallery-exhibitions-detail?pk=863079

Harold Edgerton, high speed photography

In 1931, Harold Edgarton revolutionised the motion photography by combining camera and stroboscope.

The device that he invented, extended the ability of the human eye to capture microsecond visions. By photographing motion as a single image, or in multiples of up to 600 per second, Edgarton improved the slow motion film footage.

His photography, was a manifestion of uniting art and science. As he himself states his work allowed "time to be chopped up into small bits and frozen so that it suits our needs and wished."[53]

Figure 34 : Tanner fountain by Harvard school
Source: www.flickr.com/photos/studio-s/5846041783

Tanner fountain

In 1984 Peter Walker and the SWA Group transformed a busy pedestrian crossroad in Harvard school by designing a fountain. Tanner fountain is consist of 159 granite boulders. The combination of water and this geometric space recalls the rocky, rural landscape of New England.

The stones are located randomly in concentric circles. Water flows from the circle's centre in form of mist and steam depend of the time of the year and creates a seasonal contemplative landscape.

Tanner fountain was the first institutional project in the "Landscape as Art" movement. It also received the American Society of Landscape Architects' Landmark Award.[54]

Figure 35 : Rain room exhibition
Source: http://vestoj.com/vestoj-x-vnivrs-forces-in-art-theatre-and-fashion-explosions/

Rain room MoMA

Rain room is an immersive experience created by the artists Stuart Wood, Florian Ortkrass, and Hannes Koch in the Modern Museum of Art in New York.

The installation lets the visitor is in a dark room where it is pouring down with water. As the visitor walks into the space, the rain comes to a halt where they stand. In a way by walking around in the room, one is surrounded by rain but not getting in actual contact with rain. The artists' intention was to invite the visitors to experience how is it to control the rain.

Figure 36 : Waterlicht installation
Source: https://aestheticamagazine.com/limitless-imagination/

Waterlicht

In this art project Daan Roosegaarde illustrates the dangers of sea level rise. By using blue LED lights, he created a striking horizontal beam that as a result of interaction with humidity in air make a wave-like motion.
Roosegaarde explains this work as: “Experience the vulnerability and power of living with water.”

By creating this virtual flood, he pictures the approaching scenario of flooding as a result of sea level rise due to climate change. Use of visual communication is a successful way in this artwork to raise awareness on this issue.[55]

Design manifesto

I take inspirations from nature. Observation of a raindrop on water gave rise to the idea of using this physical phenomenon and interpret this movement symbolically as a medium between human and built environment. Using this metaphor and having technical solutions in mind I designed to:

bring nature-based design into the urban life.
demonstrate the synergies between water, plants, fungi and human.
bring science into daily life.
let the landscape narrating the spirit of place.
make nature accessible in the midst of the built environment.
introduce pedagogical urban design into a place.
raising awareness on future scenarios driven from the present decisions.
create an experience that enables understanding through a different lens.

The transformation of Eriksbergsdoken from a shipyard to a residential area and consequently emerging of a new identity of place urges for recognition. Although Dockparken still carries the name from historical identity of the place, its functionality changed to adapt to the emerging identity of the place. Identifying “living by water” as a new identity of the place demands new design perspective. Dockparken is especially important place due to its location and potential as functioning public space. To introduce water and rain as a new identity, the design proposal starts by a new name for this public space: Droppeparken. Droppeparken is a place that people find themselves enclosed by water. It narrates the story of a raindrop. The elements of design imply the forms that sequences of a raindrop create, when falling from the sky. The falling drop is an inspiration for the spatial transformation of the place.

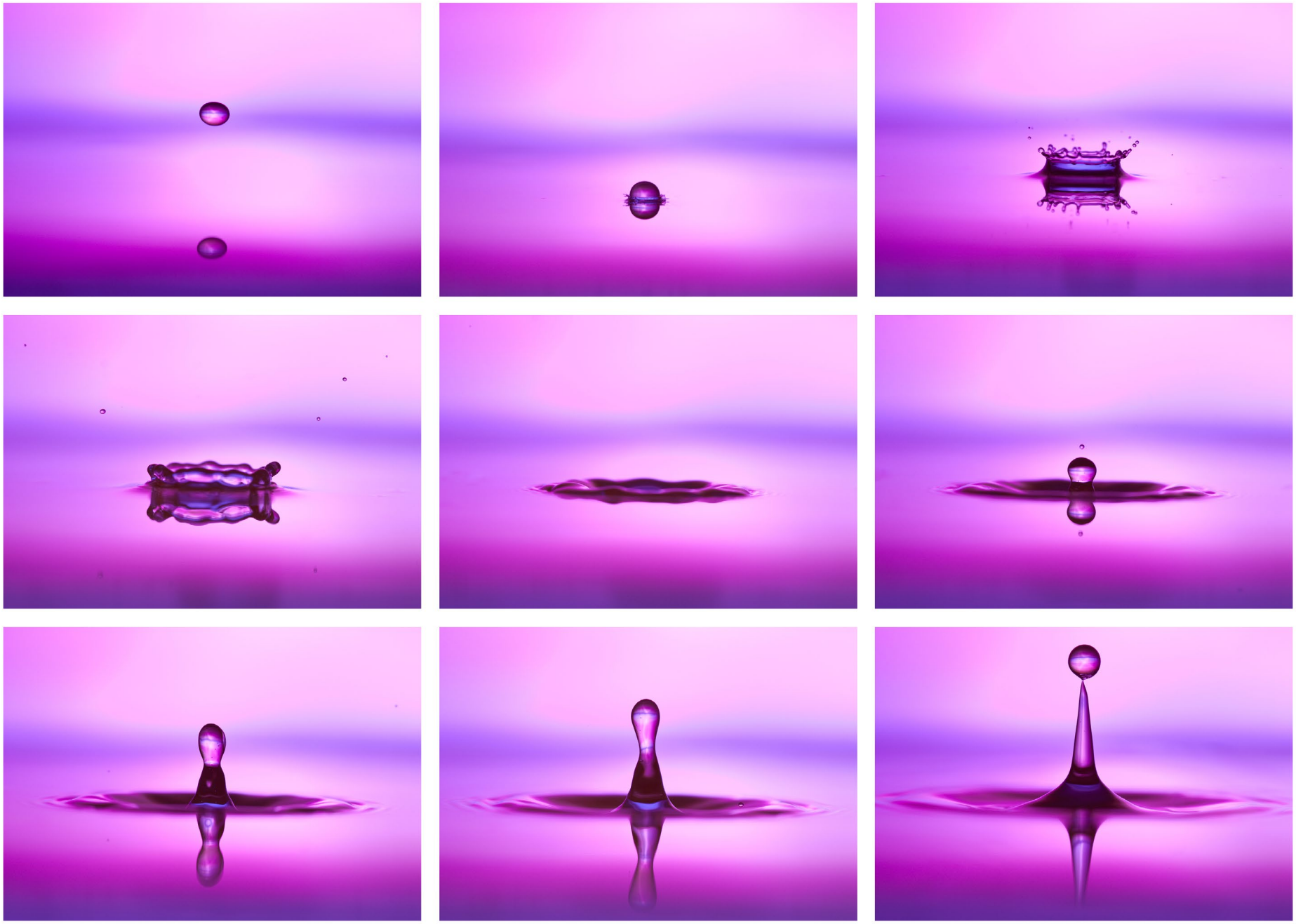


Figure 37 : Drop sequence, Photo curtesy: Gavan Mitchell

Lifetime of a rain drop

There is a common misconception that raindrops look like a stretched-out drip. However, in reality a rain drop that forms high in the atmosphere has more a shape of hemisphere with round edges. The clouds contain suspended particles of dust and smoke. The water molecules form into drops in the space between those particles. There is a strong cohesion in water molecules meaning they tend to bond with each other rather than bonding with air molecules. this is also known as the surface tension of water. As they fall, depending on their size, they get affected by the air pushing against them. Due to the high surface tension compared to the airflow on top of the rain drops they remain their spherical forms. On the bottom of the raindrops the air pressure is much higher, therefore it pushes through and make a kidney bean shaped drop. Eventually the pressure from the bottom can breakup up rain drops into smaller ones.[56] When raindrops get to the ground and reconnect with water surface, depending on their size they bounce back up to the air, and therefore collides with the falling raindrops. The result of this collision is formation of a water surface on top of the ripple.

Fall

Splash

Reconnect

Design process

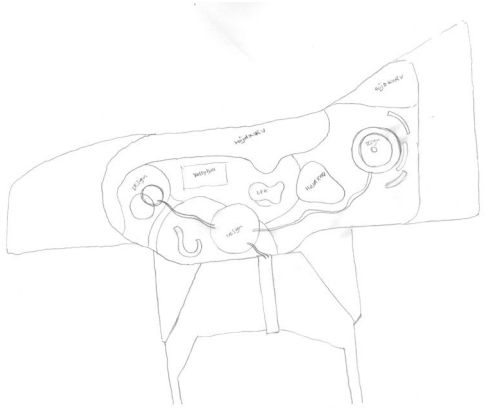
I started the process by thinking about spatial potentials of the place. I began sketching the possible alternatives to define the place. It was an important factor for me to connect the canal and the design area. There was a low hill in the middle of design area that separated the place into three different part. The middle part of the area, which was the biggest portion of three, is filled with sand and functions as beach volleyball field. There is another hill in the middle that creates space for setting up some play equipments. The western side of the site is also separated from the sandy area by a low hill and is equipped with some play elements. The eastern side is filled with gravel and some low hill and grass and basically is an open space.

Division of site in three parts spatially and my aim to connect the site with the canal resulted in the first sketch (a). I added the pedestrian path between the canal and site in my design. The site is quite large area and since it is not well connected, I decided to just focus on the central part. Taking the pedestrian path into the design was a thought to invite visitors into the site, but it has the disadvantage of restricting accessibility.

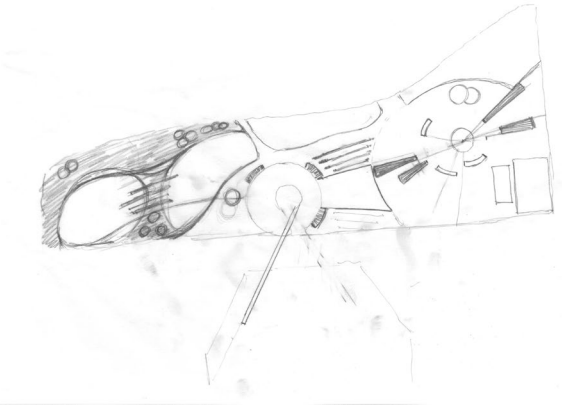
I thought about extending the canal into the site by introducing elements that make the interaction with stormwater possible. The product is the next sketch (b). My intention was to define a center for the proposal. Since connection to the deck was an obvious choice, therefore I decided to place a design element and connect it to the the canal. I also started to pay attention to how forms follow each other and tried to define the border of the design area more clearly. I was also interested to keep the existing and proposed functions of the site.

In the next sketch number (c), I put a design element in each of three section that is discussed above and tried to connect them with a possible water path. This made me thought how these elements should be designed and functioned. My preliminary thought was that these elements catch the water and then through a water play

a



b



c

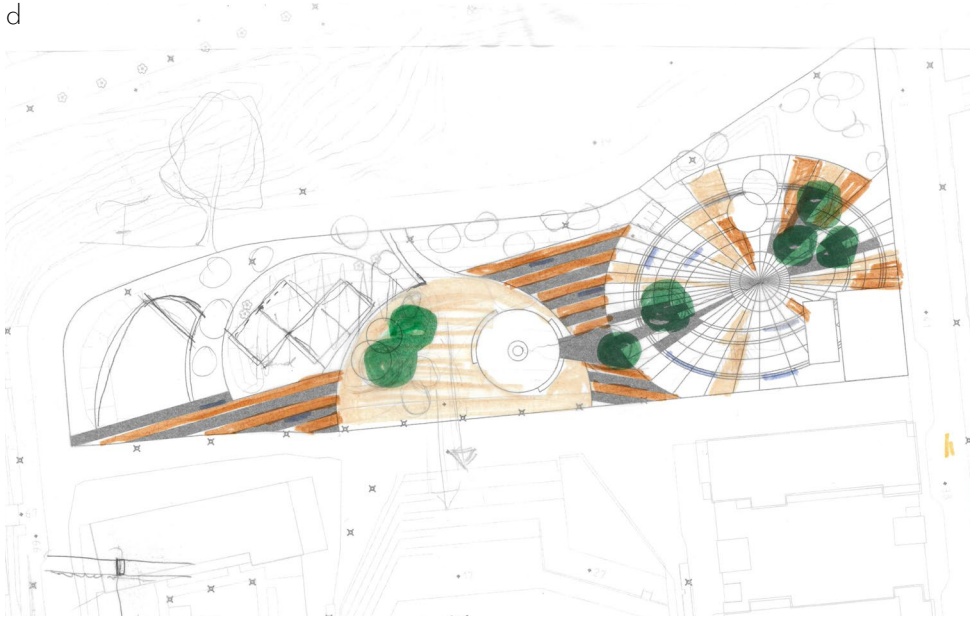
redirect it to the sea. I also thought about other possible entrances that could be defined to the site. I placed one entrance on the northern part where there is a newly built bus stop on the sidewalk, and therefore it increases accessibility to the site. also, I thought about potentials for the high points and vegetated areas in the place.

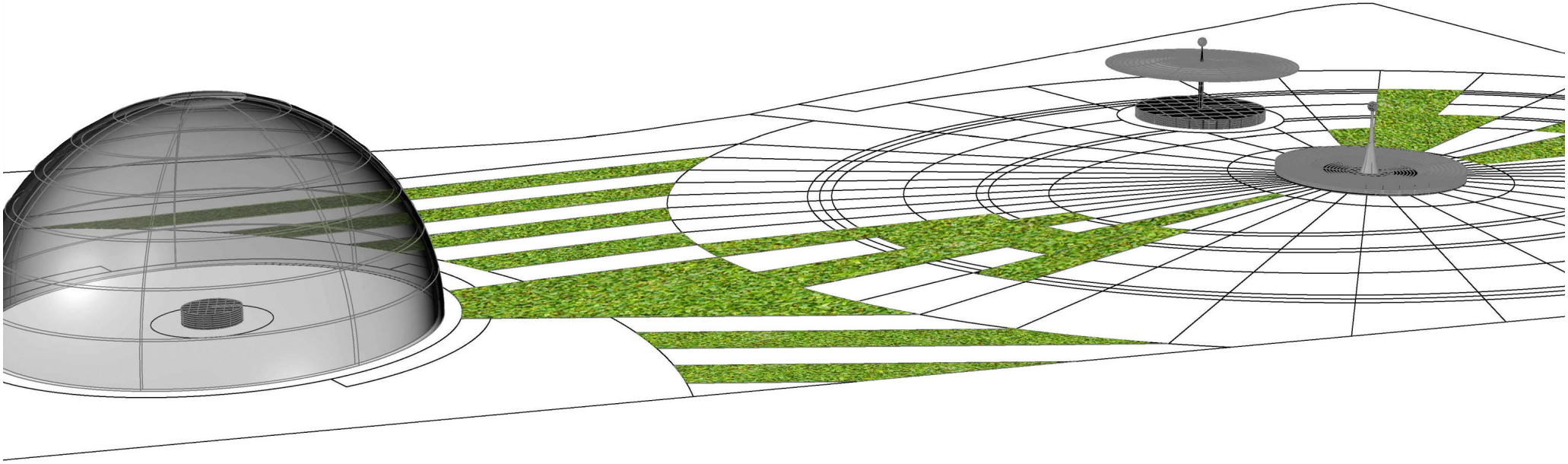
From this stage, I started to combine hand sketching and CAD drawings. Image (d) is the result of it. The playground and beach volleyball are moved towards the western part of the site. Then I defined three elements that are compatible with the narrative that I described earlier, a dome, a fountain and green roofs. The centre of the site where the dome is filled with fine crushed stone. The paths from the western side of the site to the fountain, which is located on the eastern part is combination of lawn and granite stone. The reason to use granite stone is the fact that granite is one of the characteristics of Gothenburg and is being used widely on the ground construction in Gothenburg. The fountain is located in the centre of area in the eastern section and some sitting places are located around it. The material for the ground around is the combination of blocks of granite stone, lawn and fine crushed stone. The pattern of the ground material directs towards the centre of the fountain. There is a green roof close to a fountain and two more next to the volleyball field.

The lighting of the area is partly the existing pole light stands and the lighting that is integrated with the new elements are introduced in the design. There are LED lights combined with the sitting areas close to the fountain as well as the green roof close by.

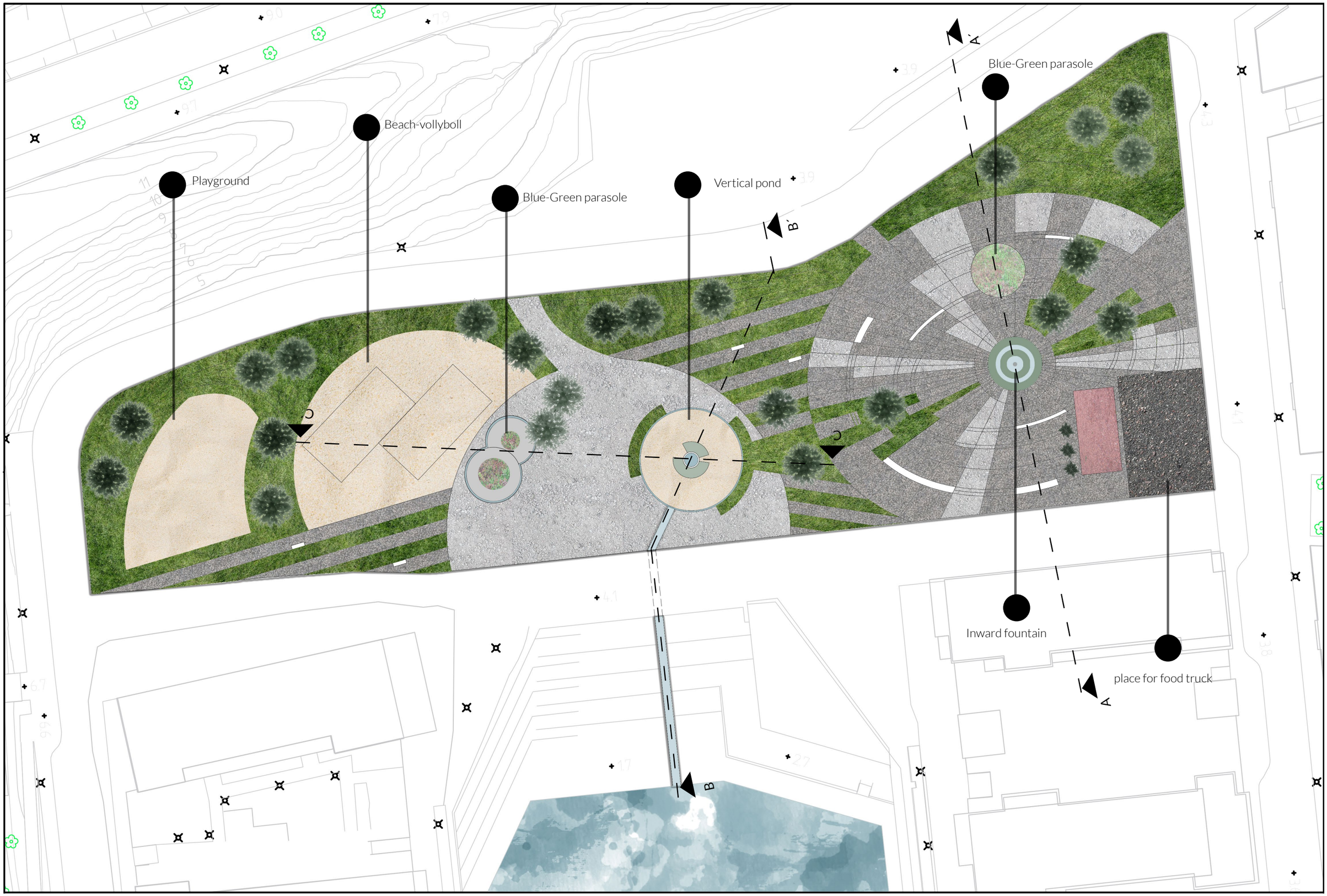
The green roofs close to the volleyball field use a gobo and with the help of it create a ripple pattern of light on the ground which is extended from the centre of the square to the western side and in a way the design is connected through lighting. The are four LED lamps on the ground in the dome as well, and because of its transparent material the effect would be enhanced.

d





Siteplan

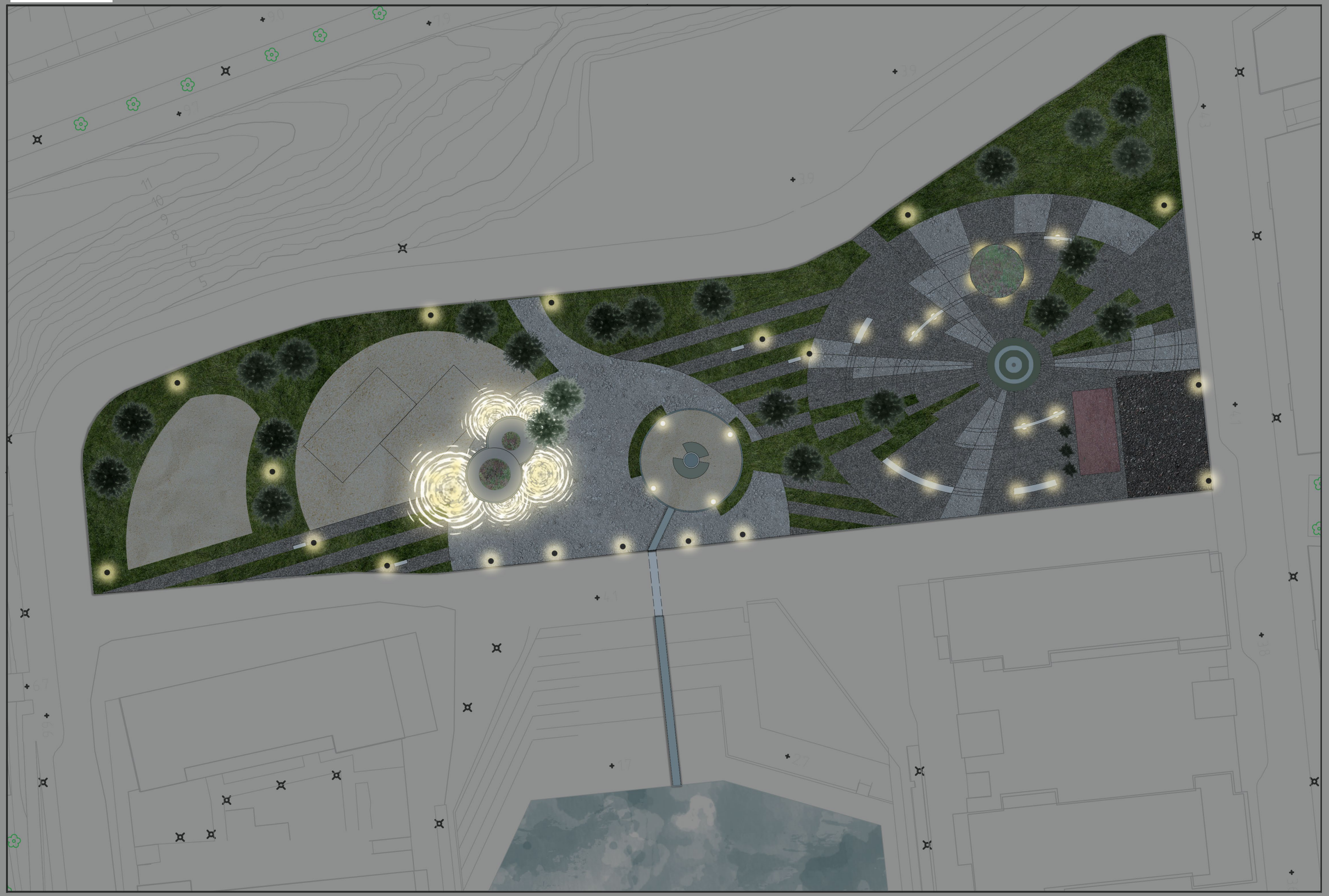


0 5 10 15 20 25 50 75m

Meter, skala 1:500 on A3

N

Siteplan at night

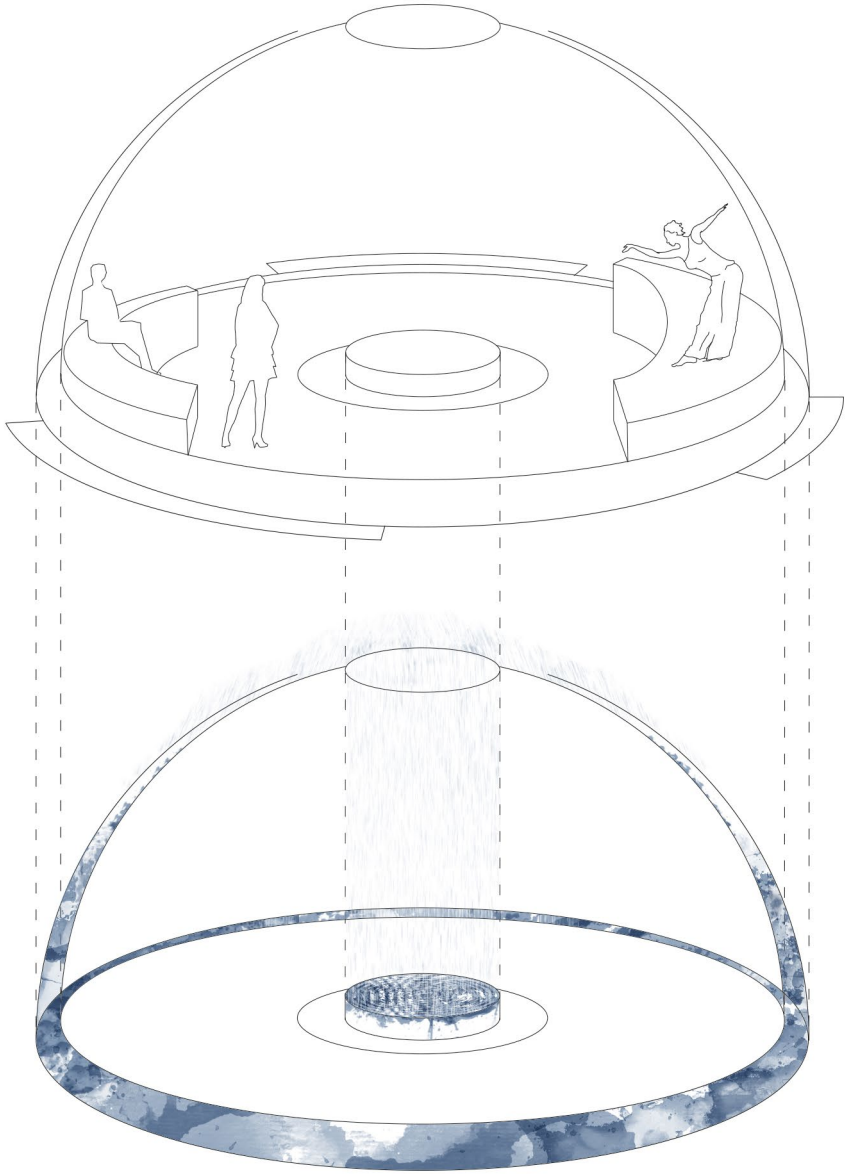


0 5 10 15 20 25 50 75m

Meter, skala 1:500 on A3

N

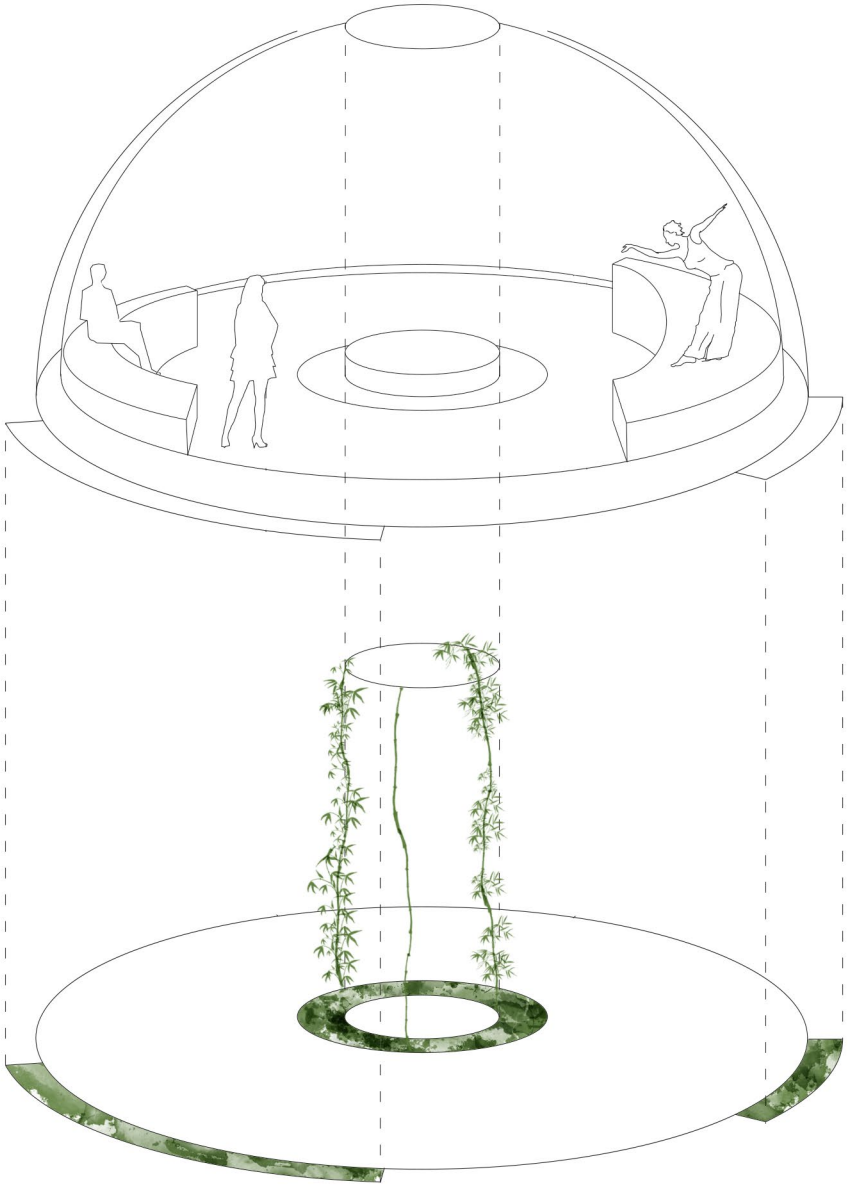
Design elements



Vertical Pond

The hemispherical structure resembles a falling raindrop and is the first part of the narrative. Basically, the dome functions as gathering space in the times of rain and also as a performance platform and temporary events. In the middle of the dome there is a basin with 0.5 meter height. It is in line with the opening at the top of the dome and therefore collects the water like a retention pond. It functions in combination with a pump that can drain the water and connects it to the underground water pipes. When the basin is full of water and it is not raining, the surface of water shows a mirroring effect. To create another effect the pump pushing air once in a while to create ripples on the water surface. The dome constructed in two layers. The outer layer of the dome has slightly shorter height than the inner layer which creates a gateway for water to be collected in the space in between. Therefore, it is also functioning as a vertical retention pond. When the basin reaches its capacity the water flows to the vegetated circle around the basin. The proposal for plants is mainly based on the capacity for water purification. There is a layer of ornamental grass outside the dome and the accumulated water between two layers of the dome can sink in. There is a gateway towards the deck that eventually directs the water to the sea. In order to not restrict the accessibility in the pedestrian path between deck and dome, a pump system is installed that moves the water to underground water system. The area is covered with a thick glass which make it possible to see the whole process.
The dome is made of ETFE foil that can be supplied as a single layer membrane supported by a cable net system.

The lighting of a dome is designed by four LED lights on the ground that due to transparent material of the dome reflect the light.
The plants around the basin are selected based on their ability to thrive in the moist soil. The plant bed is tilted so the soil can stay moist but well drained. The ornamental grass around the dome is also thriving in moist soil. The suggested plant in the following part are possible alternatives to choose from in the dome. Since the height of the dome is 7.5 meters, in order to design for human scale, the proposal is to plant climbing *Aristolochia macrophylla* on two sides of the basin to define the spatial structure of the space.



Carex oshimensis

Calamagrostis brachytricha

Veronica longifolia ‘Blauriesin’

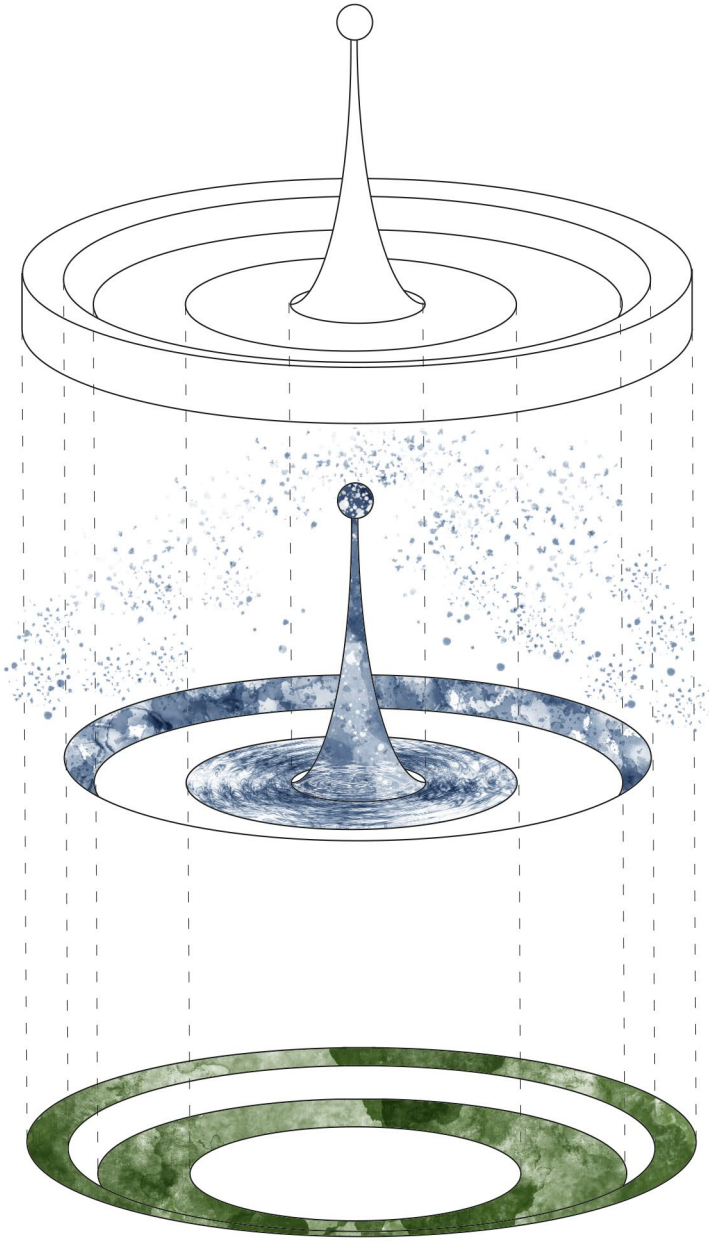
Persicaria bistorta ‘Superba’

Luzula nivea

Lysimachia clethroides

Filipendula rubra ’Venusta magnifica’

Aristolochia macrophylla



Inward fountain

The fountain demonstrates the second phase of the narrative, which is splash. This structure can be perceived as a combination of rain garden and fountain.
It is designed in two layers of plants and two layers of water in between. The proposed plant in two layers have different water tolerance. The layer closer to the centre consists of plants that thrive in 0-20 cm of water. The outer layer is constructed as a separate plant bed with plants that grow in moist and well-drained soil. The water is collected in the centre and would be pumped up through the cone bar creating an upward whirlpool. The perforated surface of the sphere on top of the bar acts as a water sprinkler to spray water to plants in the outer layer. The cone bar is made of transparent material, and therefore when the water whirls upwards it is possible to be visually engaged with it.
There is also the possibility to pump the water at extremely high pressure and create mist. The change between sprinkling water and mist adds a surprise dimension to this fountain. Moreover, the interaction between the mist and the lighting from the green roof close to the fountain adds to the visual effects of the design.
Another aspect of this fountain is to use *Stropharia rugoso-annulata* for infiltrating water and testing its potential to thrive in both moist and marsh zone. There are three types of *Hosta* which because of their wide leaves interact with the water, creating sound and visual effects from water on their leaves.

Plant composition in inward fountain

Plants

Fungi

Plants for the moist zone


Hosta tardiana ‘hacylon’


Hosta ‘Blue Angel’


Hosta tardiana ‘June’


Athyrium filix-femina


Brunnera macrophylla ‘Jack Frost’


Pulmonaria officinalis

Both moist and marsh zone


Thelypteris palustris


Iris pseudacorus L.


Stropharia rugoso-annulata

Plants for the marsh zone

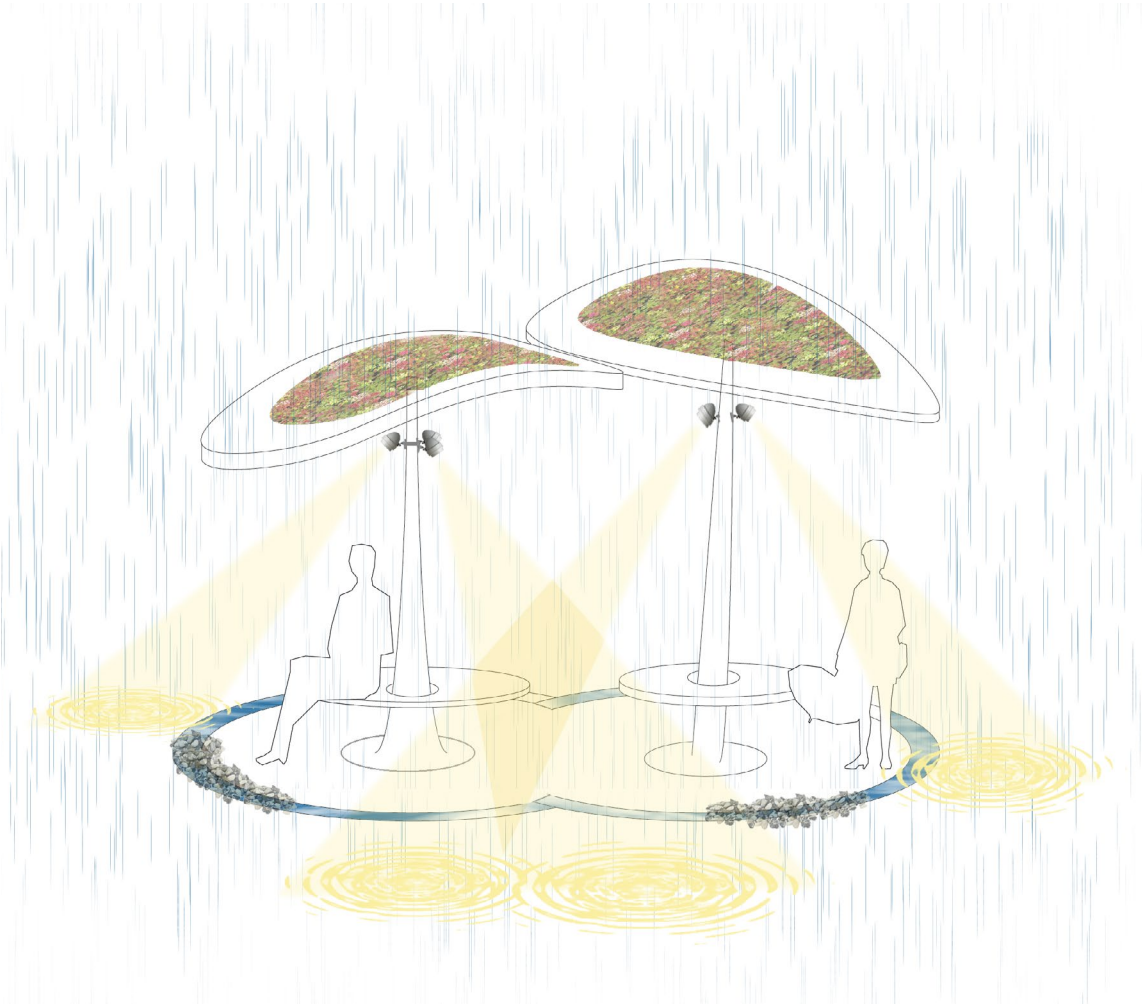

Menyanthes trifoliata


Veronica beccabunga


Sparganium erectum L.

Blue/Green parasol

This structure is a green roof inspired by the third sequence of the narrative, reconnect. There are three blue/green parasol in the design area. They have slightly different shapes that is inspired by various forms that this movement could result in. The one in proximity of the fountain is entirely green while the two others are partially green. The fact that they are partially green would increase the outflow of water from the roof. Around the roofs there are rings of gravel on the ground which intensifies the sound of dripping water from the roof.
The two green roofs are also equipped with a gobo projector that reflects the ripple pattern on the ground. Through this lighting patterns on the ground, a design is extended through the design area. With the view towards the harbour and volleyball field it provides a protected sitting area when it rains.
The other green roof close to the fountain is also used as a sitting space and the lighting around it interacts with the mist that sprinkles from the fountain.



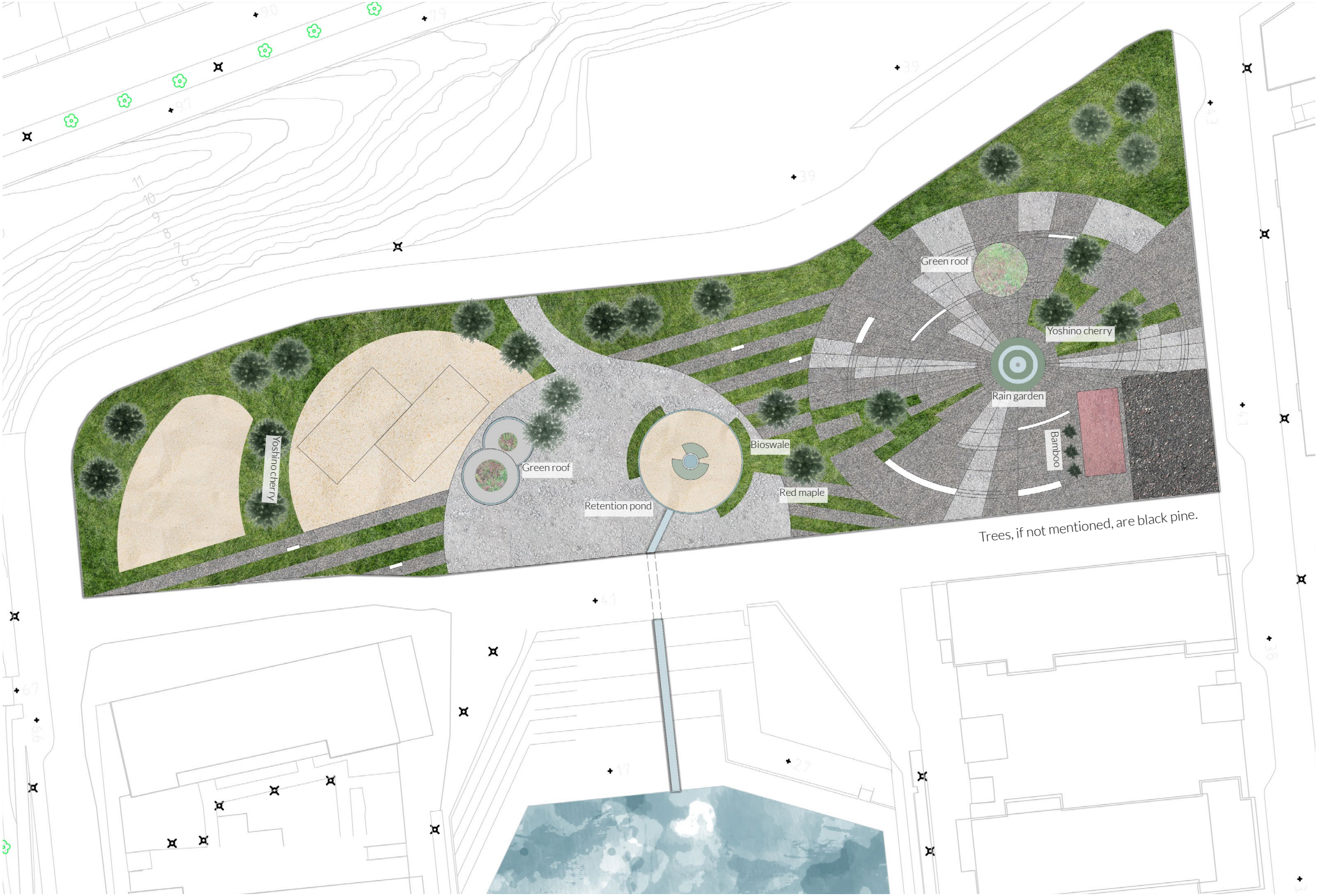
I decided to propose three different species; Yoshino cherry, Red maple and Black pine to add some seasonal colour to the design. Due to its dominant autumn colour I decided to use red maple as a solitary tree on the right side of the dome in the big turf area. The rest of the place is mostly black pine with the exception of some Yoshino cherry trees around the fountain and in between the playground and volleyball field.
In order to make some privacy and shield in the Pétanque fields, I introduce bamboo as a hedge. the reason is that even though it creates a shield, it is still very light barrier.

Acer ruburum

Pinus nigra ssp. nigra

Prunus x yedoensis

Fargesia ‘Rufa’

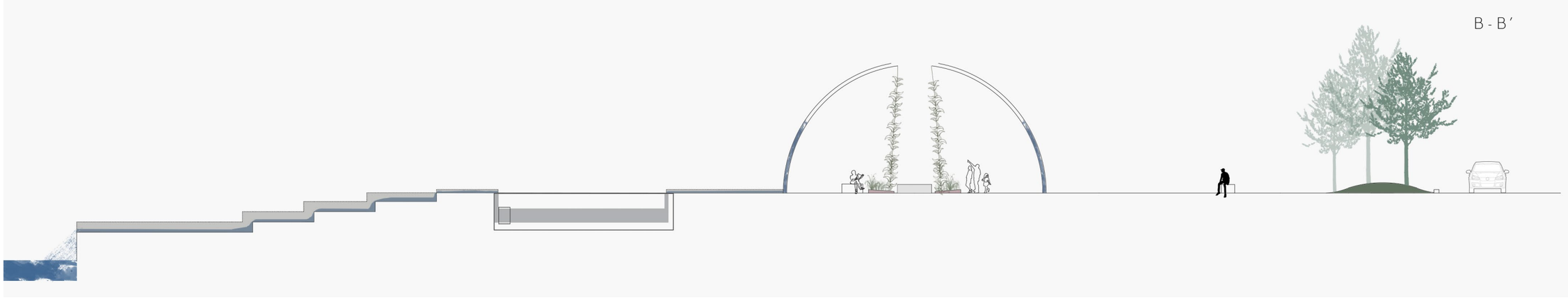

Green roof
Yoshino cherry
Rain garden
Bamboo
Bioswale
Red maple
Green roof
Retention pond
Yoshino cherry
Trees, if not mentioned, are black pine.

Bioswale - connecting vertical pond and inward fountain

Sections

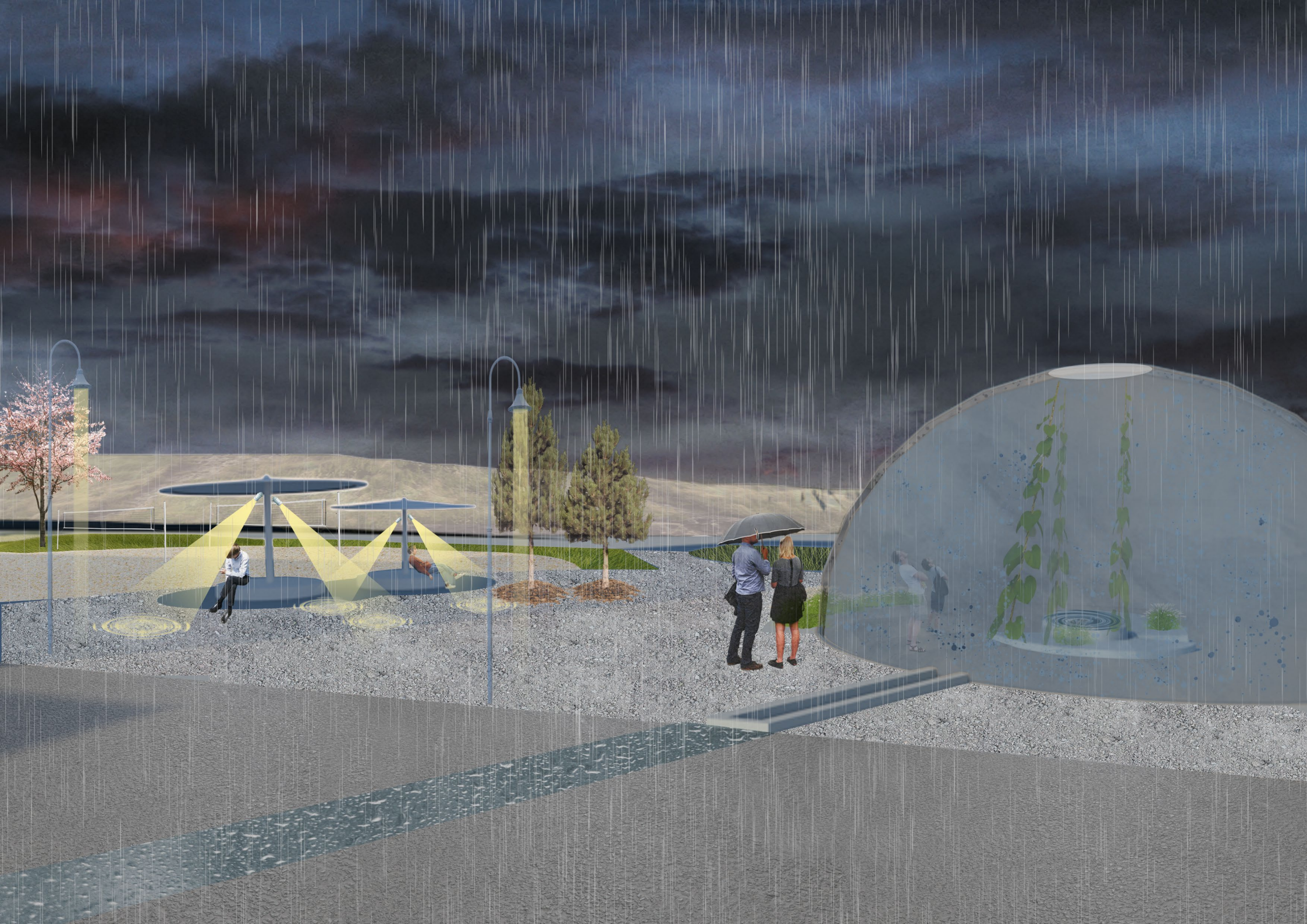
A - A′

B - B′



C - C′

Scale: 1:250 on A3



06: Conclusion

Discussion

In the beginning of this research, I had a vague idea of how to address cloudburst problems by a design solution. As I studied further about approaches to stormwater management, observing case studies and interviewing with experts in the field, my approach was directed towards facilitating the process. In other words I focused on solutions that might not necessarily responsive to cloudburst scenario, but by raising awareness on the topic, makes it more comprehendible in the society. In the personal statement I wrote about the necessity to fade the line between land and water. By bringing water flowing on the deck from the dome this idea is put into practice. In order to discuss the results of this project, I return to my research questions for the thesis.

How to create an open stormwater system in order to enhance the qualities of the urban environment?

I believe working with water provides so much room for new ideas and creativity. This in combination with technical aspect of sustainable stormwater management and application of methods that promote soft engineering can result in developing open stormwater system. The feasibility of new qualities like playfulness in public space can be achieved through adding water element in the public space. It also brings the possibility to think about functional forms that can be defined through water existence in a place and result in bringing people together and creating vibrant and attractive public spaces. The sustainable strategies of approaching stormwater would bring an extent of greenery, which would enhance ecosystem services and ecological values in the landscape while promote aesthetic values of the place.
I believe it is also important to think about other alternatives that can involve in creating green-blue spaces. As briefly discussed in this work fungi for instance have a great potential in infiltrating stormwater that is less discussed in the existing literature. I would say creation of blue-green spaces and bringing stormwater on the ground would start the conversation on what are the unknown opportunities and will result in creative solutions to work with.
In my design proposal I tried to integrate fungi and plants with different tolerance to water in the dome and fountain. Since the dome's height is 7.5 meters, I used the climbing plants to mitigate this height and design on a human scale. The fountain with a capacity to alternate between pumping up water and mist and the effects that interaction of sprinkled water/mist

with light creates is also important to create an environment that is pleasant to be at when it rains. The green roofs also provide a protected sitting place that offers visitors a place to stay. The fact that two of the roofs are partially green makes the rain to pour down on the sides and offers a different effect compare to the roof that is whole green and drains the water. Playing with these effects and using the movements of water and its combination with light makes the place attractive. In the lawn area between the dome and fountain, I design a bioswale by proposing a low hill. A red maple on a hill by the swale area with its autumn coloured leaves makes it special part of the design. The swale could be another ground to test mycofiltration. The composition of these elements in design for people to stay and enjoy the place would give a new perspective to people on an open stormwater system.

What are the possibilities for sustainable stormwater management in Eriksberg?

Eriksberg as a historical place in Gothenburg which carries the identity of an old shipyard transformed through years to be known as a residential neighbourhood with local businesses. It was an interesting task to investigate the current possibilities in Eriksberg and its identity which is prominently water and activities nowadays. I believe the connection to water is something that needs to be highlighted when thinking about Eriksberg. Eriksberg crane is distinctly a landmark from the old days that reminds the community about the identity and function of the place as a shipyard. Hence it is also necessary to understand todays function of the place and in line with that emphasise on the characteristics that this new identity bring for the area.
The fact that Gothenburg is threatened in three aspects by extreme events, which are the excessive rainfalls, the sea level rise and the strong winds that directs the water in the land is a challenge of today. To highlight the water as identity of the place and maintain the activities that aimed to be designed for a residential area, I recognized the lack of accessible public spaces. To address this issue, I distinguished Dockparken as a place that carries the history with its name, but potentially could offer extensive characteristics of an attractive public space. It was of a great importance for me that this space be understood intuitively. Therefore, I decided to mediate this process by giving a name to the place that direct the user to the inspiration of my design and the connection to water and rain. Droppeparken brings the possibility to stay at the place and experience water movement, sound and sight.

The interaction between water, plants and fungi and even the material like stone and transparent elements that allow different movements of water to be seen. Two out of three type of structures, the vertical pond and blue-green parasol are designed to protect from the rain while offer experiencing rain. The combination with vegetation and fungi creates a test bed to experiment the impact of green elements in slowing down and infiltrating rainwater. This capacity of plants and fungi will also be tested in the inward fountain. The fact that the fountain takes in water through layers of plants and have the capacity to pump up the water and sprinkle it in the form of water or mist adds a layer of surprise to the design. I believe it is significant to emerge playfulness and fun when working in water in public space.
All design elements provide sensory experiences with water. for instance, people in the dome can hear the sound of water on the structure and see water movement on the dome and in between its two layers. The open roof also brings the sound of rain inside and when the basin is full with a light rain, calming sound of rippling water contribute to creating a calm atmosphere. Full basin has also mirror effect when it's not raining. The rain that comes inside also interacts with the climbing plants and the plants in the plant beds. The climbing plants also prevent splashing rain extensively when it rains in a windy weather. The sound effect is also significant in the fountain when the water whirls up and also the sound of sprinkling water and mist that comes out with pressure. In addition, sprinkling water on plants in the fountain create an aesthetically pleasing view when concerning different forms of leaves. The interaction of mist and lighting in the green roof and area around the fountain is another aspect of design. In the green roofs that are partially green the water pouring down from the roof interacts with lighting from gobo. Also rain pouring down on the gravel on the floor has an appealing sound.

Can design be used as a tool for scientific storytelling to address urban challenges?

My attempt with this design proposal was to integrate the facts concerning water (in this case the physical aspects of a rain drop) and use it to define a form and consequently function the place. In fact, by using the science behind the form of a raindrop and what movements it experiences through falling and connecting to the surface water, I got the inspiration to design forms that are compatible with the desired functions in Droppeparken as a public space. As is stated in the landscape narrative section, although there is a great potential for using storytelling and narratives in design, not enough research and practices exist in this field. I think

in principal the interplay of landscape and time and changes of landscape through time makes the landscape itself the narrator of change. Storytelling is a method to bring human together through the history. Climate change is a dominant threat to human societies, and I believe employing storytelling through design is a method to raise awareness on scientific facts and how they affect our world and climate opens up the dialogue of change.
Creating a public space like Droppeparken with the elements of design that narrate the story of a water drop and integrate the technical aspects of sustainable stormwater management, makes a platform to review this topic closely and invite citizens for active participation in facing urban challenges.
In Gothenburg specially, which turns 400 in 2021 and is in the process of execution of many new urban projects, practices like this project could be very fruitful.

Reflection

To assess this project, I would indicate that it is a delicate task to express if the goals of the design could be achieved in the proposal phase. However, I believe with the current climate challenges in the cities that I observed in my case studies as well as Gothenburg it is necessary to think about having a permanent test bed for related issues in the city. I think in the projects as such it is important to get feedbacks from citizens, and also investigate that the technical aspect of the work is responsive to the actual situation.
I would also indicate that evaluating a project that aims to be pedagogical and raising awareness on specific issue in this case water, could be achieved through time. The primary goal of the design is to be seen and used by people. The user interaction also creates new possibilities for every design that was hidden in the eye of designer.
Hence, prototyping could be the following stage of this project as a part of jubilee of Gothenburg to get feedbacks on the idea and investigate if the goal of design of raising awareness could be met.
Creating narrative and using it as a starting point to understand the characteristics of a place and make a narrative-based design should be tested in urban development projects that are aiming for active citizen participation.
As it was stated in personal statement it is important to design for uncertainty and in order to do that, we should be expecting different scenarios. Design could be a tool to prepare citizens for possible uncertain scenarios. By rising interest in augmented and virtual reality, these tools can be used to explore uncertainty and investigate responses towards planning decisions.

References

1. Candy, L. and Edmonds, E. (2018) 'practice-based research in the creative arts Foundat-ions and Futures from the Front Line', Leonardo, 51(1), pp. 63–69. doi: 10.1162/Leon-a-01471.

2. Hauberg, J. (2011) 'Research by Design - a research strategy: Conference Bruxelles'. Available at: <https://revistas.ulusofona.pt/index.php/revlae/article/view/2680/2043>

3. Olsson, J. and Josefsson, W. (2015) Skyfallsuppdraget, SMHI Klimatologi.

4. Vad är dagvatten?, Göteborg Stad, viewed 18 October, 2018, Available at: <https://goteborg.se/wps/portal/start/vatten-och-avlopp/dagvatten/om-dagvatten/>

5. Göteborg när det regnar (2017). Göteborg. Available at: <http://www.samhallsbyggarna.org/media/635983/go-teborg-na-r-det-regnar-en-exempel-och-inspirationsbok-fo-r-god-dagvattenhantering_2018-04.pdf.>

6. Gabriella Lönngren (2001) Vatten i dagen - exempel på ekologisk dagvattenhantering. Svensk Byggtjänst.

7. Hoyer, J. et al. (2010) Water Sensitive Urban Design Principles and Inspiration for Sustainable Stormwater Management in the City of the Future, Jovis Verlag GmbH. Avai-lable at: <www.switchurbanwater.eu.>

8. LID- Low Impact Development- a design manual for urban areas (2010). University of Arkansas Community Design Center. Available at:< http://uacdc.uark.edu.>

9. Dunnett, N. and Clayden, A. (2007) Rain Gardens: Managing Water Sustainably in the Garden and Designed Landscape: Sustainable Rainwater Management for the Garden and Designed Landscape. Timber Press.

10. Uncapher, A. and Woelfle-Erskine, C. (2012) Creating Rain Gardens: Capturing the Rain for Your Own Water-Efficient Garden.

11. Pettersson Skog, A. et al. (2017) Grönatakhandboken. Växtbädd och vegetation, Vin-nova.

12. Lundholm, J. et al. (2010) 'Plant species and functional group combinations affect green roof ecosystem functions', PloS one. Public Library of Science, 5(3), pp. e9677–e9677. doi: 10.1371/journal.pone.0009677.

13. Green roof plants, Growing Green Guide, viewed September 2019, Available at: < http://www.growinggreenguide.org/technical-guide/design-and-planning/plant-selection/green-roofs/>

14. Retention ponds, Natural Water Retention Measures, viewed September 2019, Available at: < http://nwrm.eu/measure/retention-ponds>

15. WHAT'S THE DIFFERENCE BETWEEN DETENTION AND RETENTION?, Foresite group, viewed September 2019, Available at: < http://www.foresitegroup.net/difference-between-detention-and-retention/>

16. Svackdike, Klimatsäkrade Systemlösningar för Urbana Ytor - Ett VINNOVA-projekt, viewed September 2019, Available at : <http://klimatsakradstad.se/dagvattenkonstruktioner/svackdike/>

17. Stamets, S. (2005) 'Mycelium Running', Mycelium running: How mushrooms can help save the world, pp. 210–302.Available at : <https://decroissons.files.wordpress.com/2014/04/paul-stamets-mycelium-running-how-mushrooms-can-help-save-the-world.pdf>

18. Mycofiltration Enters the Commons 2015, FUNGI PERFECTI, viewed 2017, Available at: <https://fungi.com/blogs/articles/Mycofiltration-Enters-the-Commons>

19. What is Mycelium? - Definition & Function, Available at:< https://study.com/academy/lesson/what-is-mycelium-definition-function.html#lesson>

20. Stamets, L. et al. (2013) 'Mycofiltration Biotechnology for Pathogen Management'. Available at: <http://fungi.com/pdf/articles/Fungi_Perfecti_Phase_I_Report.pdf.>

21. Kaplan, R. and Kaplan, S. (1989) The Experience of Nature: A Psychological Perspective. 15th edn. Cambridge University Press.

22. Hydén, S. (2009) Vattenlek i offentlig miljö . Available at : < https://stud.epsilon.slu.

se/696/1/hyden_s_091214.pdf>

23. Ryan, Z. (2010) Building with Water: Concepts Typology Design. 1st edn. Birkhäuser Architecture.

24. Klintberg, C. (2008) Vattenanläggningar – som gestaltningselement i offentliga miljöer. Master thesis. Institutionen för landskapspsarkitektur. (elektronisk). Alnarp: SLU

25. Motloch, J. L. (2000) Introduction to Landscape Design.

26. Droplets and Light - Diffraction (no date). Available at: <https://www.atoptics.co.uk/droplets/light2.htm>

27. Rådsten Ekman, M. (2015) Unwanted wanted sounds : Perception of sounds from water structures in urban soundscapes. Available at: <http://su.diva-portal.org/smash/get/diva2:844573/FULLTEXT05.pdf>

28. Cerwén, G. (2017) Faculty of Landscape Architecture, Horticulture and Crop Production Science Sound in Landscape Architecture A Soundscape Approach to Noise. Available at: <https://pub.epsilon.slu.se/14586/3/cerwen_g_170927.pdf.>

29. Hadhazy, A. (2016.) Why Does the Sound of Water Help You Sleep?, Available at: <https://www.livescience.com/53403-why-sound-of-water-helps-you-sleep.html>

30. Schafer, R. M. (1977) The turning of the world.

31. Nikolajew, M. (2003). At læse vandet. Et redskab tl analyse af vandkunst og fontæner. Diss. Köpenhamn: Konstakademins
Arkitektskola.

32. Potteiger, M. and Purinton, J. (1998) Landscape Narratives: Design Practices for Telling Stories. 1st edn. Wiley.

33. Zube L.H. et al (1982) Landscape perception: research, application and theory Landsc. Plann., 9, pp. 1-33

34. Karsten Jorgensen, Morten Clemetsen, Anne-Karine Halvorsen Thoren, T. R. (ed.) 2015. Mainstreaming Landscape through the European Landscape Convention. Routledge.

35. Chang, L.S., Bisgrove, R.J., Liao, M.Y., 2008. Improving educational functions in bota-nic gardens by employing landscape narratives. Landscape and Urban Planning 86, 233–247. doi:10.1016/j.landurbplan.2008.03.003

36. Bishop, I. D. and Rohrmann, B. (2003) 'Subjective responses to simulated and real environments: A comparison', Landscape and Urban Planning, 65(4), pp. 261–277. doi: 10.1016/S0169-2046(03)00070-7.

37. Norberg-Schulz, C. (1980) Genius Loci: Towards a Phenomenology of Architecture.

38. TÅSINGE PLADS, KLIMAKVARTER, Available at: < http://klimakvarter.dk/en/projekt/tasinge-plads/>

39. Rotterdam Climate Initiative (2013) Rotterdam: Climate Change Adaptation Strategy. Available at: < http://www.urbanisten.nl/wp/wp-content/uploads/UB_RAS_EN_lr.pdf>

40. Water Square Benthemplein, De URBANISTEN, Available at:< http://www.urbanisten.nl/wp/?portfolio=waterplein-benthemplein>

41. Benthemplein Water Square: An innovative way to prevent urban flooding in Rotterdam 2014, C40 CITIES, Available at < https://www.c40.org/case_studies/benthemplein-water-square-an-innovative-way-to-prevent-urban-flooding-in-rotterdam>

42. RAIN(A)WAY IS THE RAINWATER SPECIALIST FOR A CLIMATEPROOF CITY, RAINAWAY, Available at <https://rainaway.nl/english/>

43. Hooimeijer, F. (2001) The Water Project: A Nineteenth-century Walk Through Rotterdam.

44. Museumpark, PAUL DE RUITER ARCHITECTS, Avaiable at: <https://paulderuiter.nl/en/projects/museumpark>

45. Museumpark Rotterdam, INSIDE OUTSIDE, reviewed October 2019, Available at:

<https://www.insideoutside.nl/Museumpark-Rotterdam>

46. City of Copenhagen (2012) Cloudburst Management Plan 2012. Available at: <https://en.klimatilpasning.dk/media/665626/cph_-_cloudburst_management_plan.pdf>

47. Tåsinge Plad: Copenhagen's first climate-adapted urban space, KLIMAKVARTER, reviewed October 2015, Available at:< http://klimakvarter.dk/en/projekt/tasinge-plads/>

48. Tåsinge Plads; naturen ind i byrummet, GHB Landskabsarkitekter, reviewed October 2015, Available at: < https://www.ghb-landskab.dk/projekter/taasinge-plads>

49. Saint Anne Square, State of Green, reviewed October 2015, Available at: < https://stateofgreen.com/en/partners/schonherr/solutions/sankt-annae-square/>

50. Sankt Annæ Plads 2016. Danish design review, reviewed November 2019, Available at: < https://john-heward.squarespace.com/kbhnotes/tag/Sankt+Ann%C3%A6+Plads>

51. Malmö Stad (2008) 'Dagvattenstrategi för Malmö', (April). Available at: < http://www.projektering.nu/files/Dagvattenstrategi.pdf>

52. Om Vattenparken, KRETSEUM hyllie vattenpark, reviewed October 2015, Available at: <http://www.kretseum.se/hyllievattenpark>

53. Barth, M. (2013) Harold Edgerton: The Art and Science of Photography. Available at: <https://news.artnet.com/art-world/harold-edgerton-the-art-and-science-of-photography-50301>

54. Tanner fountain (no date). Available at: <https://tclf.org/landscapes/tanner-fountain>.

55. Limitless imagination (no date). Available at: <https://aestheticamagazine.com/limitless-imagination>

56. The Anatomy of a Raindrop (2013). Available at: <https://svs.gsfc.nasa.gov/vis/a010000/a011200/a011288/index.html>