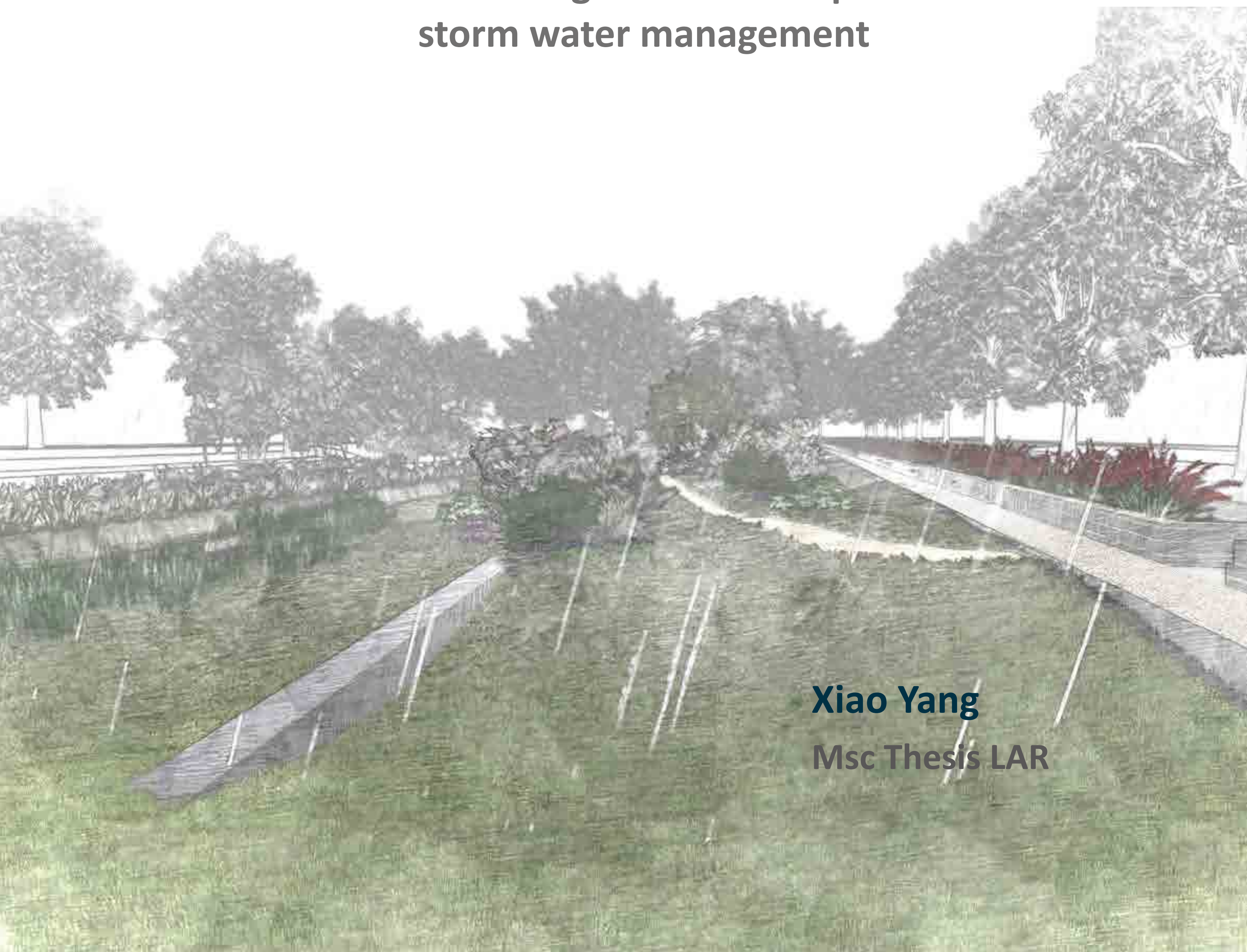
The Rainproof Landscape System for the Watergraafsmeer

Towards an integrative landscape-based storm water management



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Preface

After graduation with Bachelor degree in China, I came to the Netherlands to study landscape architecture further with the passion to learn knowledge to change the landscape in China when I am back in the future. Water is serious in the world. Especially in China, the rapid urbanisation and increasing environmental issues bring a lot of water problems. In Chinese gardening history, there is strong culture to deal with water. However, there is a little innovative water design available for a more challenge situation now.

During the process of the research, I have learned a lot about how to make a systematic landscape design. And I have learned a lot about water and integrative approach. It gives me opportunity to deal with what I have learned here.

I want to thank my supervisor Ingrid Duchhart. I already work with her for two years from minor thesis to major thesis. It was my worst time in the Netherlands with many struggles. And she brings me step by step. She pretends to be a tiger supervisor to push me a lot. And now I have the opportunity to finish the thesis for Master Degree. She has provided many insights for both design and research. In China, we have two types of words for teacher. One is called ' 师傅 '(shifu), who only teach the knowledge; the other word is called ' 师父 '(shifu), who will also teach how to be a good person. And she is my ' 师父 '(shifu) that give some advice to me how to organise my life.

I would like to thank Charlotte Buys. She is so kind and brings a lot of ideas for my design work. She helps me to frame the way of designing thinking. And when I design, I would recall her ways many times. I would like to thank to Lot Locher from Rainproof Programme Amsterdam. She really helps me a lot from beginning to the end. She gives me a lot of knowledge and guidance for the thesis.I would like to thank Rudi van Etteger, thank you for your suggestions in Greenlight Presentation. You make me to think how to make a fantastic landscape.

I want to thank Rob de Waard for his time and suggestions not only study but also something about profession. We have worked together for almost two years. You are right, I am over optimistic, but I still will be the leader of leader in the future. Furthermore, I would like to thank my family and friends for their supports.

Xiao Yang

Summary

Chapter 1
This minor thesis is motivated by water challenges in the world. There are two motivations to do this research. (1) The big influence of water issues (2) I am interested in water.

Nowadays, rapid urbanisation brings a lot of impact on natural process. The natural water cycle is one of them. Amsterdam suffers flood problems related to stormwater. They believe this issue will be worse in the future due to climate change. The assignment is initiated by Amsterdam's Department of Planning and Sustainability, Waternet and Rainproof Programme. The existing sewage system cannot deal with situation in the future and it is not sustainable.

Chapter 2
The aim of the research is to provide an integral landscape design to solve water quantity problem for municipalities in Watergraafsmeer on the street and district level. Hence, the landscape system will facilitate the functions of water resilient and other functions such as ecological conservation and development. This objective is realised by creating relevant possible interventions for different types of space and different levels. The research will provide an example of sustainable rain proof landscape in the metropolitan area of Netherlands. The measure for the rainproof objective is about 60mm/h that means 40mm/h can be temporarily stored in open space.

The general research question is
What are suitable technical interventions for to address the quantified water problems in Middernmeer-Nord, Watergraafsmeer?

The design questions is:
How to integrate these interventions for designing an integral rainproof system for Middernmeer-Nord, Watergraafsmeer to meet the future needs?

In order to find the answers for the research questions, the literature study, precedent study, interview and scenarios study are conducted.

Chapter 3
In this chapter, I discuss the theoretical concepts that were used in this project. Sustainable urban design is the major philosophy for my project and because the project is in Dutch water context, Dutch water management in relation to stormwater is discussed. The project mainly focuses on rainproof, but it also analyses the water integrated approach.

Sustainable Stormwater Management, Green and Blue Infrastructure and Landscape Based Design Approach are the main concepts. My project focuses on the overlap of these three concepts. I explain the concepts' principle and the methods employed for these concepts.

After that, the water integrated approach and the guiding principles are generated.

Chapter 4

This chapter discusses the context of the design assignment, profile of the Watergraafsmeer and site analysis of the area.

Site analysis aims to understand the local landscape syste. This particular site analysis is mainly initiated by the principles I discussed earlier. Therefore, the main focuses of the site analysis are landscape formation process, water system, ecological system and recreational opportunities related to water.

Chapter 5

In this chapter, I first describe the water assignment for the study. Secondly I present the available toolbox for the design assignment. Thirdly, I make the different scenarios that apply different technical storage interventions to explore all possibilities. The result of the exploration is given and I make suggestions for the design

Chapter 6

This chapter firstly discusses the research and design process employed earlier. It explains how the result of the research is connected to the design work. Secondly, it enumerates the opportunities and problems of the site area. The Masterplan indicates where I applied basic interventions. The water system design displays the technical interventions and the landscape conceptual map gives the three main design areas with different themes. Later on, the design of these areas will be elaborated on the street level and park level.

The design proves that this integrative approach and water technical interventions can create an integrative rainproof landscape system.

Chapter 1 - Introduction

The context of this project will be discussed in this chapter. Also, the problems associated with the study will be stated later to legitimate the research.

1.1 Context

Firstly, in this section, I will discuss why water fascinates me, flooding and storm related issues that motivate me to conducts this research. I will explain the context of the issues associated with water cycling process and the impacts of urbanisation. Then, the contributions of the three Amsterdam institutions (Amsterdam's Department of Planning and Sustainability, Waternet and Rainproof Programme) and their responsibilities will be mentioned.

1.1.1 Fascination and Motivation

As we all know, water covers 71% earth's surface and it is essential for the existence of life on our planet. Although the chemical composition of water is simple, its physical properties are relatively complex. It can be disperse or centralized, infiltrated or held, evaporated or frozen (Bijlsma, 2013). Consequently, effectively and efficiently guiding and using water have become one of the most important issues that fascinate me and other landscape architects of the past, the present and future.

The torrential downpours influenced by climate change have become a common phenomenon (Claasen et al., 2013). In July 2011, the Danish capital, Copenhagen was subjected to a torrential downpour of approximately 150mm of rainfall in just two hours. Over the coming years, about 1 billion Euros was invested in rendering the city rainproof (Claasen et al., 2013). In 2012, the Chinese capital, Beijing was subjected to a downpour of approximate average of 212mm in a day, which resulted in the death of 79 people and 1.4 billion Euros economic loss (Carlo, 2012). The extreme rainfall has become serious issue worldwide and also in Amsterdam. In In July 2012, the extreme rainfall made the Lelylaan railway and metro station water flooded etc (Claasen et al., 2013). I will discuss elaborately what happened in Amsterdam in the problem statement.

1.1.2 Water Cycle and the Impacts of Urbanisation

Scientifically, water recycling process is a succession of stages through which water passes from the atmosphere to the earth and returns to the atmosphere (UNESCO, 2006). Also, the urban water system is part of regional water cycle (Tjallingii, 2012). The natural water cycle usually consists of

Figure 1 Flooding in Cophenhagen in 2011

Figure 2 Flooding in Amsterdam

rain, infiltration, groundwater recharge, evapotranspiration, evaporation and runoff. Usually, sustainable water management can also be defined as 'closing the circle' (Tjallingii, 2012).

With the increasing development of science and technology after the three times industrial revolution, urbanisation has rapidly developed, especially in recent decades (Meijer et al., 2011). Due to the rising urban population, rural areas have been dominated by urban areas where anthropogenic pattern has dominated. This has increased CO2 emission and decreased biodiversity and hence, led to green segregation.

With regards to water issues, urbanisation has influenced the natural water cycle in the city. Due to the urgent need of a drier ground, a fast drain is top priority of the traditional sewage system. The sewage system has channelled the runoffs into the concrete sewage system and fast drain. As a result of this, less amount of water is used in the local natural process and the existence of runoffs in the city is caused by the impervious surface. In the case of Watergraafsmeer, urbanisation led to the disappearance of ditches which indicates less surface and space for the water.

1.1.3 Assignment

The assignment is initiated by three institutions in Amsterdam. They are Waternet, Amsterdam's department of Urban Planning and Amsterdam Rainproof Programme. I will discuss their responsibilities in Amsterdam in this section. For the water and spatial assignment, the municipality will maintain as much water as possible in the polder without bringing about inconvenience to the public. The objective of the rainproof is about 60mm/h (Waternet, 2016) and it will be developed as an urban solution for every scale (DRO, n.d.). The location for the implementation of this project is in Watergraafsmeer which is the deepest area in Amsterdam. This place is vulnerable to flooding.

On behalf of the City Council, the Waternet is responsible for Amsterdam's entire water cycle including storm drains and sewer systems (Claasen et al., 2013). In addition to maintaining water levels, keeping water surface clean and recycling wastewater into clean drinking water, Waternet also endeavours to transform the mixed sewage system to a separated system in the future.

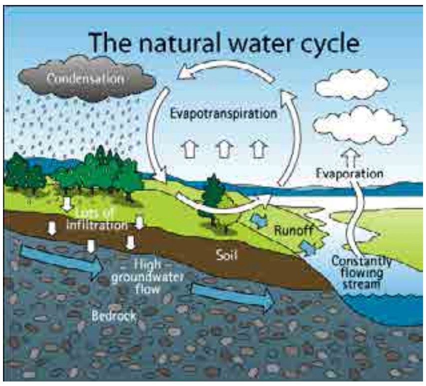


Figure 3 The natural water cycle

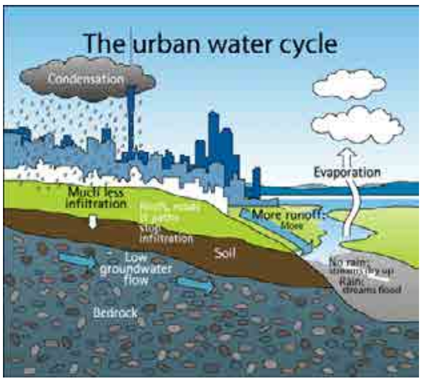


Figure 4 Urban water cycle

Figure 5 Towards a more sustainable urban water cycle

In order to respond quickly to the increasing precipitation, Waternet has started Amsterdam Rainproof Programme which involves municipal authorities, residents and businesses, and also provides an open platform for rainproof Amsterdam (Claasen et al., 2013).

1.2 Lessons from Practices Worldwide

In order to know more about problems and solutions, a total of nine practical examples are discussed in the aspect of storm water management. The criteria for processing the reference study are based on sustainability, functionality, water management and aesthetics. These are adapted from Thompson's (2000) ecology, community and delight. These examples deal with different scales and spatial types to get reliable and comprehensive solutions for later design. This study is conducted throughout the whole design process, thus helping give insights in design, and dealing with problems arising in design process.

The elaborated studies are listed in appendix. In this study, I have learned a lot concerned with water management, especially some practical knowledge about integrating water management, such as the system of catchment and the strategy of water management. As for extra functions, I learn about some practical knowledge about integrating spatial types. The multi-scale projects show the integral solution for different layers. The identity is created by detailing. I have learned the ideas about different uses of spaces under various weather conditions. Besides, I have also learned some examples showing the green park in city, and sometimes the green area in water plaza is isolated from runoff by concrete planting box.

1.3 Problem Statement

In this section, I will propose the problem statement specifically to legitimate this research. The problem is that the current sewage infrastructure cannot satisfy the increasing demand for water security. This infrastructure has mono function, not adaptive and it brings about negative impacts on the local environment.

The current sewage infrastructure cannot satisfy the increasing demand for water security. Amsterdam is vulnerable to torrential downpours. The sewage system cannot handle the heavy rain in the present situation. What is more, van den Hurk et al.(2006) predicted precipitation will be possible heavier and more frequent in the future.

Figure 6 Rotterdam (city scale)

Figure 7 Copenhagen (district scale)

Figure 8 Tanner park (park scale)

There are lots examples to showcase the disturbance caused by heavy rain recently. In July 2012, the extreme rainfall made the Lelylaan railway and metro station water flooded etc (Claasen et al., 2013). On 28th July 2014, the maximum precipitation in Amsterdam was 90mm. some areas had 40mm per hour, some places even got 12mm in 5 minutes that means 135mm in one hour (Rainproof Amsterdam, n.d).

In the nearest future, the situation will get worse if there are no changes. The current capacity of the current storm water sewage system is 20mm/h, however, Amsterdam's plan is about 60mm/h based on the extreme scenario (Waternet, 2016). 40mm of water will be temporarily stored in open space because the sewage system can't be changed.

The traditional sewage system is an infrastructure that only has mono drainage function and it is an underground construction. However, Amsterdam's Department of Planning and Sustainablity wants multiple uses of the space (DRO, n.d.). They want the space not only for water management but also for other public use such as leisure activity. Because the sewage system is static concrete and only has single function, it cannot adapt to different weather situations to provide different functions. and as a result of the infrequent downpours, a smart and temporary solution for the peak rain period must be suggested.

The traditional sewage system brings about negative impacts on the local environment because it negatively influences the natural hydrological cycle. Also, water used in the engineering facilities, will be isolated from the natural and social environment as the standard engineering facilities fail to identify other factors and focus on the effectiveness rather than how to interact with the natural system. And even lots of

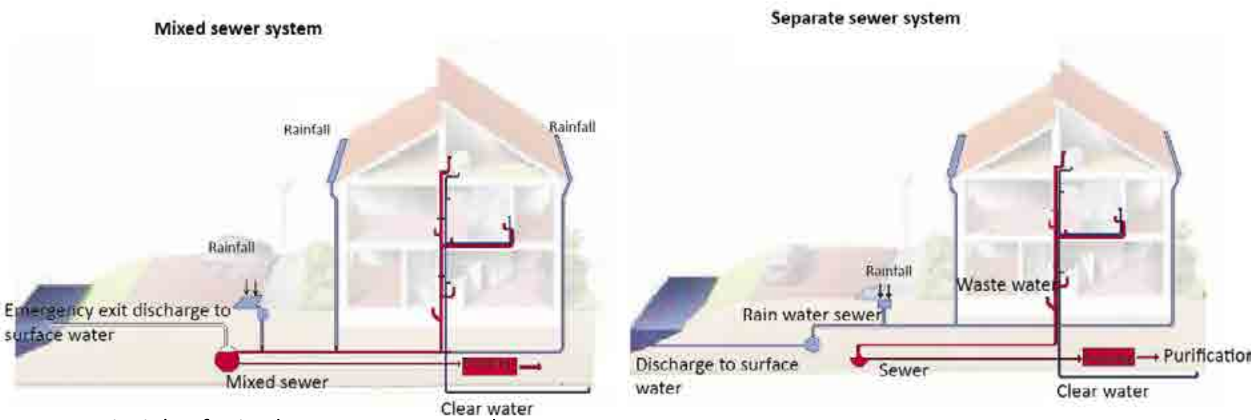


Figure 111 Principle of Mixed sewage system and separate system

Figure 9 Flooding in Amsterdam in 2012

Figure 10 Sewage inlet

Figure 11 Undergrond Maintenance

green and blue surfaces have been replaced by constructions.

In the past, water could be drained through the polder sewer system but now the ditches have disappeared thus making the urbanised area lack water storage surfaces. What is more, during the heavy rain situation, after being contaminated and mixed with dissolved nutrients through flows, the rain water via impervious surface could badly influence the health of the vegetation. For social environment, the water flow is invisible to people thereby leading to the severance of the connection with water in people's daily life. In the presence of new technology or the change in demand caused by climate change, the facilities might need to be changed.

In summary, it is necessary to create an integral sustainable solution for transferring the old sewage system into a new sustainable landscape system which will not only rainproof Watergraafsmeer with low maintenance, but also facilitate recreational and ecological functions. It will restore the links between water and others aspects of the natural and social system.

Chapter 2 - Research and Design Approach

In this chapter, I will firstly give the objective that respond the problem statement. Later I will discuss the knowledge gap that is the need of integrate sustainable storm water management on different urban levels. Then the research questions will be generated. The research methods are created to show how to conduct the research to answer these questions.

2.1 Objectives

The aim of the research is to provide an integral landscape design to solve water quantity problem for municipalities in Watergraafsmeer on the street, park and neighbourhood level. Hence, the landscape system will facilitate the functions of water resilient and other functions such as ecological conservation and development. This objective is realised by creating relevant possible interventions for different types of space and different levels. The research will provide an example of sustainable rain proof landscape in the metropolitan area of Netherlands. The measure for the rainproof objective is about 60mm/h that means with the help of 20mm/h from sewage system, 40mm/h can be temporarily stored in open space. The rainproof should without the damage of vital infrastructure and buildings

2.2 Significance

The solution to this complicated governmental-issued assignment is to explore all the possible interventions and results and then developing one case in a comprehensive manner which brings about an approach that combine existing interventions. It should be a reasonable integral solution for the local municipality, providing security and pleasant daily environment for local inhabitants, solving the water problem, improving the public spatial quality at a reasonable cost. The project can help improve public awareness about water cycle.

2.3 Knowledge Gap

In general, the knowledge gap is discussed from theory and practice's perspectives. Nowadays, sustainable urban storm water management is widely discussed throughout the world. Most of these documents describe it from the general perspective and focuses on technical solutions. The technical solution favours the layer of water management rather than how to interact with other layers such as using water conditions for creating special groups of plants.

However, the problems of low interactions between water and other layers still exist. Therefore, the integrated approach on different scales is needed. Tjallingii (2008) introduced some integrated water planning principle which is on the planning level still too general for the multiple levels practice of landscape architecture.

In the Dutch practice, Rotterdam proposed the Water Plan (2007). Although it is a regional plan, it requires more examples for different spaces and the realised example of water plan lacks green elements. In Amsterdam, there is no integrated spatial stormwater design on district level.

We have some sustainable stormwater projects, but most of them are in the residential area such as GWL. Water is systematic. We do need systematic solution on different scales and spaces. It is quite a challenging task for the rainproof project in water graafsmeer, we need to quantify the result of all the possible solutions to make the appropriate design.

	theory	Practice
World	SUDS, WSUD, LID...	Copenhagen etc.
Netherlands	Related: Tjallingii's model, general water management policy	Rotterdam water plan etc. ***Lack*** of green approach in the populated metropolitan area
Amsterdam	Spatial technical measurement (Based on Amsterdam Rainproof Programme) ***Lack*** of systematic solutions on different scales and spaces	Examples are mostly in resident area (Based on examples in Amsterdam Rainproof Programme) ***Lack*** of systematic solutions on different scales and spaces

Table: The knowledge of integrated sustainable storm water management available and needed

2.4 Research and Design Questions

Overall Research Question:

What are suitable technical interventions for to address the quantified water problems in Middernmeer-Nord, Watergraafsmeer?

Design Question

How to integrate these interventions for designing an integral rainproof system for Middernmeer-Nord, Watergraafsmeer to meet the future needs?

Sub Research question

What is the current situation of water system in Watergraafsmeer?

What are the present and near future demands of rainproof system for Watergraafsmeer?
What are the potential technical interventions for rainproof system?

What is the quantitative result of possible rainproof technical solutions?

2.5 Research methods

In this section, I will provide an overview of the research scheme that shows the relationship between the research question, research methods and the output. Then, I will discuss the main research methods employed in this research. Finally, the research-design procedure will be illustrated.

Literature review

This literature study is conducted to acquire the knowledge about the concept of green and blue infrastructure, sustainable stormwater management and landscape-based approach. 'Literature reviews help to distil information and catch the essence from previous published credible sources that can help the current research' (Martin and Hanington, 2012 p.258). The literatures are mainly selected from peer reviewed relevant scientific articles or books. I summarised the literature I read in order to generate an understanding of the definition, origin, principles of these concepts. Subsequently, this will provide the guiding principles for the design assignment.

Precedent study

The precedent study is a method used in reflecting theory and practice by checking precedent examples. It can help the researcher study in-depth in reality. It acquires an extensive and in-depth explanation of the practice of landscaping (Yin, 2009). The selected precedents are landscape projects related to sustainable rainwater management related. It is necessary to take samples from different countries and different levels to acquire the comprehensive understanding in the methodical level globally.

Research question	Research methods	output
What is the current landscape situation in Watergraafsmeer?	observation, map study, chorological study, literature study, interview with expert	Understanding the landscape system and specifically how the water system work. Identifying the landscape typologies, the current water plan about the area, specific landscape objective of the design
What are the potential interventions for rainproof system?	Literature study, precedent study, interview with expert	Identifying relevant design principles and design tool based on problem and site characteristic, criteria for reference study and design
What are the demands of rainproof system for Watergraafsmeer?	Interview with expert, literature study	Quantifying water data for design assignment
How to integrate these interventions for designing an integral rainproof system for Middernmeer-Nord, Watergraafsmeer to meet the future needs?	swot analysis, apply models and evaluation	The strength and weakness of the area according to site analysis and principles, problem map, concept design, design, detail design

Table: The overview of research methods and the outputs

The criteria for evaluating the projects of precedent study are sustainability, functionality, water management, and aesthetics. They are adapted from the general principle of spatial qualities of landscape architecture (Thompson, 2000). Subsequently, the precedent study can provide inspiration and possible solutions for my design assignment. I will get more details of the specific situation that the literature review hasn't provided.

This study is mainly happened in the beginning of my research. But it is throughout the process of designing, the study helps to give insights to design, and the problems generated in the design process seeks the solutions from the practical examples.

Interview

Interview is necessary for gathering detailed in depth information (Boyce et al., 2006). In this research, the interviewed group are related experts in Amsterdam. They were selected from the department of planning, waternet and Rainproof Programme and the interview is structured into 'introduction, duration, question guide, closing part'. The methods for creating the questions are: open-ended, factual before opinion, positive before negative (Boyce et al., 2006).

In accordance, the interview will help the researcher to frame the assignment specifically. The interview with experts especially those from Waternet gave me vast first-hand information such as the challenge of assignment, the understanding of the local situation and some water-related knowledge. They help to evaluate the design work. They are able to provide some valuable suggestions and solutions. And I will provide all alternatives to them and we will make design-decision together.

Explorative Design Senario Study

Design senario study is used to make a connection between the problem and the design through scientific based explorative approaches. In this research, the study surrounds stormwater stroage design scenarios. After creating the technical interventions, the research will apply the

Presentation to experts in Waternet

intervention where possible. Consequently, it quantifies all solutions visible in maps, so that it can provide reasonable suggestions for further design assignment. The results from different scenarios help the expert and commissioner in waternet to make choice with designer.

Designing

Designing is an activity that can help to build the theoretical approach and bring creative ideas for the approach that beyond literature (Amstrong, 1999; Ibrahim and Utaberta, 2012). In this study, in one way, the results of researches such as literature study, water storage design scenarios and site analysis provide the spatial requirements for design activity. And as return, the designing adds values for the research. It can test the existing theoretical ideas and can bring new problems and ideas during the problem-solving process. Those problems can help the researcher to understand the approach and site situation in depth. The design assignment could be redefined more specific during the process. Designing helps to understand the limits of theoretical approach. The emerging problems from designing lead the researcher to seek for more solutions that could add to existing approach. And designing can bring creative ideas. In this

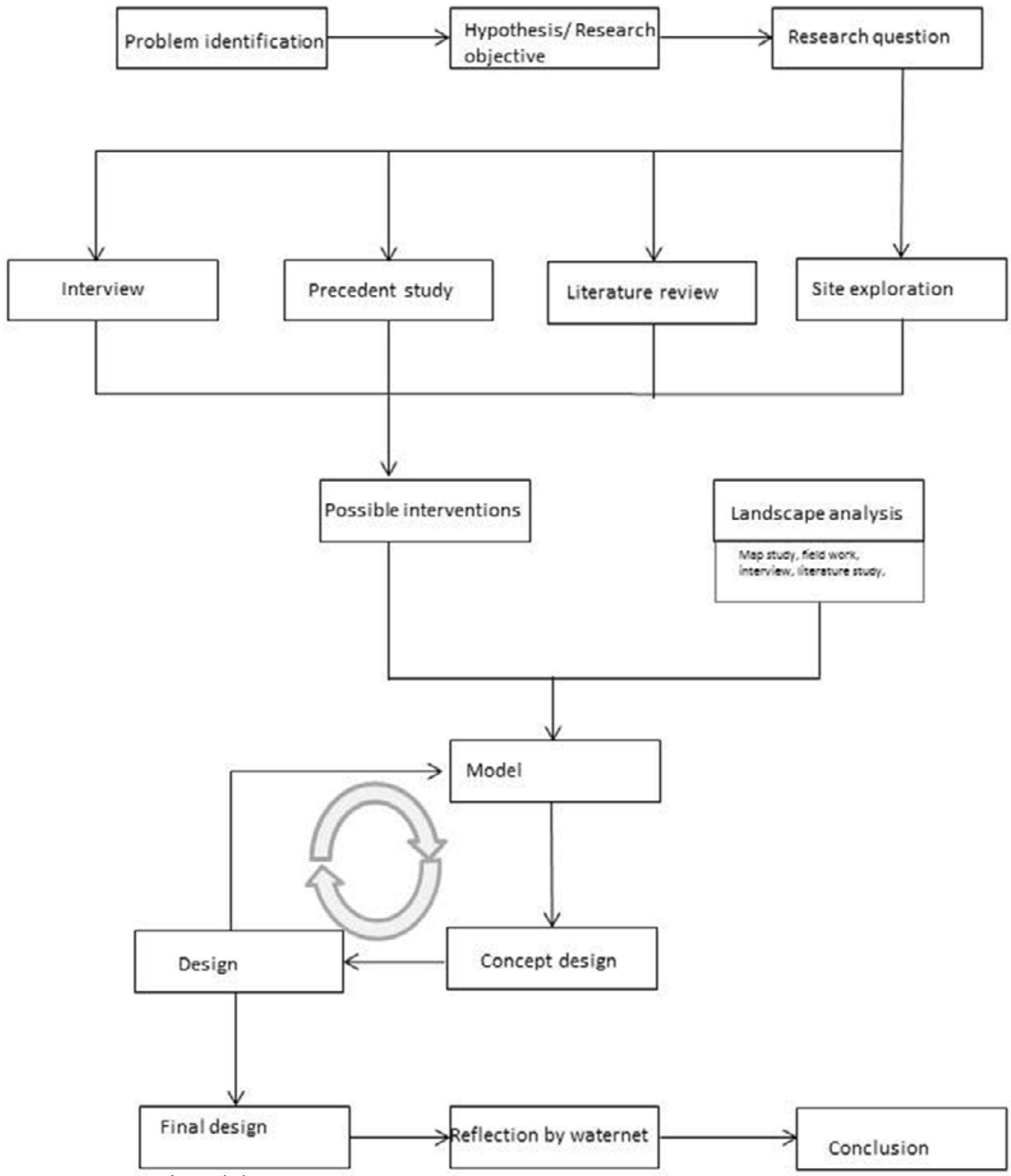


Illustration: research and design process study, some innovative design ideas such as the dam are created during the process.

Chapter 3 - Conceptual Framework

Conceptual famework

In this chapter, I will discuss the theoretical concepts that were used in this project. Sustainable urban design is the major philosophy for my project and because the project is in Dutch water context, Dutch water management in relation to stormwater will be discussed. The project mainly focuses on rainproof, but it also analyses the water integrated approach.

Sustainable Stormwater Management, Green and Blue Infrastructure and Landscape based design approach are the main concepts. My project will focus on the overlap of these three concepts. I will explain the concepts' principles and the methods employed for these concepts. After that, the water integrative approach and the guiding principles will be generated.

3.1 Existing General concepts

3.1.1 Sustainable urban design

The general philosophy of this research surrounds sustainable urban design. Sustainable development is the 'development that meets the needs of current generations without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development, 1987, p.45). A sustainable city is a city that keeps its value through time. Urban sustainability is bound to high-quality spaces and buildings, a healthy environment and robust infrastructure.

Concurrently, a sustainable city is a city that can accommodate change over a period of time (Meijer et al., 2011). The role of landscape architecture is to improve spatial systems effectively. Sustainable landscape design is related to three principles – ecological health, social justice and economic prosperity (Meyer, 2008).

3.1.2 Dutch water management

Context

Dutch people have a long and skilful history in water management. The powerful traditional means in which water is managed with technical intervention has protected the Netherlands for centuries. However, these technical interventions cause land subsidence, deterioration of

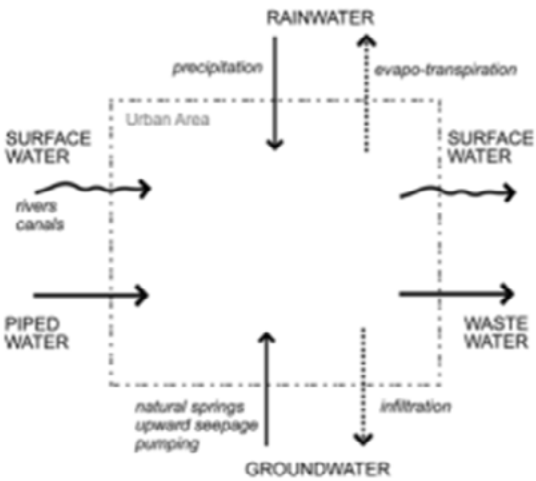


Figure 12 urban area and water balance

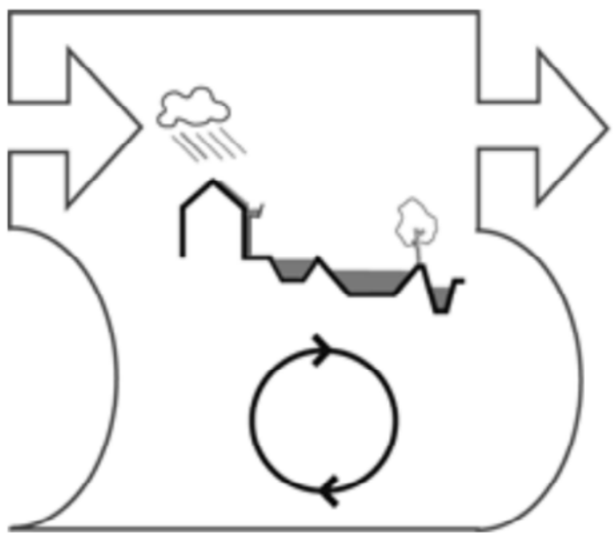


Figure 13 closing the circle and cascading the quality of water and soil. Hence, these would lead to the land becoming more vulnerable to hazard, exposing it to a higher level of infrastructural constructions such as reinforcing the dyke (Hooimeijer et al., 2005).

Climate change and rising sea level rise have made the challenge more complicated, many integrative infrastructure are built with nature such as 'Room for the River'. The water management in Netherlands started to shift to a more sustainable, integrative and adaptive approach.

Mechanism

The Netherlands is located in the delta of west-north of Europe and part of the Netherlands is below the sea level. It faces various water challenges from rain to sea related issues. This thesis will focus on the Rain water management for water logging in the urbanised polder area.

Previously, I explained the water cycle. The urban water cycle is a part of the regional water system. In the sustainable urban context, watershed system should be controlled. Tjallingii (2012, p.95-102) discusses five water flow issues in the city:

- Rainwater: from down-the-drain to first retain
- Groundwater: from pumping to careful use and recharge

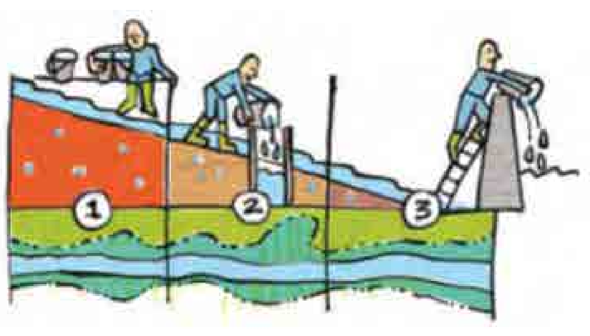


Figure 14 The Strategy of Dutch Water management: detain, retain, convey

- River water: from taming the stream to create space for the river
- Drinking water: from shortage and wastage to sufficient and efficient
- Wastewater and pollution: from problems to prevention

Polder is one of essential components of the Dutch water management system. The others include high grounds, river, streams between components and interconnectedness (Rijkswaterstaat, 2011).

In the urbanised polder area, waterlogging problems are often caused by limited storage capacity, overly rapid discharge and combined sewage system that cannot cope with the amount of water and overflow. Besides, the overflow of combined sewage system will pollute the water resulting into debilitating health issue (Rijkswaterstaat, 2011).

In order to solve these problems, there are two guiding principles for the urban water management ‘keep water clean and keep it longer’, and ‘do not shift water problems to downstream neighbours’. Tjallingii also introduces the ecodevice model. The strategy is: closing the circle and cascading, the guiding model on different levels (Tjallingii, 2012).

In the political era, the Dutch water policy of the 21st century acknowledged water quantity with three principles (Vlies et al., 2006):

- Retain: rainwater should be retained as far as possible at the location upon which it falls
- Store: if retention is not possible, the rain water must be stored in the same area (polder or community),
- Remove or drain: only if retention

and/or storage are impossible.
Other than the mono function of water management, the Dutch approach shifts to an integrated manner to meet the increasing awareness of human and animal wellbeing. 'Room for river' is the one of the most typical programme that people have created to enable sustainability of water and other natural species.

In order to meet the increasing needs of the integrated approach, a senior expert in spatial planning of water and ecology, TJallingii (2008) provides integrated principles and models to guide the planning assignment. There are several points that need to be mentioned in this thesis, and they include: Creating conditions for biodiversity, making identity with water, making water visible.

In addition to this principle, urban technical models (Tjallingii, 2007 in Winter 2014) and ecodevice is also proposed theories for different situations:
(1) green lane model
(2) sluice model (suited for river and stream valleys):creates more space for water
(3) infiltration model (suited for sandy soil)
(4) circulation model (suited for city districts with its own water system)
(5) slow down model : disconnect rainwater discharge from the sewage system
(6) switch model: combined slowing down, circulation and infiltration model

Apart from these measurements, there are two main Dutch water management authorities that should be mentioned, they are Water Boards and Rijkswaterstaat. The Water Boards have the responsibilities of creating water barriers, water ways, polder and surface water qualities (Dutch Water Authority, n.d.).

There are 26 Water Boards in Netherlands. They are divided by watershed or polders. Since the 11th century, people had their own land; they built dikes and water drainage to protect their land. In the 13th century, people develop common interests to cooperate to create safe water management. Water Board was established centuries ago and it is the oldest form of water management scheme ever launched since the inception of a democratic government (Rijkswaterstaat, 2011).

Rijkswaterstaat is a power central organisation that aims to protect the country from being flooded by the sea and rivers. It is responsible for the design, construction, management and maintenance of the main infrastructure facilities in the Netherlands. This includes the main road network, the main waterway network and water systems (Rijkswaterstaat, n.d.).

Summary
The water management in Netherlands has shifted to a sustainable and integrative manner. The water will be kept clean for a longer period of time. The management should also consider not only the water itself but also its relationship with the environment and human wellbeing.

3.2 Main Concepts

3.2.1 Sustainable Storm Water Management

There is a wide range of concepts of sustainable storm water management globally (Dickhaut et al., 2011). These concepts are mainly used to recover the natural hydrological cycle (Fletcher et al., 2013). The goal of sustainable storm water management is to reduce runoffs by treating the storm water as close to the source as possible, ideally on-site (Dickhaut et al., 2011). A sustainable water management does not only control the runoff on the surface, but also provide the ecological value and natural process of the water cycle (CIRA, 2007). And in this research, many knowledge is based on the work of Winter(2014) and Winder(2013).

Context

Controlling the quality and quantity of storm water is called storm water management (BMPs, 2005). The issues of storm water management deals with the quantity and quality, and this thesis mainly focuses on rainproof. Urbanization brings about impervious surface that need urgent sewage system to drain rain water to prevent flooding.

For the traditional method, the sewage system mainly consists of pipes and pumps. However, the traditional sewage system causes many challenges especially for the combined sewage system. The traditional sewage system can impact the local natural system negatively as it breaks the natural water cycle more or less. It reduces infiltration and the groundwater level would decrease and will introduce extra problems to the cities such as drinking water and land subsidence issues.

Also, if the waste water is not treated well, it would pollute water system of the downstream. The combined sewage system has to unnecessarily clean the rain water. What is more, the traditional sewage system cannot adapt to future uncertain changes, because they are fixed. Traditional system 'has no value as a useful resource and adds little to the amenity (aesthetic, recreation, education etc.) of an urban environment' (Wong et al., 2000). This launches the storm water management towards a sustainable approach.

Mechanism

The sustainable storm water management is mainly planned for the recovery of the natural hydrological cycle (Fletcher et al., 2013). The goal of sustainable storm water management is to reduce runoffs by treating the storm water as close to the source as possible, ideally on-site (Dickhaut et al., 2011). A sustainable water management does not only control the runoff on the surface, but also provide the ecological value and natural process of water cycle (CIRA, 2007). The main concepts of global sustainable storm water management will be discussed as follows:

SuDS (sustainable urban drainage system) aims to mimic some altered process of the natural hydrological cycle due to urbanization and manage rainwater close to where it falls, while using natural vegetation to maximum the benefits (CIRA, 2007 p.28).

The objective of water sensitive urban design (WSUD) is to combine the demands of sustainable storm water management with the demands of urban planning, and thus bringing the urban water cycle closer to a natural one. The technical elements of WSUD address the infiltration. Compared to others, it addresses the decentralised storm water management (Dickhaut, et.al. 2011 p.16). WSUD develops integrative strategies for ecological, economic, social, and cultural sustainability. It can reduce the risk of flood and provide better water quality. It can be integrated with landscape to create recreational, visual etc. values.

LID (low impact development) aims to minimize the impacts of urbanisation on the natural system. It tries to close the natural hydrologic process of infiltration, storage, evaporation and transpiration by emphasizing conservation and use of on-site natural features, site planning, and distributed storm water management practices that are integrated into the project design (Chui, 2012). It aims to maintain the natural conditions such as hydrology before the development (Winter, 2014 p.26).

For this concept, Lists of technical interventions mainly based on Woods-Ballard et al. (2015)(detailed in appendix) follows:
- Rainwater usage: rainwater harvesting
- Treatment: bioretetion, gravel or sand filters
- Detention and infiltration : green roof, retention, permeable paving, infiltration zones ad trenches, swales, geocellular system, detention pond (dry), retention pond (wet).
- Conveyance: open storm water canals/ drains

Summary

The principle of the sustainable method is to bring water management closer to natural process of water cycle. The water cycle process consists of evaporation, precipitation, infiltration/groundwater recharge and absorption and transpiration by plants. The urbanisation and modern sewage system drain fast and lesser space was created for water surface to reduce transpiration, infiltration and evaporation, and peak runoff issue is always complex to solved because of the comined consideration of investment and the impacts of peak runoff that not happened often.

In response to these issues, the sustainable storm water management protects and enhances the natural water system. In general, it is achievable by harvesting, infiltrating, slowing, storing, conveying and treating runoff on site. It reduces runoff and peak flows by employing local detention measures and minimising impervious areas. The sustainable storm water management can integrate storm water treatment into landscape by incorporating multiple use corridors that maximise the visual and recreational amenity of developments. It adds value while minimising drainage infrastructure development costs (Lloyd et al., 2002).

3.2.2 Green and Blue Infrastructure

Green and blue infrastructure is the combination of green and blue elements (Rozos et al., 2010; Lundy et al., 2011). Van Der Velde et al., (2015) have made a summary based on related literature about green and blue infrastructure. They defined the green and blue infrastructure as the physically interconnected 'green' space ranging from nature reserves, parkland, urban wood, river and etc. Also, they summarised three principles of green infrastructure from three perspectives of different disciplines.

In ecological terms, they considered green and blue infrastructure as a means of preserving or developing ecological network and biodiversity. In the field of urban planning, the network is suitable for water management, storm water and flood prevention. As for recreational planning, the green and blue infrastructure provides the framework with recreational facilities that will provide easy access and good connection to the populations.

Green and blue infrastructure is a network for solving urban and climatic challenge by building nature (Potz et al., 2012). It brings about climate adaptation and city resilience (Foster, 2011). Nature and water in the city can enhance biodiversity of the city, wellbeing of people and economic value.
For the traditional infrastructure of water management, there is concrete and mono function which is only capable of flood mitigation. Besides, the technical approach is concrete and static which means that they cannot adapt to possible increasing demands in the future. In recent decades, landscape plays a more important role in the public area. It can integrate many functions including storm water management. Besides flood mitigation, green infrastructure with regards to storm water can create space for recreation, wild life, and aesthetic landscapes and build climate resilience (Fletcher et al., 2014).

The green infrastructure aims to provide a natural and dynamic sustainable rain water management rather than the concrete and static approach (Winder, 2014). For the green infrastructure, vegetation and soil can be used to mimic natural processes of the local landscape to manage rainwater flows and to create a healthier urban landscape (CIRA, 2007).

The design principle of green and blue infrastructure helps to provide robust framework for conversation and development by creating the green and blue linkage and high quality of core areas or dense green and blue patches. Subsequently, it provides the ecosystem proofing service to the city.

3.2.3 Landscape Based Design Approach

Kerkstra et al., define landscape as ‘the visible result on the surface of the earth from the interactions between man and nature’ (Duchhart 2007, p.16). Landscape based approach tries to explain how landscape formation process is used to make the design fit in the environment. It is a site specific approach and it is based on the geographical condition (Duchhart, 2007). It concerns the interrelation between social and natural process and incorporates different layers on different scale levels (Cresswell, 2009; Duchhart, 2007).

I am interested in the adaptive and integrative approach of landscaping. As for this topic in relation to Amsterdam, it provides many opportunities of exploring the climatic adaptation as well as integration between city and landscape, water management and landscape spatial qualities.

“Using landscape structure for climate adaptation and hydrological cycle and air quality, recognizing the network of habitats and patch matrix; all are enabled by a landscape approach to urbanism” (Koh 2013, p.20).

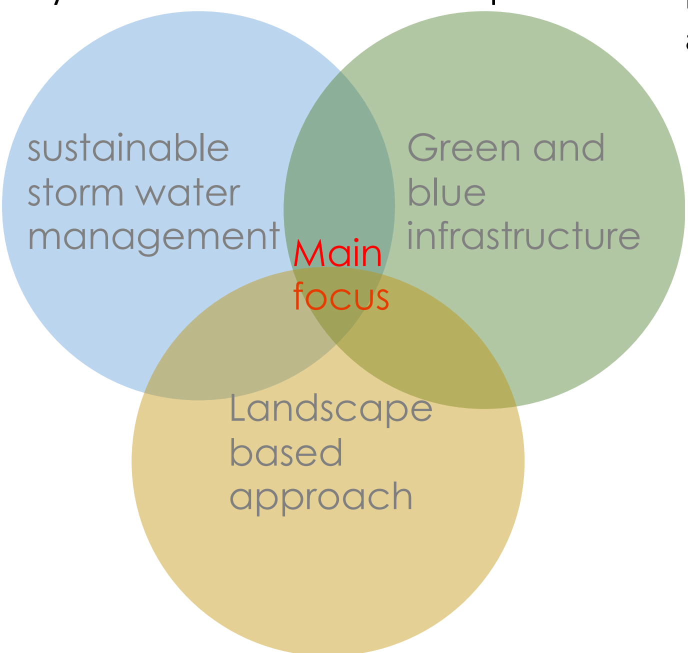
In summary, landscape based design approach focuses on the interactions between natural and human subsystem through the time scale. It tries to identify the different dynamics process in different layers and understand their relations. Hence, we can use this site-specific approach to design a robust resilient sustainable landscape system for the future.

3.3 Water Integrative Approach

There are many literatures that mention the different values of sustainable storm water management or how to plan green and blue infrastructure to manage water. However, the different values or different functions are separately explained. They are different themes, but can work with water only once. This research will focus on how to make a rainproof landscape system that can use water as media of integrating different functions.

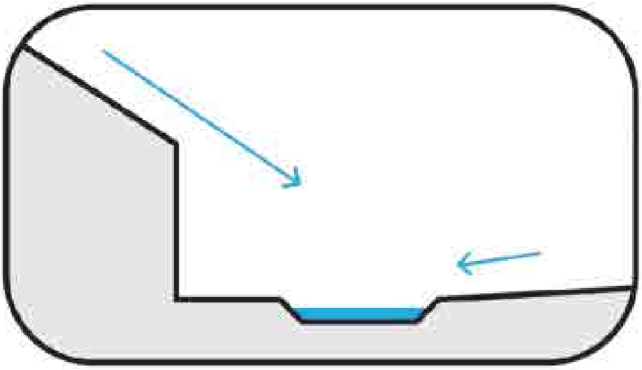
These three main concepts all involve water. In principle, Sustainable storm water management treats the runoff on-site and make the management close to the natural hydrological cycle. Green and blue infrastructure aims to connect green and blue area and provide conditions for developing ecological network, sustainable water management and recreational opportunities. Landscape based design approach tries to understand the landscape formation process which is the interrelation between natural and social organisations. Landscape-based design approach is used to propose local ideas for the design.

My thesis focuses on the overlap of these three concepts. Water links these concepts to contribute a landscape with more conditions for biodiversity, identity and recreation. These concepts are interrelated and can contribute to each other. In this integrative approach, green and blue infrastructure can provide robust framework that incorporates the water cycle process both for cleaning and retaining on the site. Landscape based-approach provides a durable water system that can adapt climate change and incorporate different dynamic process such as the long term needs of human water management, the access to water and plant system; the unpredictable short term needs in different period such as transport in the past. This landscape system can bring back the interrelation between water and others such as the water and species. The site specific approach also brings exposure to the local environment.



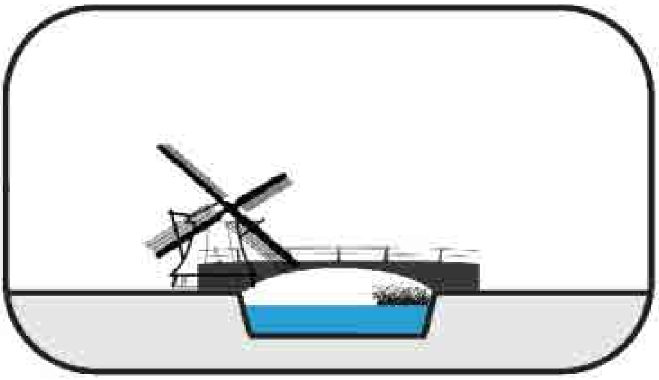
3.4 Design principle of Integrative Approach

The design principles are generated based on the theories that I mentioned before. They are the interface that related to water among the theories of sustainable stormwater management, green and blue infrastructure and landscape based design approach.



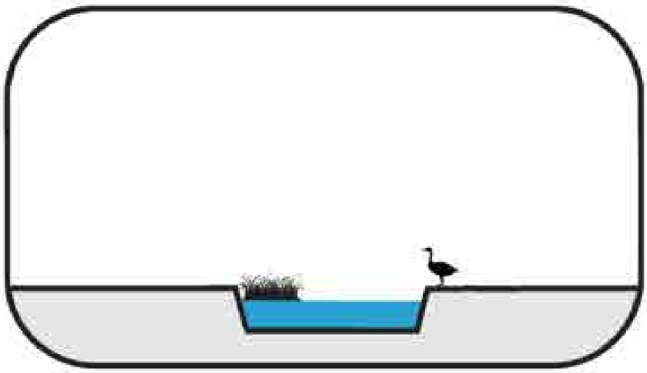
Hold rainwater

It needs to hold the raintwater as much as possible to close to the source point



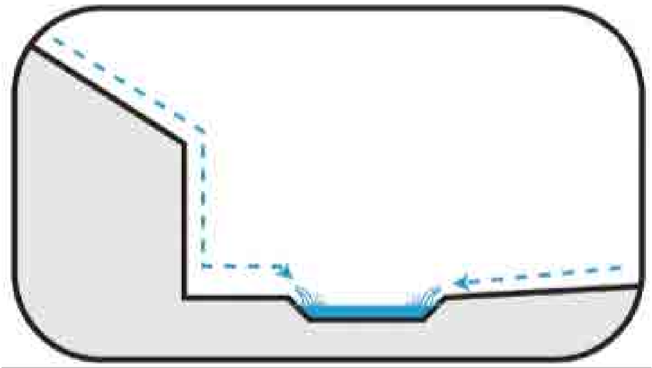
Identity with water

Place and placeless in terms of people perception. this thesis focuses on visual perception that is the visual result of human or natural product that related to water



Biodiversity with water

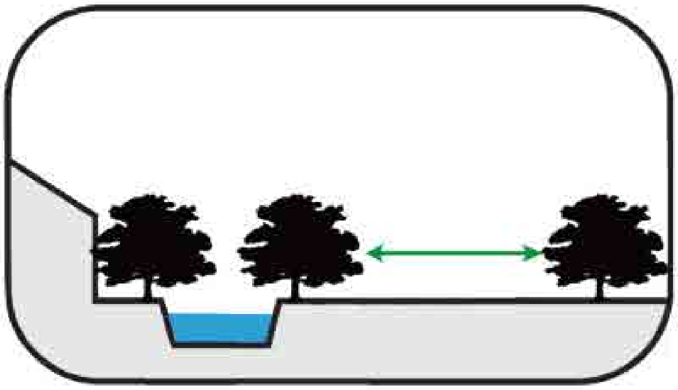
Create conditions for species that live in wet area



Make water runoff visible

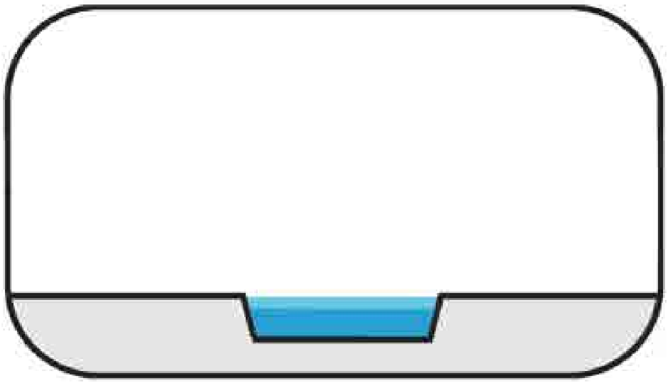
The water runoff flow process is visible for people

NB the colour dot indicates the principle based on which concepts



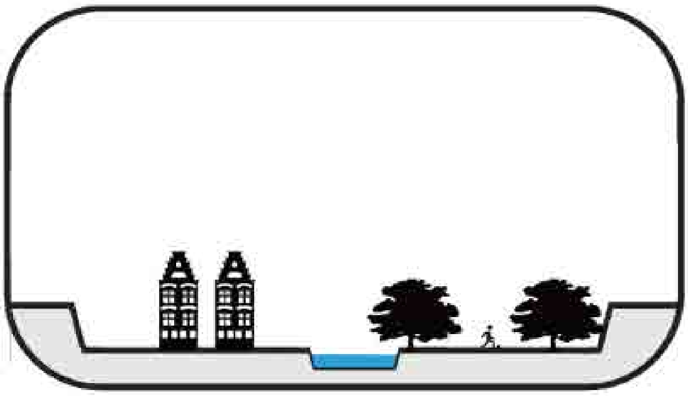
Linkage

The connection of green and blue elements



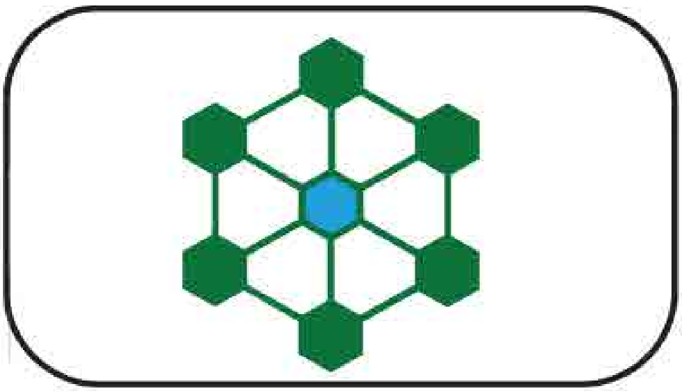
Resilient

The landscape can adapt to different weather situations



Site specific

Understanding the historical forming process and geographic characteristic



Robust framework

The avability of high quality ecological core area or has high denisty of patch areas

Chapter 4 - Site Analysis Middenmeer-Noord, Watergraafsmeer

This chapter will discuss the context of the design assignment, profile of the Watergraafsmeer and site analysis of the area.

Site analysis aims to understand the local landscape system and the water system. This particular site analysis is mainly initiated by the principles I discussed earlier. Therefore, the main focuses of the site analysis are landscape formation process, water system, ecological system and recreational opportunities related to water. The history inforamation about Watergraafsmeer are mainly based on Graaf's (2008) work.

4.1 Background of Assignment and Area

The assignment is initiated by Waternet and Amsterdam’s department of Urban Planning and Sustainability. Amsterdam is located in the mouth of Rhine river watershed while Watergraafsmeer is located in the east of Amsterdam, it is an urbanized polder. It is the deepest site in Amsterdam. The average height is -5.5 NAP. It is vulnerable to diverse flood issues. Waternet has planned to transform the mixed sewage system to separated sewage system in this project area.

Waternet has mentioned the goals of rainproofing which will be 60mm in one hour to respond to the possible extreme rain event in the future. Because the existing sewage system can deal with 20mm/h, therefore, 40mm stormwater will be temporarily stored in the open space such as green roof, water plaza and basins etc. The total area of the project area is about 32ha. Therefore, the water assignment is about 12800m3 which is about 5 times the size of the Olympic-sized swimming pool (50m*25m*2m). Also, waternet want to create visible runoffs to make people aware of the water cycle. Amsterdam’s department of Urban planning and Sustainability wants to integrate different uses in the public space to respond to the densely usage of land by the increasing population.

In summary, the design assignment consists of two aspects with respect to rainproof and spatial quality. One is that the rainproof should to get 12800m^3 in one hour while the other is more for spatial; the multiple use of public space.

Figure 15 Amsterdam is located in the mouth of Rhine river watershed based on(Verbeek, 2011

Figure 16 Amsterdam is the part catchment area of Amsterdam-Rijnkannal and Noordzeekanaal. Amstel river passes the Watergraafsmeer

4.2 Watergraafsmeer, Living under sea level

The history of Netherlands is history surrounding water. Amsterdam is in Rijn Delta of Rhine river. It is the part catchment area of Amsterdam-Rijnkannal and Noordzeekanaal. The Noordzeekanaal is created by the Dutch. As a result of the rising sea level, it is difficult to drain water into the Northern Sea in high tidal situation. In normal situation, the water will drain into Northern Sea through gravity, if the water level of North Sea is high, the water will be drained through pump. If there is a combination of heavy rain and high water level in the Northern Sea, the water will be drained into Ijmeer. Therefore, it is important to deal with water on-site in order to relieve the pressure on the downstream especially in Dutch situation.

Amsterdam is surrounded by agricultural polder. There are many urbanised polders in the city. Watergraafsmeer is one of them and it is connected by Amstel River. The polder of Watergraafsmeer is located at -5.5m NAP in average. Therefore, we can conclude that the residents are living under the sea level.

Figure 17 The schematic cross-section of Amsterdam. The Watergraafsmeer is located at the lowest part of Amsterdam. Marked area is the Watergraafsmeer

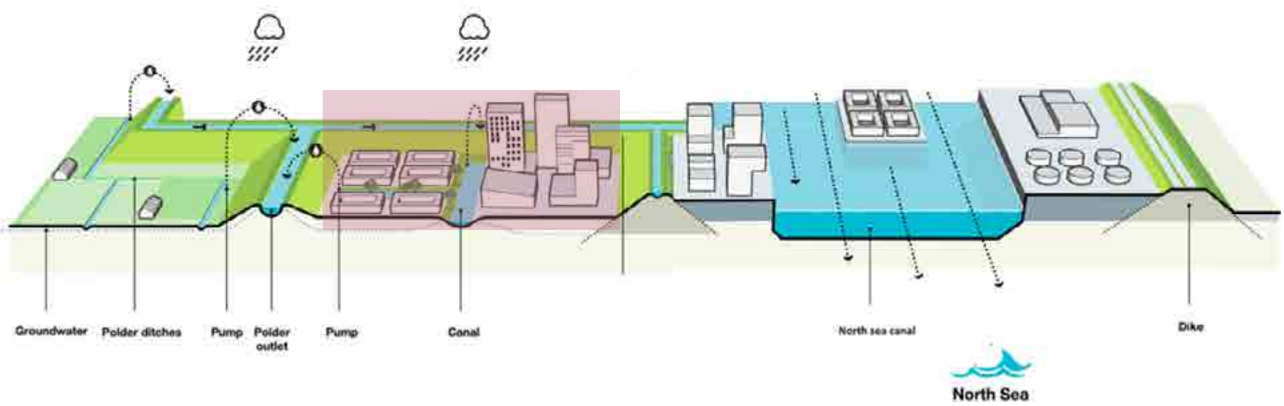


Figure 18 The urban water management of Amsterdam on city level. Marked area is the Watergraafsmeer

4.3 History context of Watergraafsmeer, A history with Water

In 1575, the location of the present Watergraafsmeer was the site of a lake, it became a polder after drainage was constructed in 1629 (Graaf, 2008). The land was mainly used for agriculture in that period. Food was transported through the canal or by the main road. Inside the polder, there are rational layouts that consist of ditches. The water in the ditches is drained by the ring channel (Molenwetering in Dutch) in rectangular pattern. The polder was divided by two diametrical routes into four parts. Each part has lots which are separated by ditches. These lots will be sold to people. Rich people escaped the city to build estates and gardens here. Frankendael Park was firstly built in that period. After the 19th century, the trends of gardening disappeared and only three areas still exist; and they are located along the ring channel and Middenweg.

In the age of industrial revolution, railway was constructed in 1843 along Utrecht. The other railway was constructed in 1874 which connects to Amsfoort. The railway and road have replaced the canal in terms of transportation and the ditches started disappearing.

Now it becomes an urbanised area, there are more sports area and residential area in

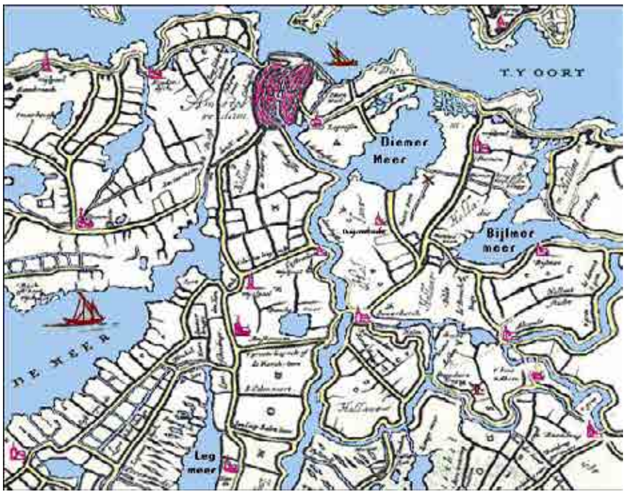


Figure 19 In 1575, it was a lake

Figure 20 Outer-ring canal 1725, People has leisure activities along the ring canal

Figure 21 The garden in the Watergraafsmeer that is used to escape the city life in 1777

Figure 22 The perspective view of the Watergraafsmeer 1953

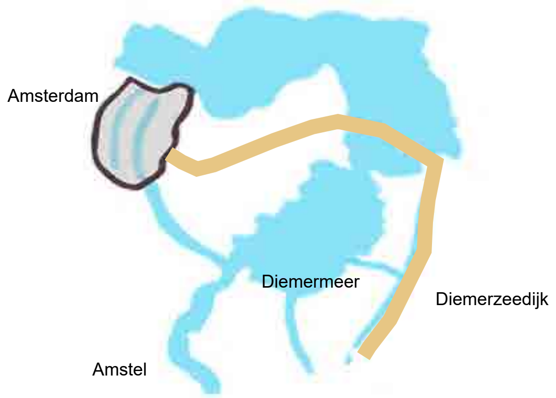


Figure 23 In 1300, the Watergraafsmeer was a lake

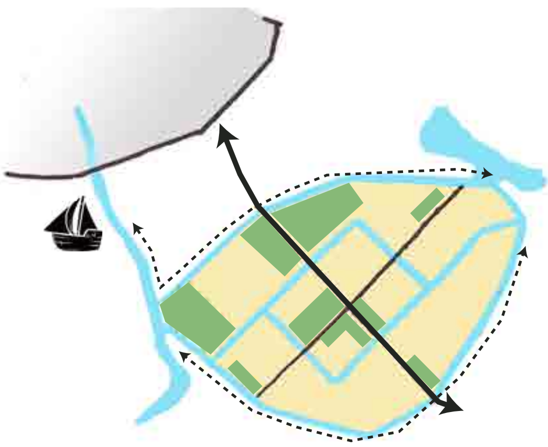


Figure 24 In 1860, it becomes an agriculture polder and there are some gardens in the area closed to channel. The canal was used for shipping transporting

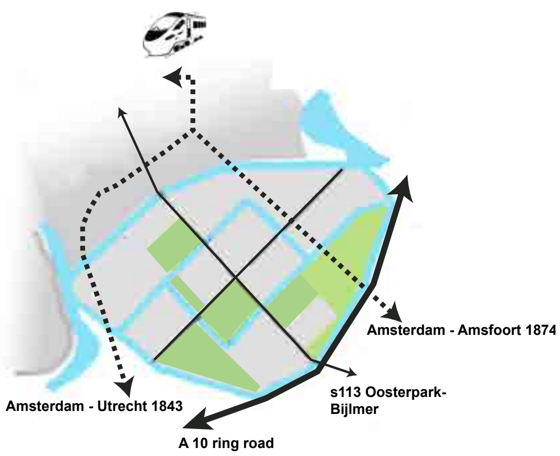


Figure 25 In 2016, it becomes an urbanised polder. The railway and road take the role of transporting. Green areas are closed to channel, Based on (Graaf, 2008)

this district. Many sports parks have been built. The green parks are closed to the internal channel.

Throughout history, the internal and outer ring channel remains, and it shows the consistent demands in drainage and the effectiveness of this polder drainage system. In the future, the demands will be increase as a result of climate change.

The canal served the purpose of shipping transportation, but the invention of train and car converted transportation modes to railway and road. The development of technology can also change the form of infrastructure. This is the characteristics of uncertainty in human activities. During the urbanisation, the ditches are replaced by constructions. The water surfaces have reduced.

The greenery has gotten closer to the water system in the past and present. The water system can transport nutrients to the green area. The green area can work well with water in present times. Also, people like to have leisure activities at the waterfront through direct access to water. The green area creates a relaxed environment for the people.

It is recommended that a robust water network working with nature is created which will helps to prevent flooding and incorporate leisure function and natural development.

4.4 Water system

In this section, I will discuss the surface water system, water quality and sewage system.

Open water system

In the open water system of Watergraafsmeer, the input of water is obtained from rain water and seepage. Most of rain water and seepage will be collected in internal channel and parts of the rain will drained by mixed sewage system. The surplus water in the internal channel will be pumped to the outer ring channel.

Figure 26 Most runoff in the neighbourhood is from north to south to Galilei Park based on the experts from Waternet

In the polder of Wategraafsmeer, the outer ring channel located at highest level while

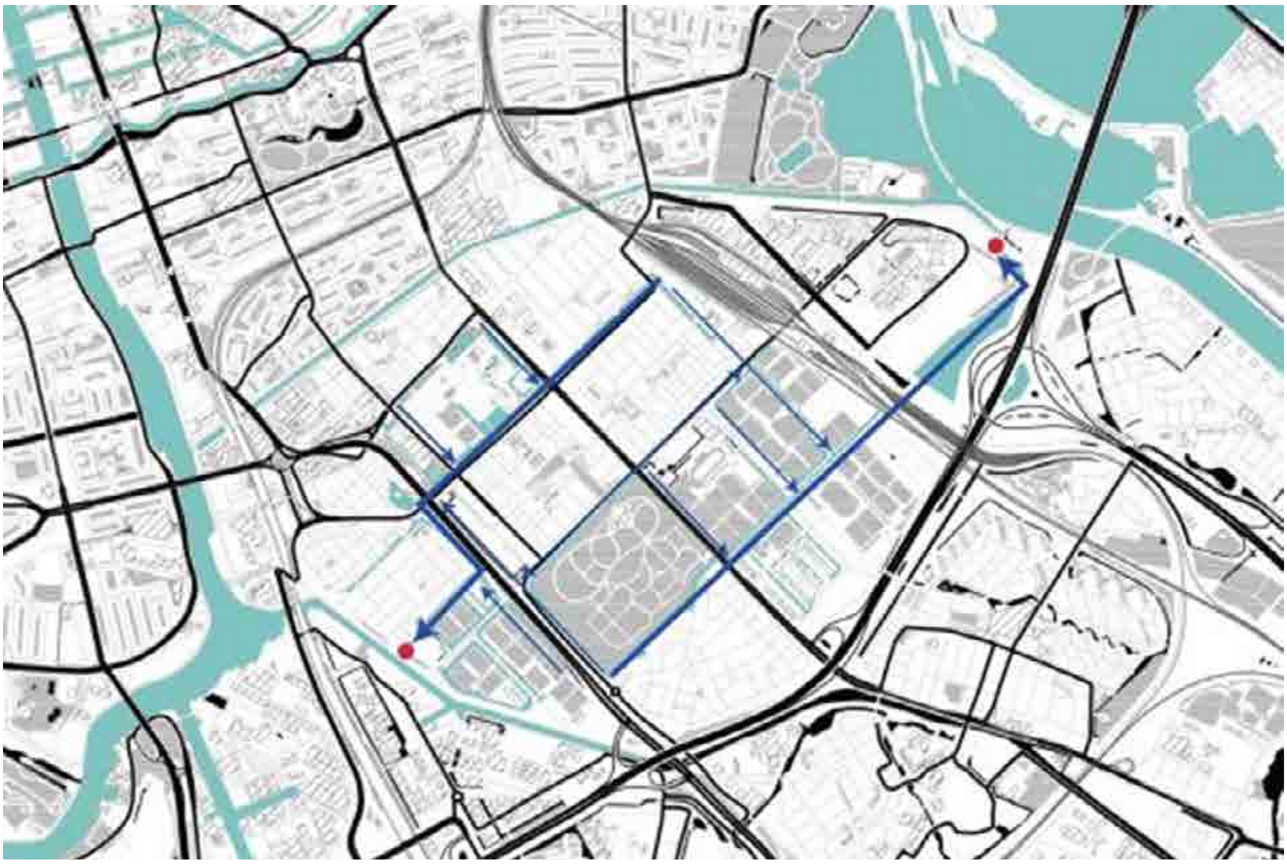


Figure 27 The open surface water system on district level, there are two pumps stations. One is in east, the other is in west

the internal ring channel is located at lowest level. There are two pump stations in the area, the surplus surface water will be drained into the ring channel and then pumped to the regional water system. The water level of the internal ring channel must be strictly kept. The maximum fluctuation level must be 50cm according to experts from Waternet. This is because of the case of the outlet of sewage system. If the sewage system is out of order, the waste water will drained here by the emergency outlet. The emergence outlet of sewage system is 50cm above the normal water level of the ring channel. The level of the ring channel in winter will be kept lower than that in summer in order to keep dry during the wetness of winter. In the project area of Middenmeer-Nord, the runoff flows from western-north parts to the internal ring channel.

Watergraafsmeer is below 5.5m NAP in average and the ground water level is very high, which is about -1.2 below the ground. This results in much regional seepage in the area. In the permeable surface area such as green area, the seepage will emerge on ground and flows into the internal channel. In the impermeable surface area, the seepage will be blocked by constructions and will become the underground streaming channel that flows into the internal channel.

Water Quality

The level of water quality in internal ring channel is urban usage water that is below the standard level of urban living level (Faasse, 2011). The pollutes make negative impacts on the local ecological system. The main pollutions are Phosphate and Nitrogen. According to the research of Waternet, above 90% of Phosphate and Nitrogen are from seepage. They come to internal channel through runoff in permeable area and underground streaming in impermeable area.

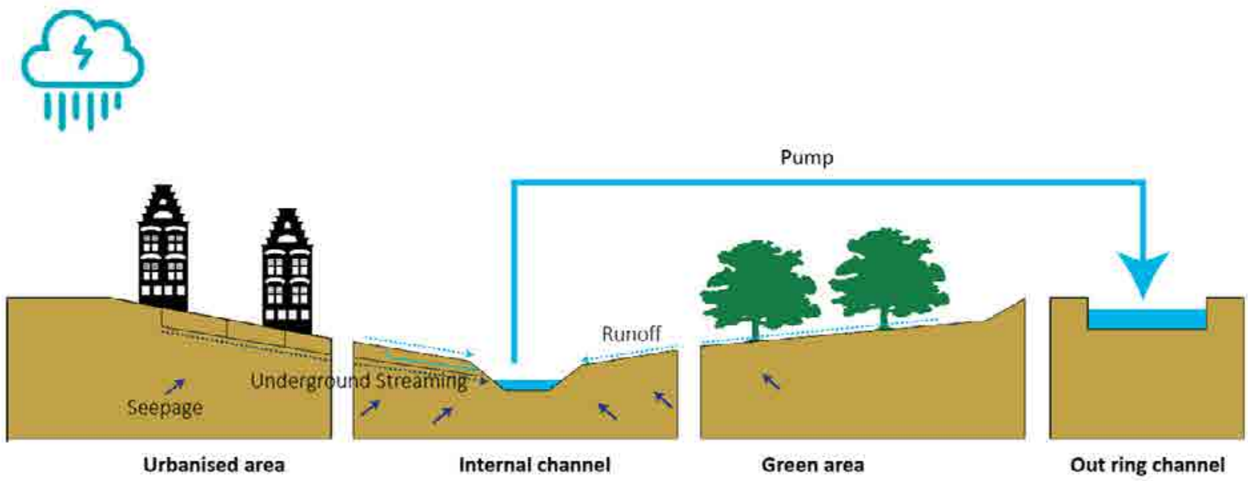


Figure 28 Water balance of surface water. The surface water from rain and seepage. They will be collected in internal channel and to be pumped to outer ring channel later. The seepage under urbanised area will be blocked by pavement and become undergrond streaming to internal channel, Based on (Faasse, 2011)

Sewage system

Most sewage systems in Watergraafsmeer are separated. However, some parts are combined sewage system that has to be renewed to be separated. In the separated part, the rain water will be drained into the ring channel nearby. The waste water will be collected in the pump station near Galilei Park, and then pumped into the sewage system in the city.

Summary

The surplus water will be pump into the regional water system. It is important to retain water as much as possible on-site within the polder in order to decrease the energy needed for the pump in the peak time and less pressure for the downstream. There consistent seepage and infiltrate is limited and it can be ignored. The fluctuation in water level in the ring channel should be controlled. The main Nitrogen and Phosphate in the water channel are obtained from underground streaming and runoffs in permeable surface. It is recommended to provide treatment system that can remove the contamination.

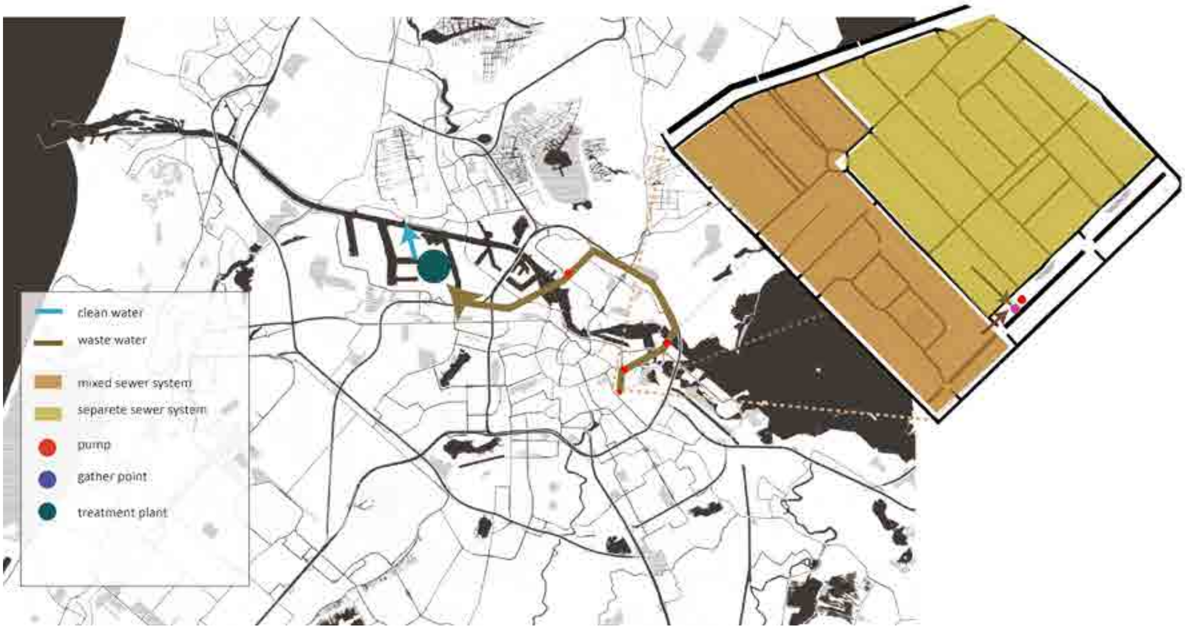


Figure 29 The waste water sewage system on city and neighbourhood level, the waste water will be collected in the pump station in Galilei Park and transport to treatment plant

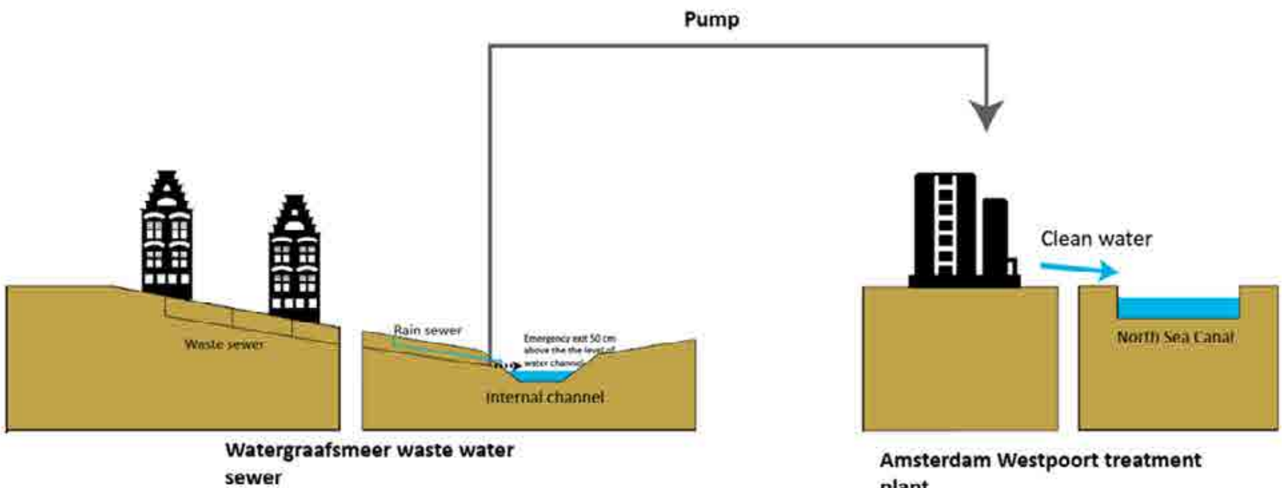


Figure 30 The schematic cross-section illustration of waste water sewage system. The emergence outlet of waste water sewage system is 50 cm above the water level of internal channel. That means the water level of internal channel can only increase 40 cm in maximum

4.5 Biodiversity with water

The National Ecological Network appears in several areas in Amsterdam. Two parts are located near the Nieuwe Meer and Nieuwe Diep respectively. Ecolint was constructed in 1990s and it proposes that wet connection must be made between these two areas. The targeted species for the Ecolint are Pike, bank dragonfly, grass snake, weasel and reed warblers (Faasse, 2011). These species are majorly found in the ecologically-friendly bank area with many alternatives. Some plants can attract targeted species such as reed warblers. The grass snake likes sheltered areas and wetland, Pike favours clean water with aquatic plants.

Part of ring channel consists of the main ecological wet passage of the Ecolint that connects Science Park, Sports Park and the cemetery. The types of green structures are park, cemetery green, and sports park and allotment garden. The channels and shores provide the main ecological bases. This environment provides diverse conditions of wet and dry, sun and shadow, and open space and shelter. The average water depth of Ecolint is 0.8m. The bottom of the channel is -6.3m NAP (Faasse 2011). The range of the width of the channel is between 6m to 15m and the length is 2.5km approximately.

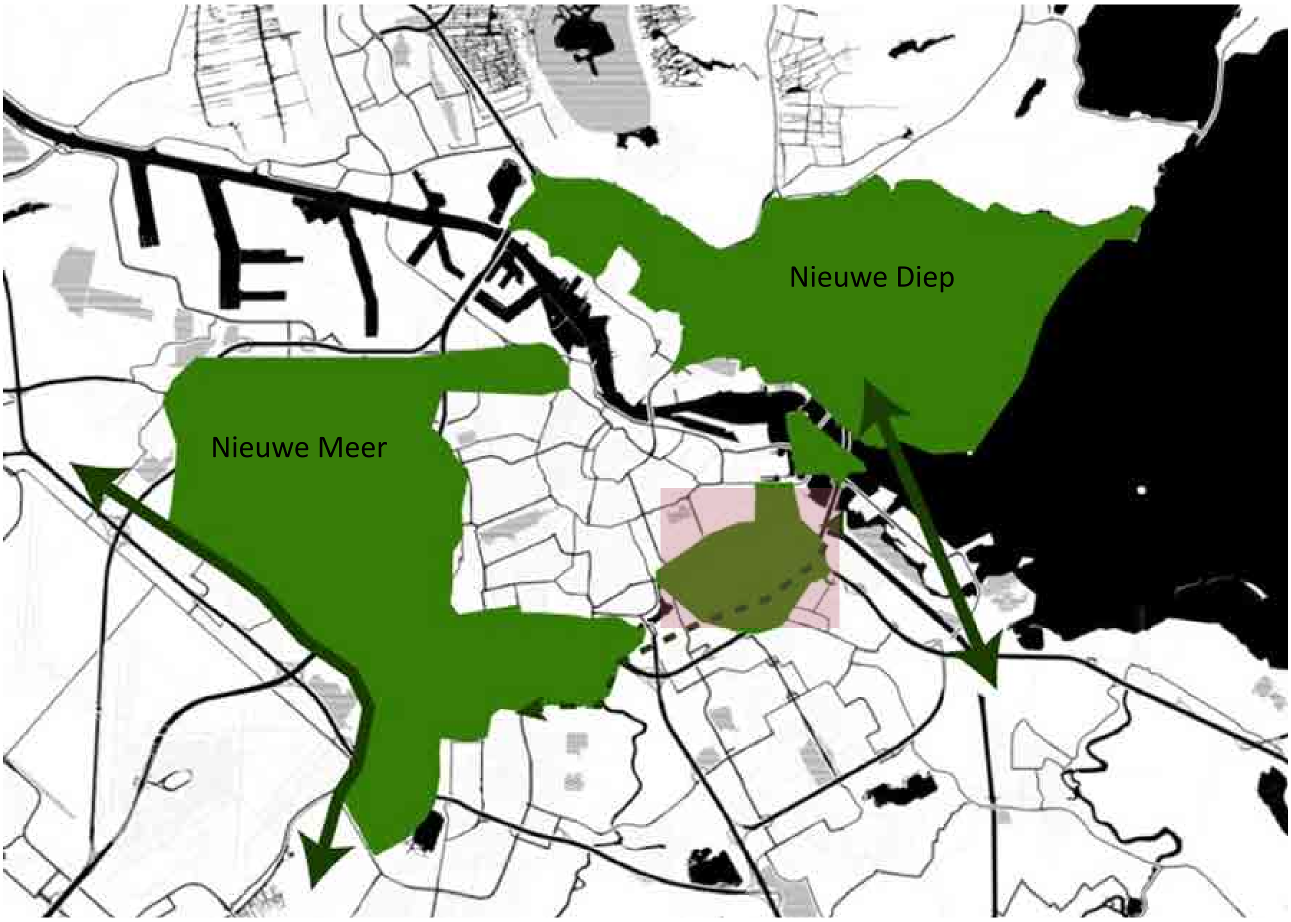


Figure 31 The ecolint pass the Watergraafsmeer. It connects two parts of National Ecological Network. That are Nieuwe Diep and Nieuwe Meer

However, the quality of the ecological passage could be improved. In the southern and western part of the ring channel, the ecological consistent connection is well constructed and the biodiversity in Frankendeal Park and cemetery are relatively high. However, in the project area of Galilei Park and the eastern part of the ring channel, the biodiversity is quite insufficient.

According to DRO (n.d.), the biodiversity in the city of Amsterdam is determined by its distance to the outskirts, sizes and diverse of spaces such as openness or plants. For example, some parts of Waterland with an open homogeneous landscape are relatively low (DRO, n.d.). In the district of Watergraafsmeer, Frankendael Park and Cemetery have large area for green and diverse spaces and different group of plants such as forest-like which has formed a sufficient successional area of ecological shore. However in the Galilei Park, the water way is simply straight with green strip. The main green area is an open lawn. The bushes and trees are isolated. There are no diverse spaces and sufficient successional water bank area for biodiversity conditions.

Apart from the quality of ecological connection, lots of nutrients in form of Phosphate and Nitrogen in the water makes the bottleneck of the ecological development. It makes some plants overgrow and makes the rate of growth of some plants slower. As result of this, it evolved into a homogeneous environment. For example, Phragmitesaustrlis grows very well, but Schoenplectuslacustris died after it was planted (Doren et al., 2010).

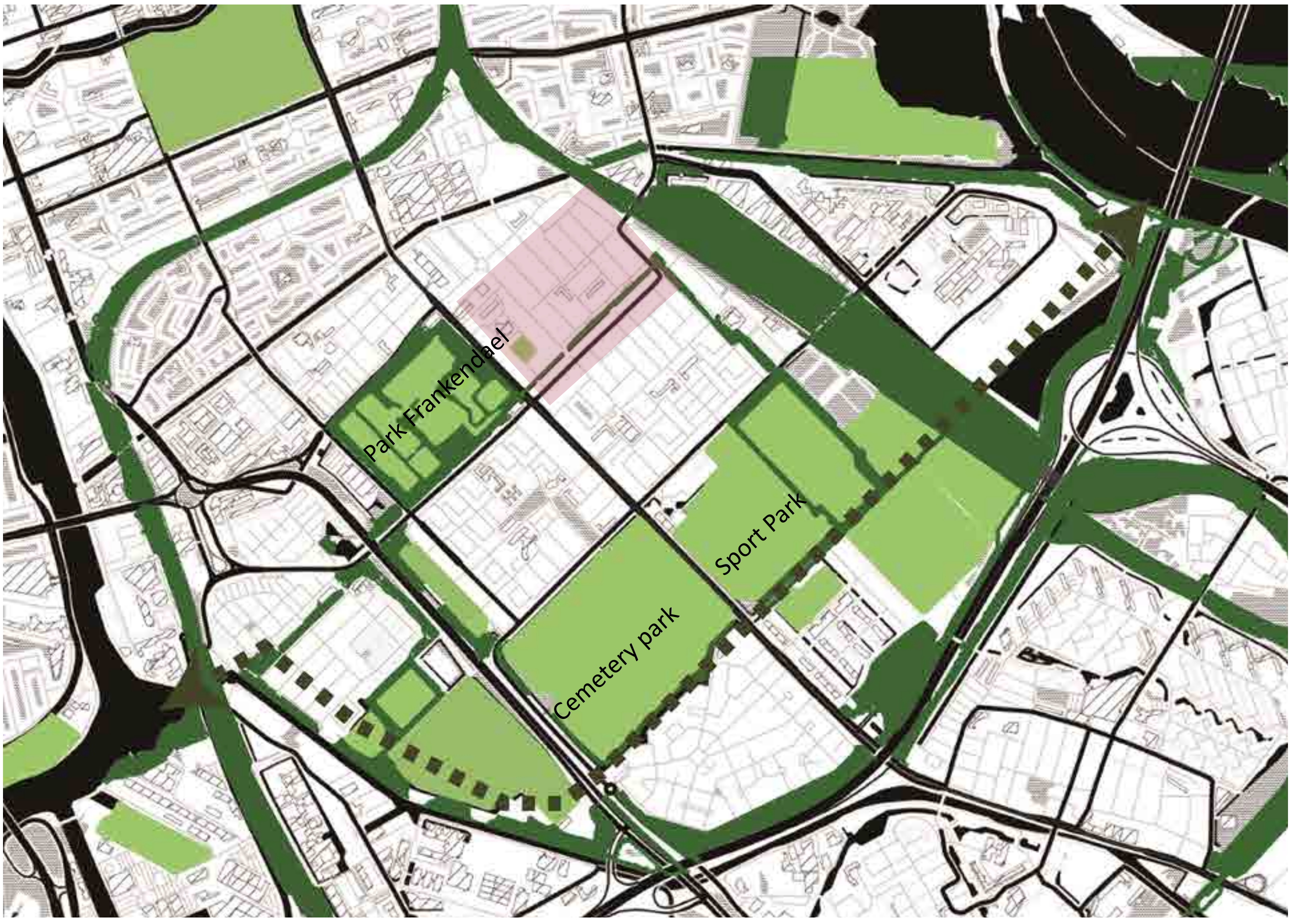


Figure 32 The primpary passage of ecolint passes sports park. The secondary passage passes Galiei Park

In summary, Galilei Park is the weakest point of ecological connection. In order to attract the targeted species, it is important to create ecological-friendly bank area with alternative wet or dry, sun or shadow and open and shelter. It can become the stepping stone between Frankendeal Park and Sports Park. The Phosphate and Nitrogen nutrients are the bottleneck of the ecological development, therefore, they need to be treated.

Figure 33 The targeted specie of weasel

Figure 34 The targeted specie of reed warblers

Figure 35 The targeted specie of pike

Figure 36 The targeted specie of bank dragonfly

Figure 37 The targeted specie of grass snake

4.6 Recreational analysis

There are diverse Metropolitan levels of recreational opportunities nearby. Watergraafsmeer is 5 km away from the city centre of Amsterdam that means 20 minutes by bicycle. The Amsterdam Defence Line which is UNESCO World Heritage is nearby the east of the project area. The distance is about 2 km which means 7 minutes by cycling. On the east side, the Amstel wedge is about 5 km from Watergraafsmeer.

Watergraafsmeer is a polder that offers special visions. The outer ring channel provide special experience and atmosphere to the people. They can walk and cycle along while taking a look down into the polder or by enjoying the waterfront. The sports parks and Park Frankendael also provides recreational opportunities. There are three important recreational routes that connect outside to become the recreational framework of Watergraafsmeer. They are recreational route of out-ring channel, the Hugo de Vriesllan-Galileiplantsoen and Middenweg.

Figure 38 Outer ring channel

Figure 39 Park Frankendael

Figure 40 Sports Park

Figure 41 The recreational map. the indicative number on the map is related the figures on right and in order

Inside the project area, there are several special recreational opportunities that should be mentioned. (1) The historical bridges with Amsterdam School style on the internal channel; (2) Galilei park (3) Recreational route of Arntzeniusweg; (4) Linnaeusparkweg with big trees in the middle and historical buildings; (5) The fountain square (6) waterfront (7) and Amsterdam School is the main architecture style.

There are two exiting recreational route across the project area of Middenmeer-Nord, which is marked by a dark green line on the map. One is the route along out ring channel and the other, in Arntzeniusweg, aims to connect the waterfront and Sport Park. However, the second recreational route itself lacks identity and the trees are relatively small. On the other hand, the big trees of Linnaeusparkweg offer comfortable walking and cycling experience. On visitation, I discovered that more people cycle here than in Arntzeniusweg. The experts in the Rainproof Programme also confirmed this fact. Furthermore, the fountain is in Linnaeusparkweg. I will therefore propose an alternative recreational route in Linnaeusparkweg.

In summary, in the project area of Middenmeer-Nord, the recreational connection should be made for connecting the waterfront, Galileiplantsoen and sport park on the district level. There is an existing recreational route for these connections. However, there could be an alternative in Linnaeusparkweg which can offer the same connection while providing conformation experience, fountain and historical characteristics.   Amsterdam School is the main architecture style employed.

Figure 42 Bridge on internal channel with Amsterdam School style

Figure 43 Galilei Park

Figure 44 The existing recreational route of Arntzeniusweg

Figure 45 Linnaeusparkweg with big trees

Figure 46 Foutain square

Figure 47 Waterfront of outer ring channel

4.7 Conclusions

(1) History: There is a considerable less water surface that can be used for water storage. The internal ring channel is effective for drainage which could deal with the increasing demands in the present and the future. Green area and leisure activity favour the waterfront. It is recommended that a robust water network working with nature is created to prevent flooding and incorporate leisure function and natural development.

(2) Water system: The groundwater level is very high and it brings about enormous seepage. The contribution of infiltration is minimal so water retaining is the main strategy to use for the water assignment. The storm water in the project area should be maintained during the peak time. The height difference makes the water flow from west-north to internal ring channel. We need to locate possible retaining area before getting to Galilei Park. As a result of the emergency wastewater outlet, the water level of the internal channel will only increase by 40cm in maximum. Therefore, the main extra retaining space should be considered for the space outside the channel area. The water quality is insufficient to provide biodiversity.

(3) Biodiversity with water: the area is in the Ecolint that connects two parts of Ecological National Networks. Galilei Park can be an ecological stepping stone between Frankendael Park and Sport Park. However, Galilei Park is the weakest point for such connection. The park lacks alternative for species in terms of light, shelter and plants. Also, the excess Nitrogen and Phosphorus nutrients make up the bottleneck of the ecological development. The Galilei Park can help to remove parts of the contamination before it flows into the internal ring channel. The targeted or indicator species for Ecolint are Pike, bank dragonfly, grass snake, weasel and reed warbers. It is suitable for creating ecological friendly bank habitat with diverse alternatives in GalileiPark.

(4) Recreation: There are lots of recreational opportunities nearby and inside Watergraafsmeer. The existing recreational route that passes across the site area does not offer comfortable experience. There is one special road called Linnaeusparkweg with high spatial quality in Watergraafsmeer which does not only link the waterfront of the ring canal, GalileiPark and Sport Park, but also connects the fountain. The main Architecture style in Watergraafsmeer is the Amsterdam school. It is recommended to offer alternative recreational route in Linnaeusparkweg.

Chapter 5 - Explorative Design Scenarios

In this chapter, I will first describe the water assignment for the study. Secondly I will present the available toolbox for the design assignment. Thirdly, I will make the different scenarios that apply different technical storage interventions to explore all possibilities.

Figure of Olympic-size swmming pool

5.1 Water Assignment

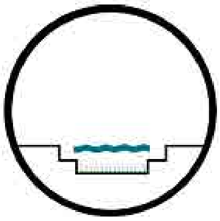
As I discussed in the chapter of site analysis, the water assignment is to make rainproof for the neighbourhood in 60mm/h rain event for one hour. Because the existing storm water sewage system can deal with 20mm/h. So the target of open space is to deal with 40mm in one hour. The total area of the neighbourhood is 32ha that means 12800m3 in one hour. It is about 5 times Olympic-size swimming pool (50m*2m*2m). The calculation is made by me.

As I mentioned in the site analysis, the groundwater level is really high and it brings enormous seepage that makes infiltration a little in the heavily rain situation. Therefore retention and detention are the main strategies to deal with water. Retention is long-term storage. Detention is temporary storage and discharge or infiltrate later.

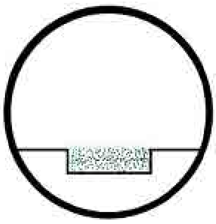
5.2 Availabe Toolbox

The toolbox is created mainly based on literature study. Small of them are created by interviews of experts and my inspiration. As storage is the main strategy used for the design, I will show the schematic tools here, and the description, average depth or volume of this intervention and its photos are available in appendix.

The schematic illustrations of tools for storage are follows:



Storage basin

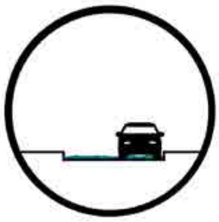


Bioretention

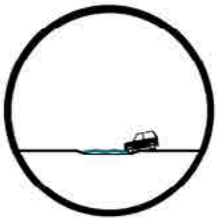
Bioretention parking

Gutter

Speed bump

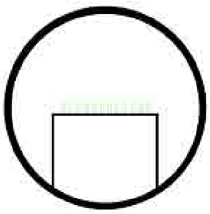


Storage road

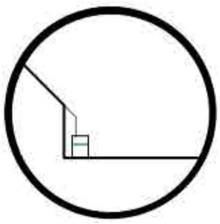


Speed pit

Undergrond storage



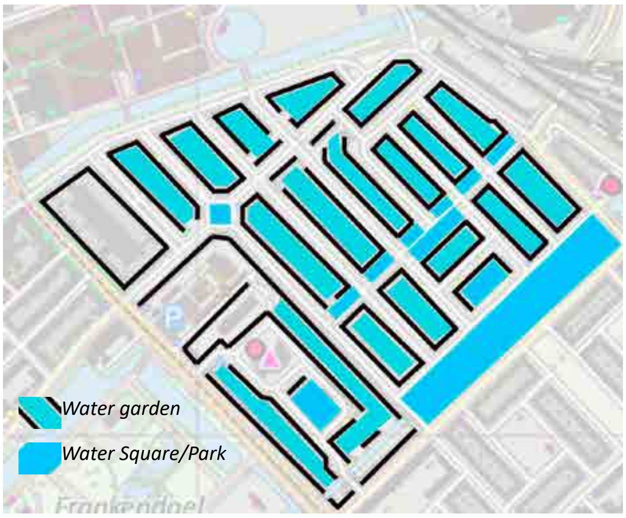
Green Roof



Harvesting

5.3 Quantified Stormwater Storage

Storage scenarios study is a scientific comprehensive solid method to link the assignment to solution. Because water assignment is complicated and has the characteristic of quantity, it is necessary to use scenarios study to explore the maximum quantified result. The storage scenarios study is to test all technical intervention of storage with only consideration on spatial conditions.

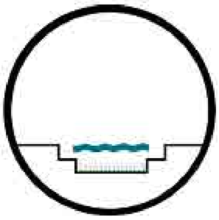


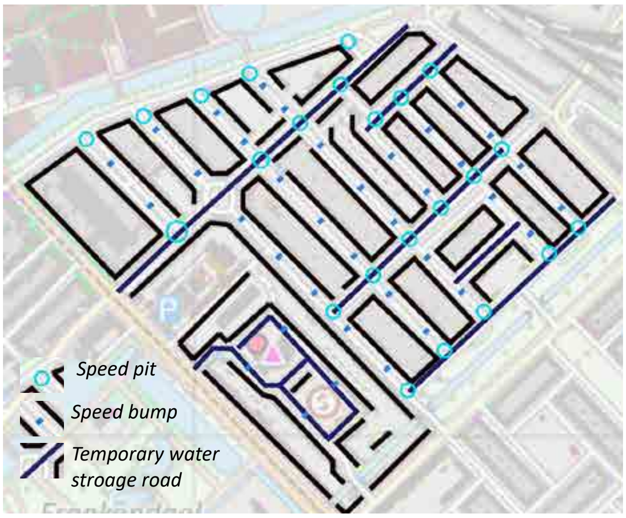
name	Area (m^2)	Water storage capacity (m^3)
1 water square/garden	12500	2812.8
2 water park (Galilei)	19400	5808
3 water garden (private)	private	private

Intervention: Storage basin

Applied area: Park, green area, square

Percentage of Total assignment (12800m3): 67%



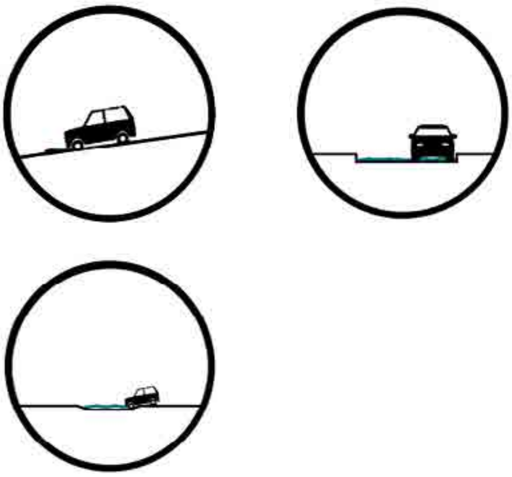


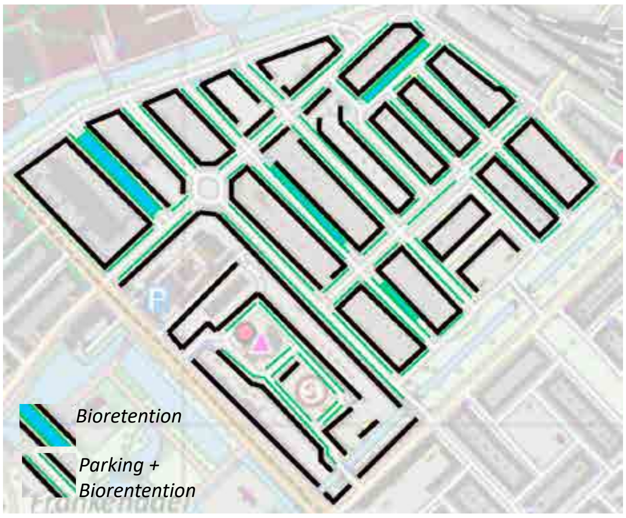
name	Area (m^2)	Water storage capacity (m^3)
1 speed pit	3300	495
2 speed bump	240	24
3 temporary water storage road	7000	700

Intervention: storage pit

Applied area: street

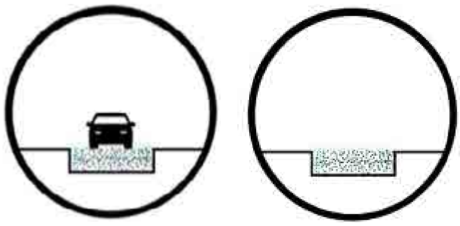
Percentage of Total assignment (12800m3): 10%





Intervention: Bioretention

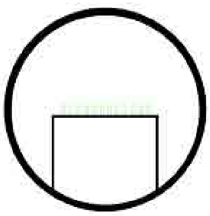
Applied area: green area, parking area and conner of street etc.
Percentage of Total assignment (12800m3): 36%



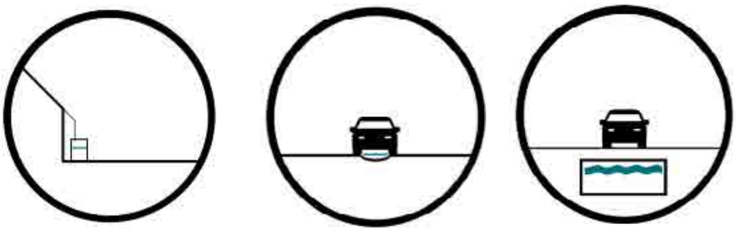
name	Area (m^2)	Water storage capacity (m^3)
1 Bioretention	4000	1200
2 stormwater tree trench	1400	420
3 corner bump-out	256	76.8
4 Parking + bioretention	9600	2880

Intervention: Green roof

Applied area: Flat roof (a) and flat with slop roof (b)
Percentage of Total assignment (12800m3): 8%



name	Area (m^2)	Water storage capacity (m^3)
Green roof	9600	960



name	Area (m²)	Water storage capacity (m³)
parking + underground storage	9600	4800
Parking + gutter	9600	960

Other intervention: harvesting, undergrond storage, gutter:
The harvesting is getting runoff from roof and depends on barrels. Undergrond strorage and gutter mainly happened in parking area

Percentage of Total assignment (12800m3): 37.5% of underground storage and 8%of gutter

5.4 Conclusion

This study provides two aspects. Firstly it get feeling which intervention is suitable for where. The other is getting the feeling of the quantified results of different technical interventions. It provides the visually mapping result. That is easy to communicate commissioners and help them to make decision with designer. Galilei Park and Copernicusstraat could be good places to store the water as primary and secondary storage area based on the potential capacity of water storage and water flows.

name	Area (m²)	Water storage capacity (m³)
1 water square/garden	9380	2812.8
2 Galilei park	19400	5808
3 speed pit	3300	495
4 speed bump	240	24
5 temporary water storage road	1200	120
6 parking /underground storage	9600	4800
Parking/ gutter	9600	960
Parking/ bioretention	9600	2880
7 swale	4500	1350
8 stormwater tree trench	1400	420
9 corner bump-out	256	76.8
10 green roof (a) in terms of 60mm	38500	2310
Green roof (b)	24500	1470

Table: result of water storage caculation according to different technical intervention

The total potential storage capacity is 19615.8 m^3, and the assignment is 12800 m^3.

Chapter 6 - Design of Middenmeer-Noord, Watergraafsmeer

This chapter initially discusses the research and design process employed earlier. It explains how the result of the research is connected to the design work. Secondly, it enumerates the opportunities and problems of the site area. The Masterplan indicates where I applied basic interventions. The water system design displays the technical interventions and the conceptual map gives the three main design areas. Later on, the design of these areas will be elaborated on the street level and park level.

6.1 Linking to the Research

The design surrounds a case study for the water integrative approach. The approach is based on the literature study conducted on Sustainable Stormwater Management, Green and Blue Infrastructure and Landscape based design approach. After analysing the literature of the existing concepts, I created an innovative integrative approach that also gives the principles for the design. The site analysis that is related to the design principles provides the scientific bases for the design.

Also, I summarized the exiting toolbox that can be used for the design process. The result of storage design scenarios study provides the quantity result for the latter design of the water system. In general, the design tries to integrate water technical perspective and the design principles that I created before and the result of site analysis to make an integrative rainproof system with multiple space availability for the Watergraafsmeer.

Problems and Opportunities for Design

Although, the water assignment is complicated, it still can be achieved through storage as I discussed in the water study. Besides, the private space in the green roof and semi-public space of the school square, there are two places that provides vast spaces to retain water; one is Galiei Park, the other is Copernicusstraat. Water can easily flow through these areas by gravity.

The seepage produces Nitrogen and Phosphorus which is bad for the ecological development. All runoffs and underground streaming flows into Galilei Park. The park can provide ecological treatment service for removal of contaminants.

The Ecolint is located across Galilei Park. The ecological transition is insufficient in the existing Galilei Park. However, one side of Galilei Park span about 25 meters, and the park has 2 hectares. They are above 15 meters and 2 hectares respectively which are the minimum standard for constructing stepping stone and building the ecological corridor for most targeted species (U.S. Environmental Protection Agency 2009; Rooij et al., 2003; Jongman and Pungetti, 2004). Also, there is enough space to create alternatives in the Galilei Park. There are several opportunities to build a riparian habitat here as stepping stone of connecting Frankendael Park and Sport Park.

The existing recreational route is not meant for people's leisure. Linnaeusparkweg can offer an alternative comfortable cycling and walking experience along with the view of historical buildings. There is limited open public space for daily social activities such as meeting inside the neighbourhood. The Copernicusstraat is located in the middle of the neighbourhood and has enough space to offer daily social activities.

Figure 48 Galilei Park

Figure 49 Part of Ecolint

Figure 50 Linnaeusparkweg

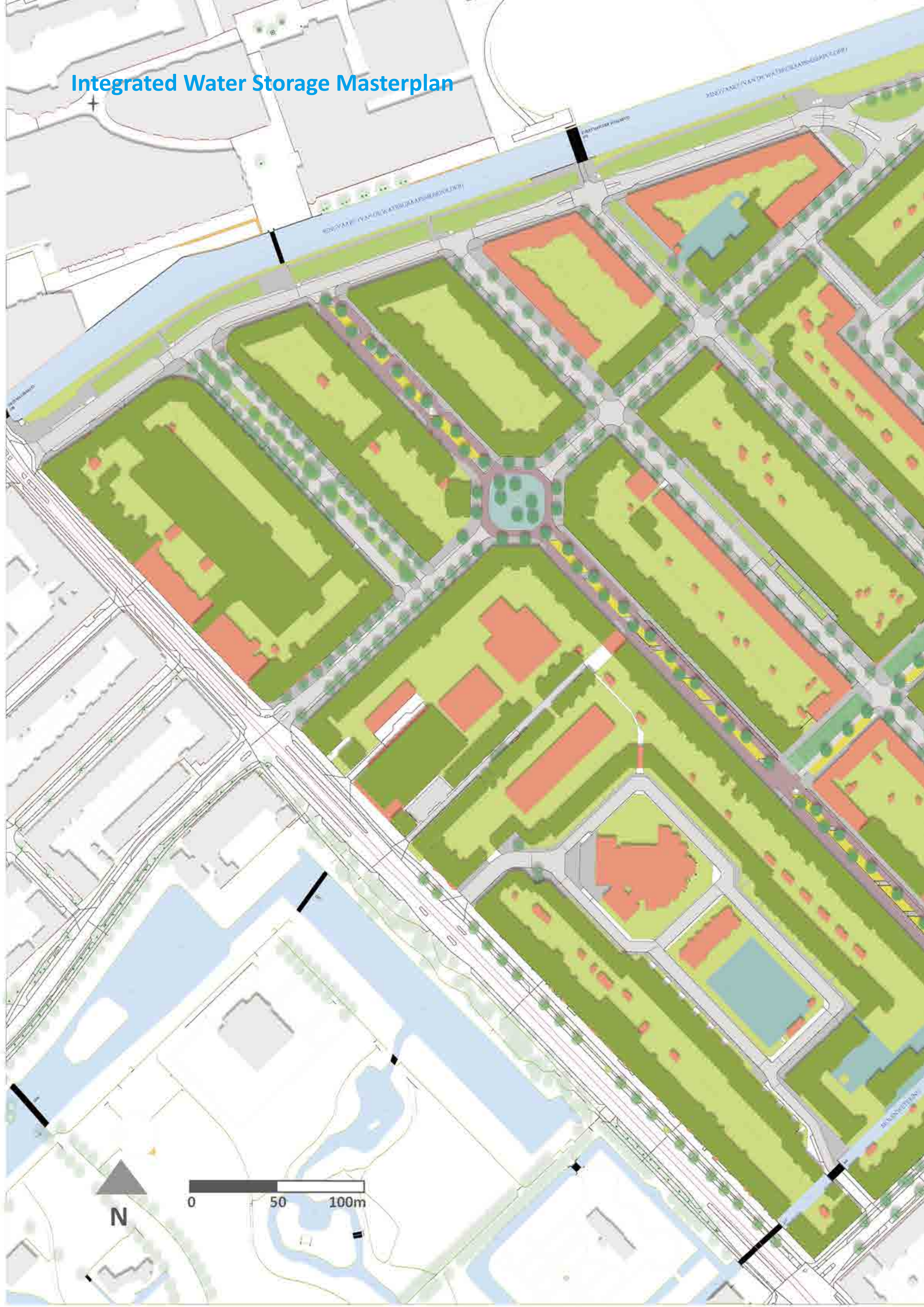
Figure 51 bridges with Amsterdam school

There are three bridges located across the internal ring channel. The main Architectural style of bridges and buildings in this district is the Amsterdam School.

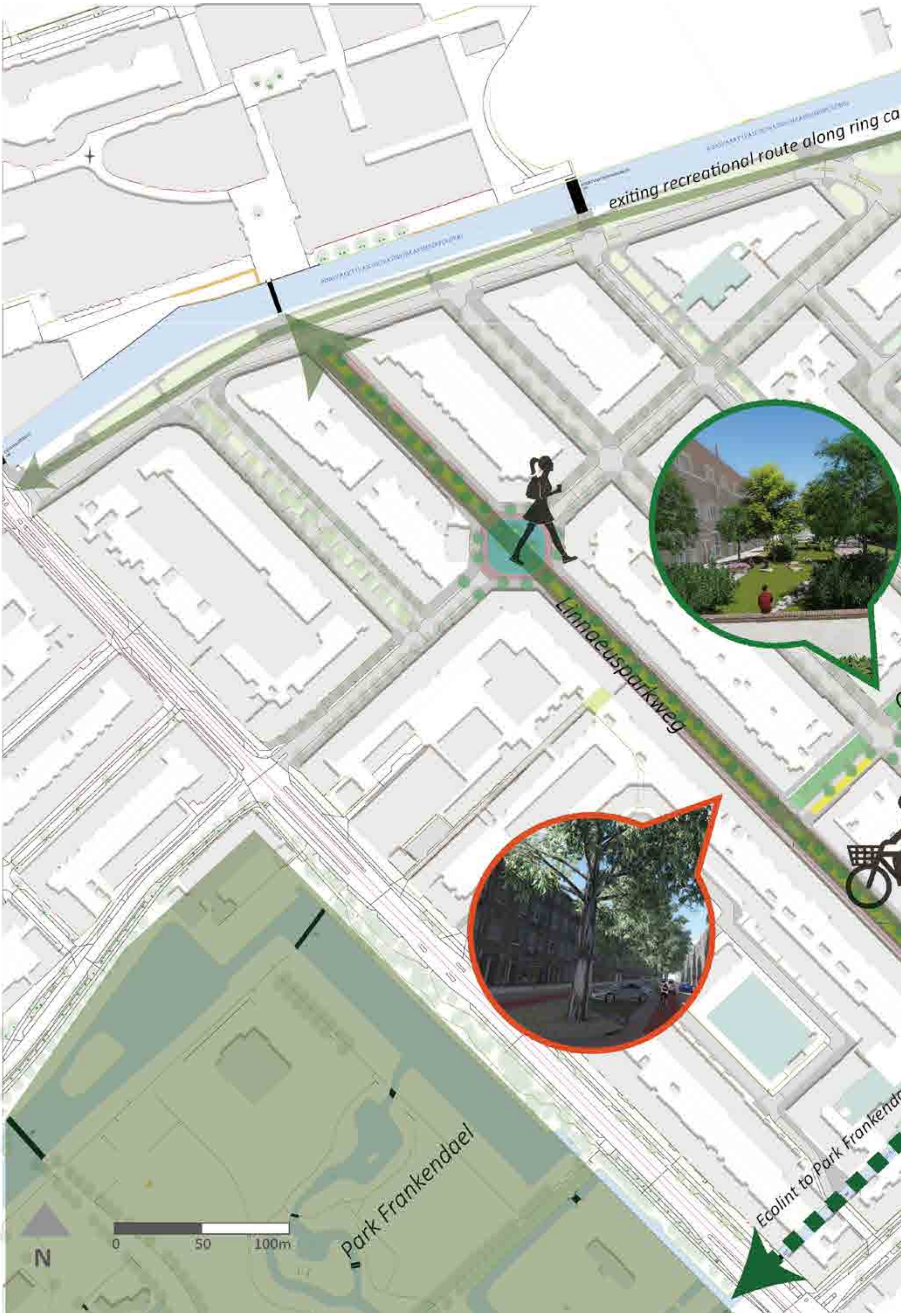
6.2 Integrated Water Storage Masterplan of Middenmeer-Noord

In general, Galilei Park is the main retention area for the neighbourhood while Copernicusstraat is the secondary detention area. On the building level, the flat roofs are designed to meet the requirements of green roofs. On the street level, the parking areas in Linnaeusparkweg are designed to match biorenetion parking. The streets in eastern north– western south direction such as Copernicusstraat are designed as retention streets. The liner green along the roads are designed as swales. On the park and square level, they are integrated with wetland or detention basin to form the Water Park or Square. I will elaborate these later in the design on street and park level section.

Integrated Water Storage Masterplan




Legend
Private Garden
Water Plaza
Bioretention Park
Galieli Park
Green Roof
Cycling Route
Normal Roof
Detention Green
Swale
Recreational route


exiting recreational route along ring ca
Linnaeusparkweg
Park Frankendael
Ecolint to Park Frankenda
0
50
100m
N

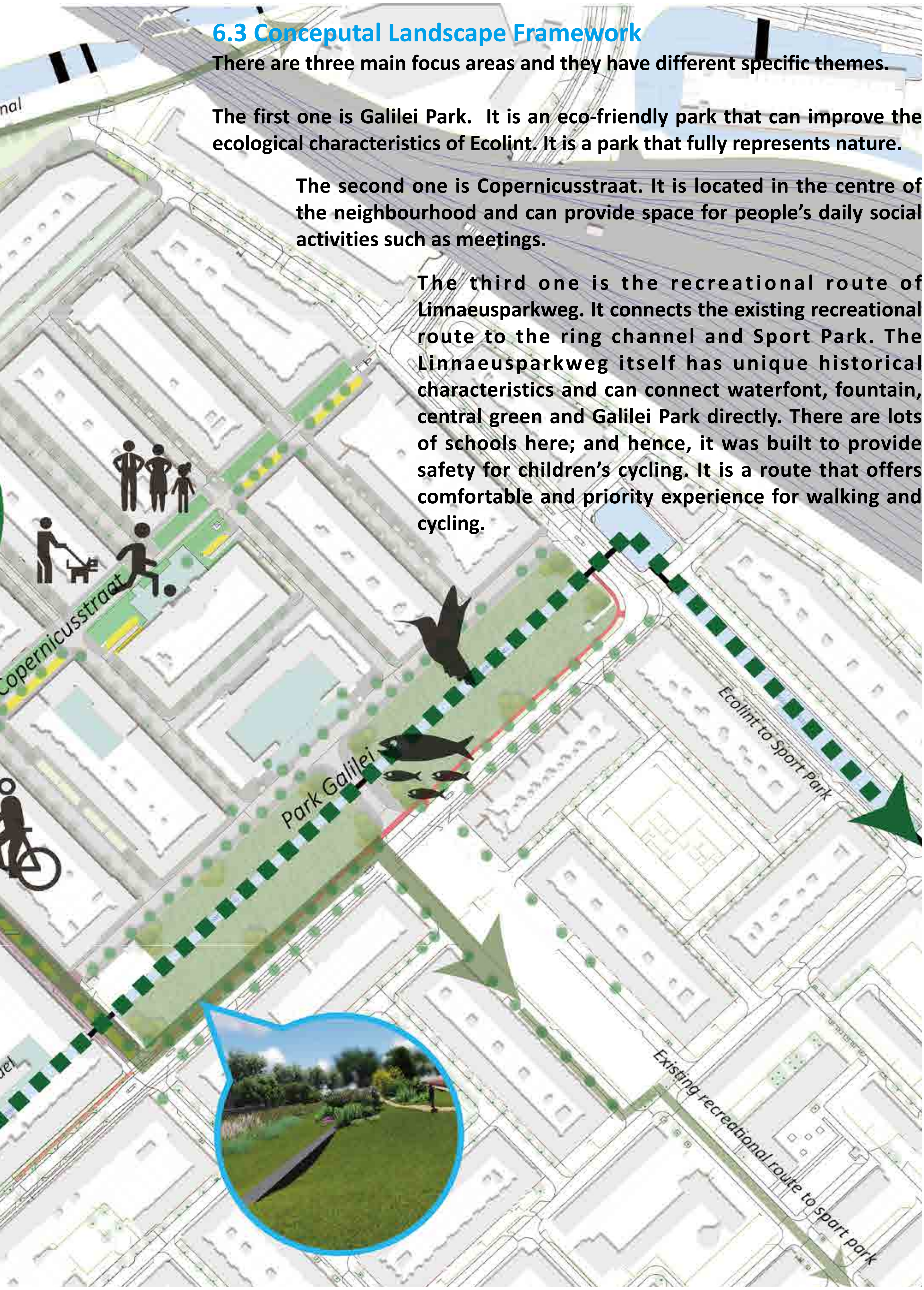
6.3 Conceputal Landscape Framework

There are three main focus areas and they have different specific themes.

The first one is Galilei Park. It is an eco-friendly park that can improve the ecological characteristics of Ecolint. It is a park that fully represents nature.

The second one is Copernicusstraat. It is located in the centre of the neighbourhood and can provide space for people's daily social activities such as meetings.

The third one is the recreational route of Linnaeusparkweg. It connects the existing recreational route to the ring channel and Sport Park. The Linnaeusparkweg itself has unique historical characteristics and can connect waterfont, fountain, central green and Galilei Park directly. There are lots of schools here; and hence, it was built to provide safety for children's cycling. It is a route that offers comfortable and priority experience for walking and cycling.



6.4 Water system

The total water assignment is 12800m3 and the designed rainproof system can only deal with 15424m3 in 60mm rain event. The result of the calculation is shown in the table. In general, there are three strategies that can be applied in the water system and they include detention, retention and transport. The detention mainly occurs on the green roof, water squares and detention Street. Galilei Park consists of constructed wetland that can retain water.

Galilei Park is the primary storage area, and Copernicusstraat is the secondary.

Name	Area (m^2)	Water storage capacity (m^3)
1 water square/garden	9380	2812.8
2 Galilei park	19400	2400
3 speed pit	3300	495
4 water road	7000	700
5 Parking/ bioretention	9600	2880
6 central green	3960	1584
7 swale	2320	696
9 corner bump-out	256	76.8
10 green roof in 60mm	63000	3780

Table of storage calculation
Total: 15424.6 m^3
The assignment is 12800m^3

Figure 52 Surface Water system on neighood level. Galilei Park as primary retention area, and Copernicusstraat is the secondary

6.5 Design On Street level

In this section, the designs of the two streets are discussed. The first street design I will discuss is Linnaeusparkweg and the second street is Copernicusstraat.

6.5.1 Linnaeusparkweg - A Water Street

Linnaeusparkweg was built in the end of 19 century. It connects Galilei Park, Copernicusstraat and outer ring Channel from south to north. The Big trees are found in the middle which made the landscape in the district of Watergraafsmeer unique. This can offer comfortable experiences for the people. Also, the buildings were older than the others in the district. Besides the general assignment, Linnaeusparkweg has special theme for creating comfortable experience for walking and cycling.

Presently, the road is shared by cars and cyclers. On visiting, I saw lots of children cycling, and this is because of the primary schools situated here. It is recommended that the cycling route should be visually distinguished so that drivers would take care to drive in this road. Besides the shared space on the street, as a result of the height difference, it is suggested that runoffs should be made visible and bioretentin parking should be created not to only only delay water but to also create awareness of the water process.

Figure 53 The location of Linnaeusparkweg

Figure 54 the old picture of Linnaeusparkweg

Figure 55 Fountain square

Figure 56 There are a lot of primary school near Linnaeusparkweg. Many children cycling here

Figure 57 The design of Linnaeusparkweg. It transforms the parking area to bioretention parking. And cycling become the priority of the shared road by changing the pavement

Water system

Water flows from the north to south and it can be detained in the bioretention park. The overflow will flow into Copernicusstraat. The technical intervention involved in the design area includes speed bump, designed gutter and bioretention parking.

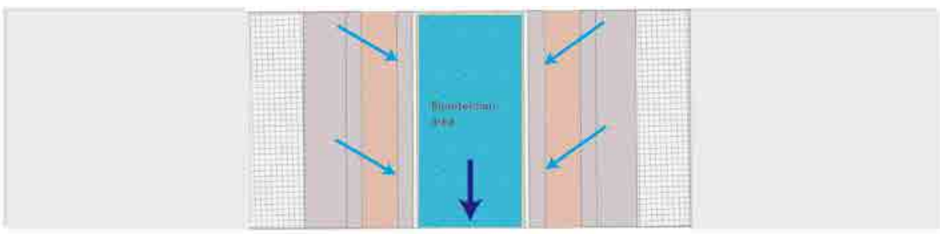


Figure 58 Water system of Linnaeusparkweg. The runoff will be gathered in bioretention parking area. The overflow will go to Copernicusstraat

Figure 59 The current situation of Linnaeusparkweg. Because of school, many children cycling here

Figure 60 The impression in dry situation

Figure 61 The impression of extreme rain situation (60mm in one hour)

Evaluation on water
*Bioretention parking: 1800m*0.3m = 540 m3*

Total:1216.7m3

6.6.2 *Copernicusstraat - Detention Street Park*

Copernicusstraat was built in the 1940s. It is located in the centre of the neighbourhood and there are two primary schools there. The special theme for this area is daily social activities.

The green area is located along the street but inaccessible through the bushes. The existing road is meant for two way drives. However, the road is blocked at both sides. This indicates that there are no big driving demands here and it is not the primary road for the district. There are two primary schools located in this area that needs to slow down driving and give priority to walking and cycling. The design proposes making the green area bigger and accessible to the people to provide spaces for daily activities in dry season. In the rainy season, the green area is always filled. And in extreme rainfall situation, the water will be accumulated on the road causing major problems for the drivers. The extra space in the green area is excluded from the reduced area between the parking space and the road. Hence, the two way driving road is designed and reconstructed to for a one way route.

Figure 62 The location of Copernicusstraat

Figure 63 Green area in Copernicusstraat

Figure 64 One school in Copernicusstraat

Figure 65 Green area in front of buildings, the green area is inaccessible for people

Figure 66 Masterplan of one unit of Copernicusstraat. Two way drive becomes one way. A dry wandering stone stream acoss the green area. Constructed rain garden box with Amsterdam School detailing become the edge

Water system

The Copernicusstraat serves as the secondary detaining area for the neighbourhood. During heavy rainfall, the green area is always filled with water. The road is relatively dry compared to the green area. In extreme rain situation, the water will accumulate on the road causing major problems for the drivers.

It connects most north-south directed water transporting roads and runoffs of the downstream empties. The overflowing water will be emptied into the Galilei Park via transporting water roads.

The technical intervention involved in the design are retention road, detention basin, bioretention, bioretention parking.

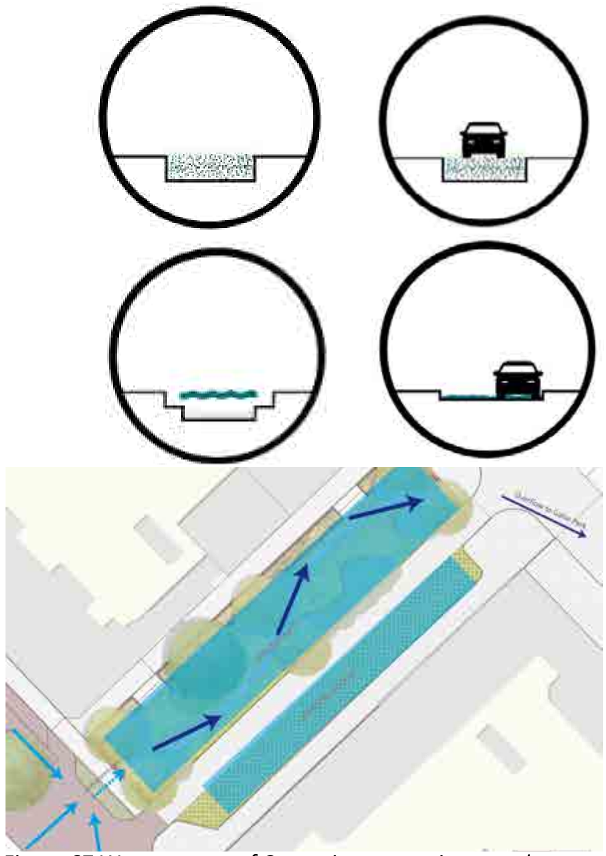


Figure 67 Water system of Copernicusstraat, in normal situation, the runoff flow stream. The overflow will go to Galilei Park

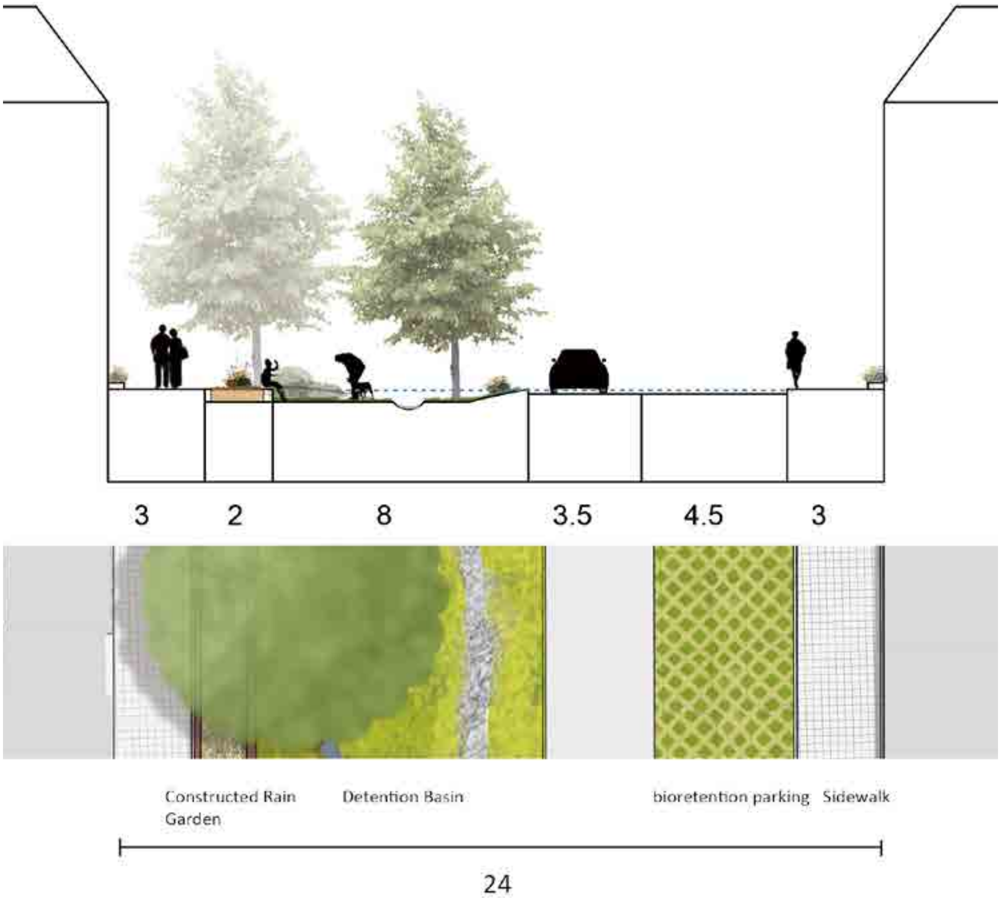


Figure 68 Cross section of Copernicusstraat

Figure 69 The current situation of Copernicusstraat, the green area is inaccessible for people

Figure 70 Design Impression of dry situation, people can enjoy the stone dry stream

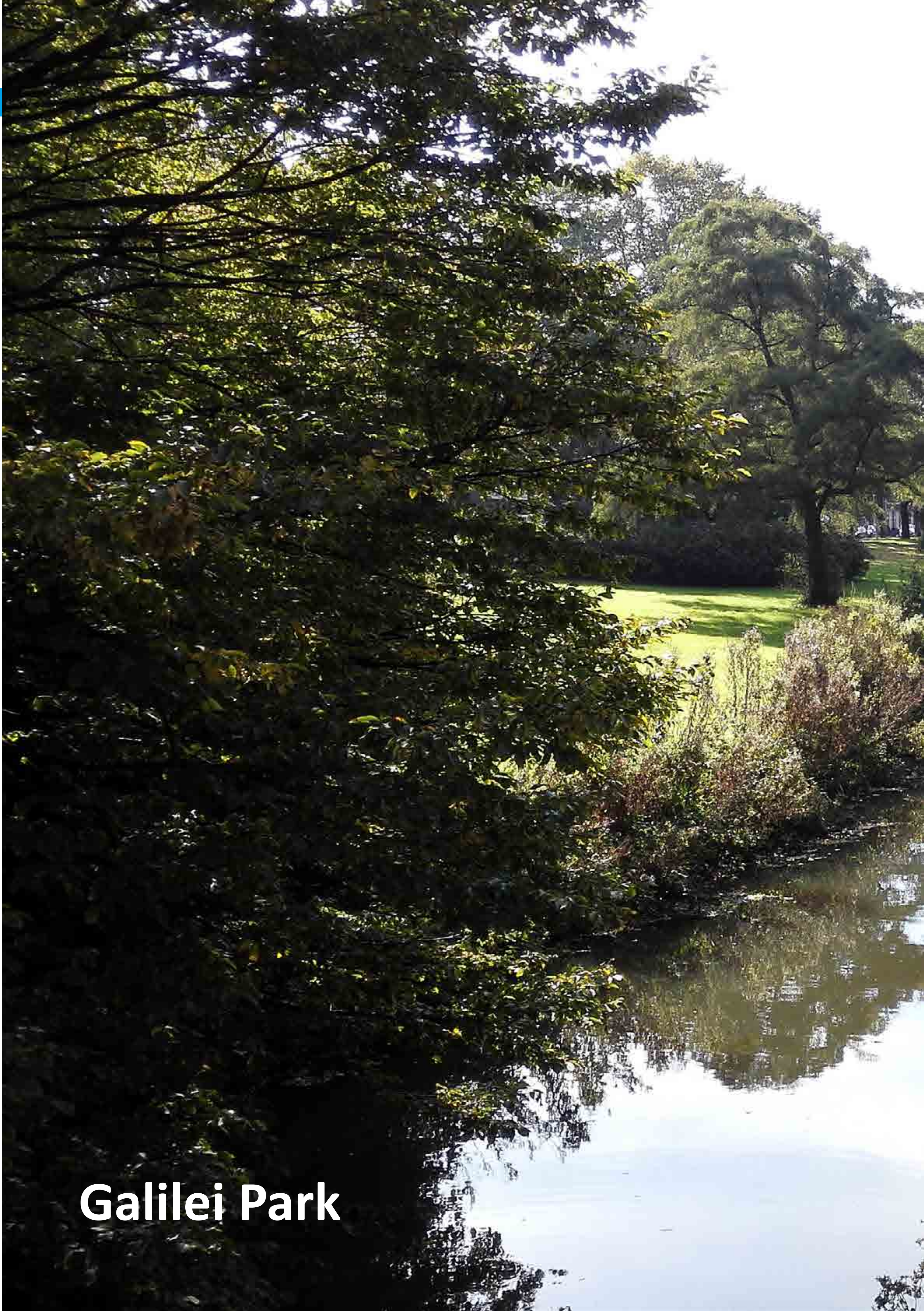
Figure 71 Design Impression of normal rain, the stone stream can direct the water flow

Evaluation on water assignment of Copernicusstraat

Detention street: 1277*0.1 = 127.7m3
Detention green area: 2050*0.3 = 615m3
Bioretention street corner: 500*0.3 = 150 m3
Bioretention parking: 1080*0.3 = 324m3

Total:1216.7m3

Figure 72 Design Impression of extreme rain event. The road will be temporary flooded. The walking path is kept dry



Galilei Park

6.7 Design On Parkl Level - Galilei Park, An Eco-water Park

Galilei Park is located in the southern part of the project area. It is a branch of the T-shaped layout and the internal channel is located across the park. The park was created in 1927 and it was named after Italian mathematician Galileo Galilei (Wiki, n.d.).

Problem, opportunities and objective

Galilei Park is located in the lowest region of the project area and forms a part of the Ecolit. The open lawn consists of the main parts of the park. It lacks alternative for species in terms of light, wetness and shelters. Besides, the buffer transition between trees and water is insufficient. There are no physical accesses to water for the people. However the area of Galilei Park is 2.4 hectare and the total wide of riparian is about 50m. They are sufficient as stepping stone and ecological corridor for targeted species, which I will discuss in section of riparian later.

The internal channel is across the park and it brings nutrients, water, and support water related life. Every runoff and underground streams with nutrients will end up at the Galilei Park through gravity. It provides the strategic opportunity of cleaning the water into the internal channel. Besides, the large open space provides the opportunity for water retention.

The park has a rectangular symmetric layout. The planting style is semi-natured. Big trees are plated in the corner and which strengthens the symmetry layout. The bridges that are across the park are built in Amsterdam School style.

Figure 73 The location of Galilei Park

Figure 74 The old picture of Galilei Park

Figure 75 the park lacks of alternative for species and the transition area

Figure 76 Open lawn in the park

All water from runoffs accumulates here; retention for overall in extreme event takes place, the final step before entry into the internal channel. For the cleaning assignment, the more the retention needed in the northern parts, the more the interaction with biodiversity and the relationship between internal channel for drainage and ecological connection.

Besides water assignment, the specific objectives of Galilei Park are

(1) to improve the ecological quality, strengthen the connection of Ecolint as stepping stone and ecological corridor by creating an ecological buffer area and a multi-wetland system

(2) to preserve the historical value of symmetry and functional layout while integrating the Amsterdam school elements

(3) to preserve semi-natural atmosphere in redesigning the current trees to island-pattern plants area

(4) to preserve trees especially the tall and grown ones. The neighbourhood don't want to cut trees even though tree preservation is good for keeping landscape identity

(5) daily life such as meeting, walking, jogging, fitness, rain gardening, small event and especially access to water etc.

Figure 77 The bridge

Figure 78 The big trees in the corner

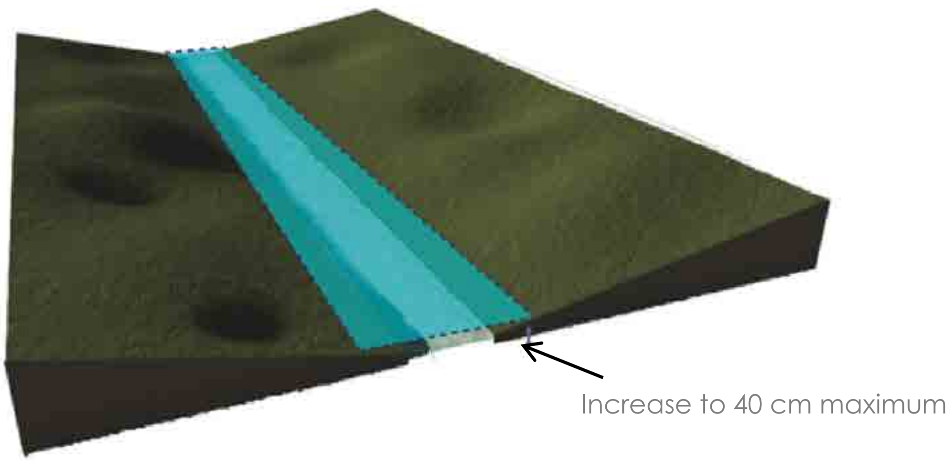
Figure 79 outlet of stormwater sewage pipe

Figure 80 lack of ecological transition area

Modelling

For the assignment, I have created three spatial models. The first model is the Natural model. It uses the curve surface and terrains to create diverse spaces that imitate the natural environment; the second model uses the terrace to hold the water in different level of height; the third model is water technical model that uses water-related technology as much as possible to imitate the Dutch water culture. Finally, they will be evaluated by the principles I mentioned earlier. I need to mention that the increase of the water level in internal channel is 40cm maximum.

There are certain points to be mentioned. (1) The curve surface and height difference provides an alternative for animals and people. It provides a relaxed atmosphere for the people. This spatial characteristic is suitable to apply to the area that needs to create bio-diversity and diverse human experience. These places are often close to the water or the area that currently has diverse plants groups. (2) The design could take the advantage of terrace structure to create vertical storage. The area that need more space for water could use this structure. (3) The third model is technical model which shows how to use technical interventions maximally and to also recall the Dutch water culture. This structure

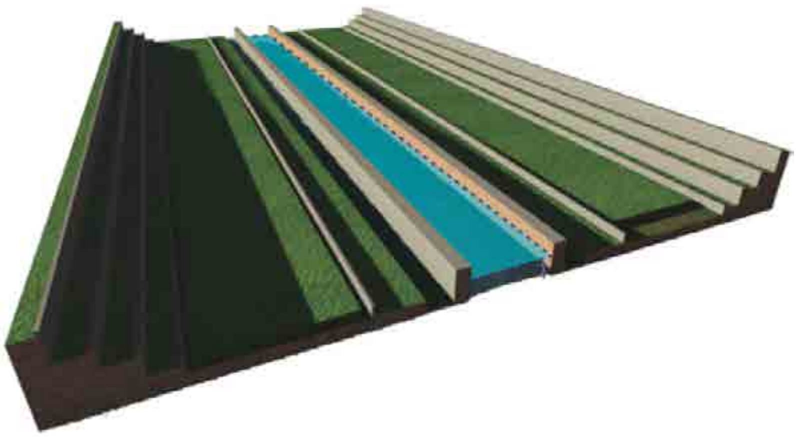


Model 2: Terrace
+ Diverse alternative spaces
+ More relax atmosphere for people
- Weakness on water retention because of limited rising level of water

NB The water level can only increase to 40 cm in maximum will be integrated in the area where water retention is needed and to also provide space for human activities.

In general, the design will take up the different advantages for the different needs of these areas. For example, the place with water challenge will apply terrace and technical model rather than a natural one. For the ecologically conserved and development areas such as the ecological friendly bank area, trees transition area and wetland area, natural models is applied to create alternatives for the species. For human exploration area with routes, natural model is also used. Because the northern part deals with the water challenge assignment, it applies terrace structure and uses technical model when needed.

Model 1: Natural model
+ Diverse alternative spaces
+ More relax atmosphere for people
- Weakness on water retention



Model 3: Water technical model
+ Effective in storing and managing water
+ Have more relax space for people
- Lack of identity
- Difficulties to access to water

Masterplan of Galilei Park

In general, the design preserves the symmetry layout. The technical components are integrated within the natural terrace structure.

The ecological connection with Ecolint is mainly strengthened by the ecologically friendly bank. There are several quiet areas which involve various groups of plants and it is exclusively meant for people. They were also groups of plants before the design was erected. There are more transition buffer between trees and water such as shrubs. In the northern part, some small islands are used to create conditions for attracting species such as birds.

There are two areas for accessing water. One is visual access, the other is physical access. The design makes the route closer to the water in some parts. A bridge is located across the internal channel which connects two places that could hinder movement of people. Then, People can enjoy the natural atmosphere and play in the park.

In the northern part, the water system use more rectangular layout in order to achieve the challenged water retention assignment. The natural-like wetland is created inside the layout. In the south part, where the retention assignment is not that heavy, there are more terrains on this side used

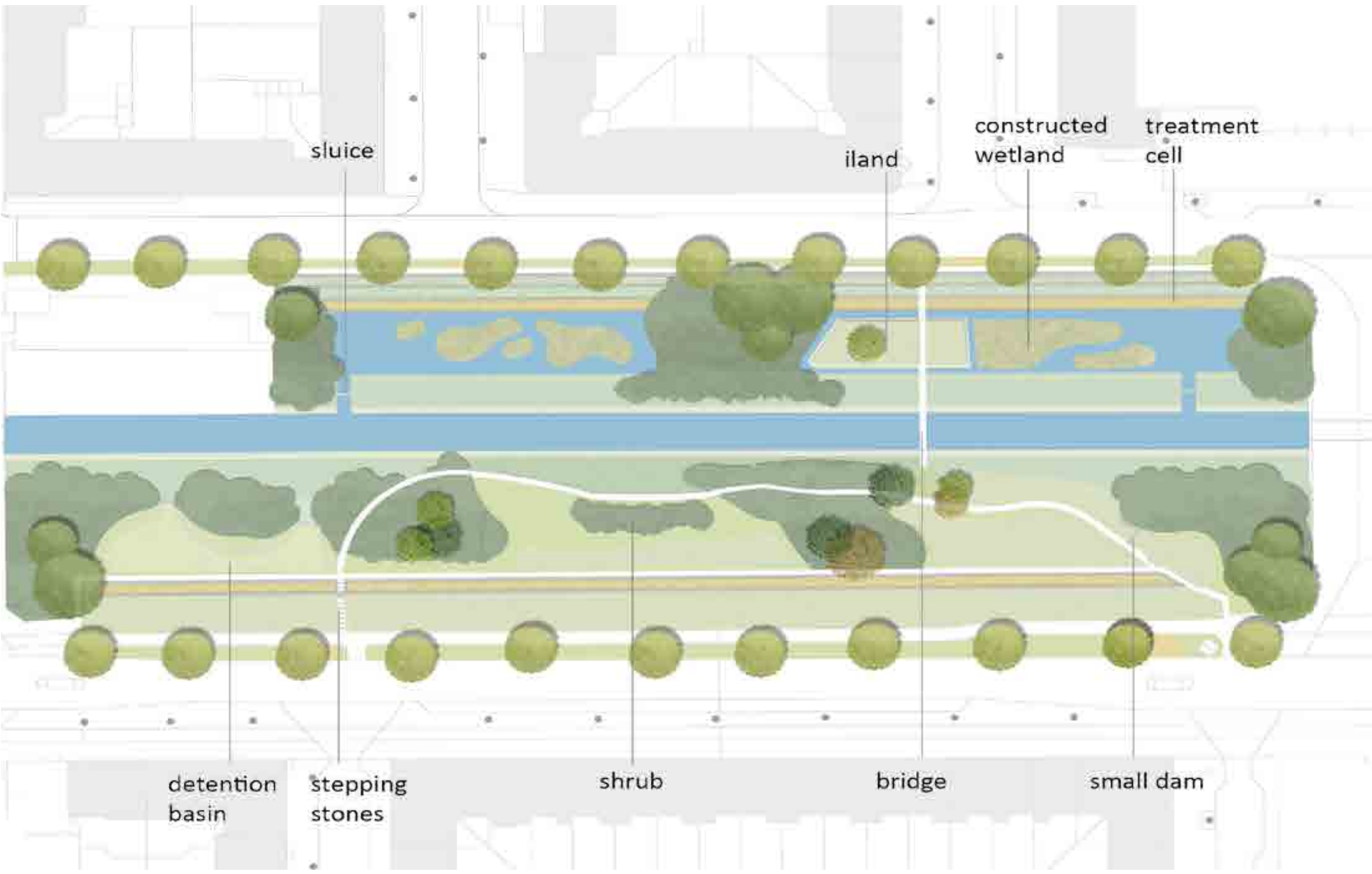
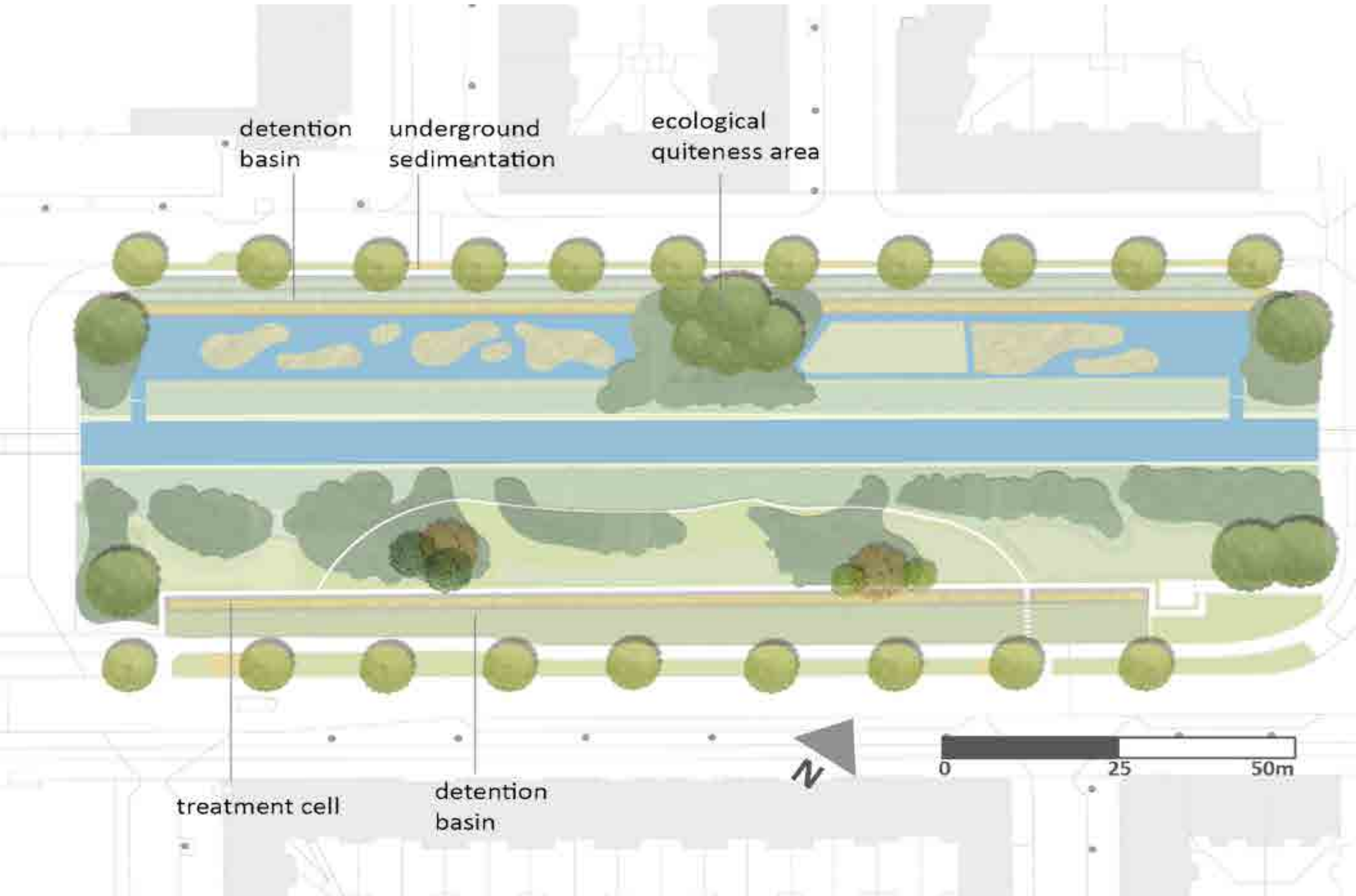


Figure 81 The masterplan of Galilei Park

to create semi-natural atmosphere. The water technical interventions of dams are integrated in this area. The water system design will be elaborated later on.
The symmetry layout is preserved in response to the layout of the context. The semi-natured atmosphere is made stronger by the presence of various islands, terrains and plants. People can have alternative views and experience in or along the park. They can look through the park by the edges or explore the natural word inside. Amsterdam school design elements are integrating the details of the constructed wetland.

Design elements
- technical components such as dam, constructed wetland, detention basin and seasonal storage ditch, pond etc.
- bridge, platform, diverse plants, variations of terrains and island than can create relax and natural friendly area



Water system

In general in terms of water storage, there are two sides in Galilei Park. The water system in northern side consists of constructed wetland and detention basin. The southern side is the only part that has detention basin. The components of Galilei Park are follows: Sedimentation basin, detention basin, constructed wetland treatment cells, constructed wetland, dam and sluice.

In the system, the contaminated water is first passed to the sedimentation basin to remove the sediments. The detention basin will temporary store water and control water flow into the treatment constructed wetland cells. In the so-called integrated vertical flow constructed wetland. The volume of flow is controlled at 0.9 m3/m2 per day. It provides ideal diverse oxygen conditions for aerobic and anaerobic bacteria (Vymazal, et al., 1998). The Nitrogen and phosphorus contamination will be heavily removed in the treatment. Consequently, the constructed wetland would obtain clean water which is essential for creating diverse ecological development. The sluice is open when the water level is stable to provide access to the aquatic species of the wetland. In the southern side of the park, there are some dams that temporarily store water on the different levels in the park.

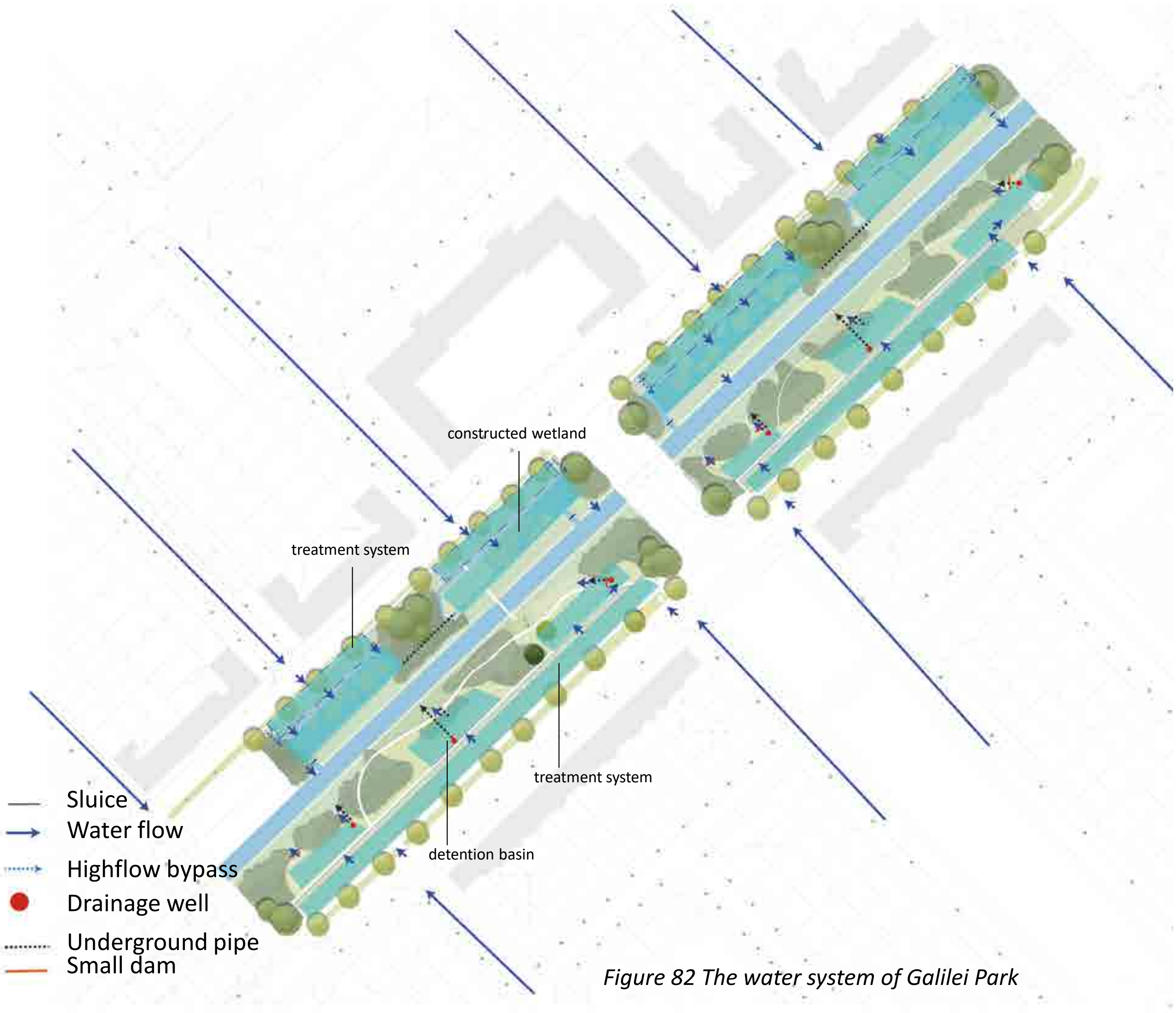


Figure 82 The water system of Galilei Park

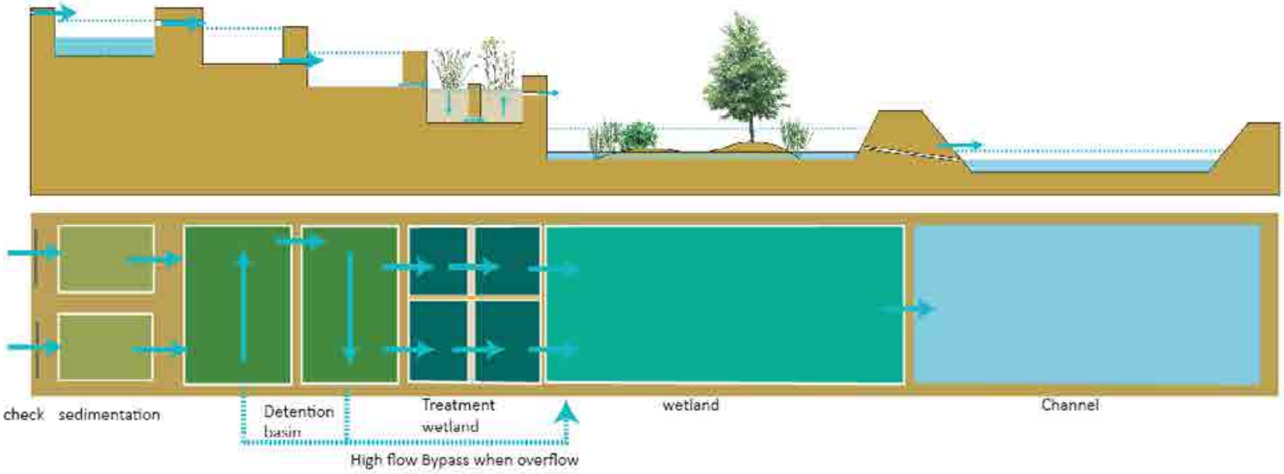


Figure 83 The schematic cross-section of water system of Galilei park

The map indicate where the components in Figure 83 are

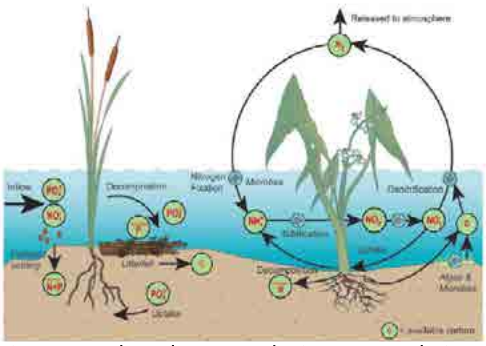


Figure 84 phosphorus and Nitrogen cycle in wetland, the aerobic and anaerobic bacteria help to remove contamination

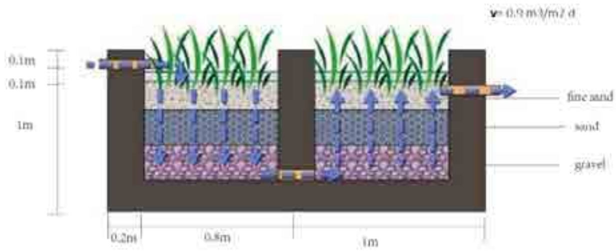


Figure 85 The integrated vertical flow constructec wetland, It provides ideal diverse oxygen conditions for aerobic and anaerobic bacteria

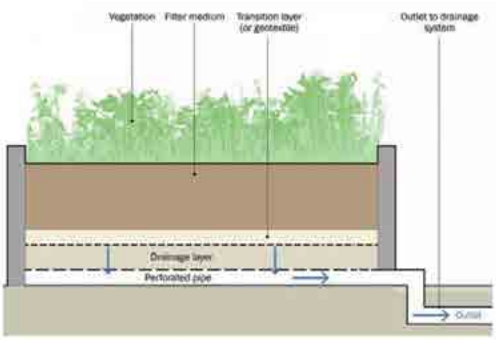


Figure 86 Typical draiange system for detention basin

Design

Biodiversity with water - riparian area

The riparian area is an ecologically friendly bank transition zone. They are applied along the internal ring channel and wetland area. The shapes of the shoreline should be diverse if possible to create alternatives for species. 6 meters is the minimum width for creating ecological bank riparian. 25 meters is the minimum width requirements for creating ecological corridor. And 2 hectares can satify the most requirements of stepping stones of targeted species. These specific requirements I have mentioned in the descriptions of figures below. The transition area provides the diverse and dynamic situations related to the different rainy seasons so that it has relatively higher biodiversity than the dry or wet area (France, 2003). Community succession will occur in the transition area that includes the indicator species. The submerged area (ASLA, 2013) blows the normal water level to 0.6 meters; the area consists of submerged plants and floating aquatic plants. The emergent area D is the shallow marsh that is found between 0.3 -0.6 meters below the water level. The emergent area C is wet meadow area that is located 0.3 meters below the water level (France, 2003). Above the water level, firstly is the wetland shrub and meadow zone. Then it is the upland zone with trees.

Figure 88 The schematic cross section of Riparain are in Galiei Park based on ASLA(2013)

Figure 89-96 The recommandation list of plants and animals. Reed Warble favors reed wetland Bank dragonfly likes ecological friendly transition area and pike like clean water with aquatic plants. For the requirements of stepping stones, bank dragonfly and grass snake require 0.5 hectares, Least Weasel need 2 hectares, and reed warbler need 2.5 hectares. The area of Galilei Park is 2 hectares. Therefore it only slightly below the requirement of reed warbler. And most of these targeted scpecies only need 15m width corrider (U.S. Environmental Protection Agency 2009; Rooij et al., 2003; Jongman and Pungetti, 2004).

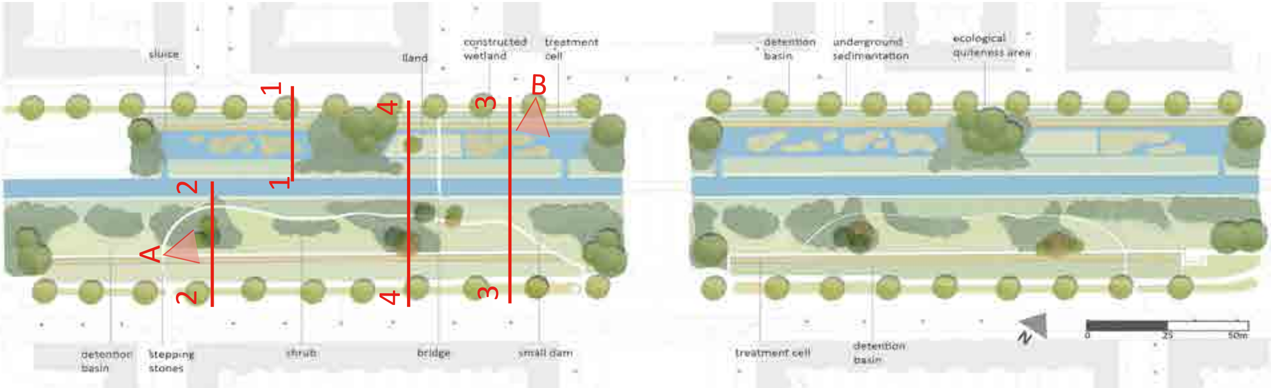


Figure 97 The selected cross-section and design impression area

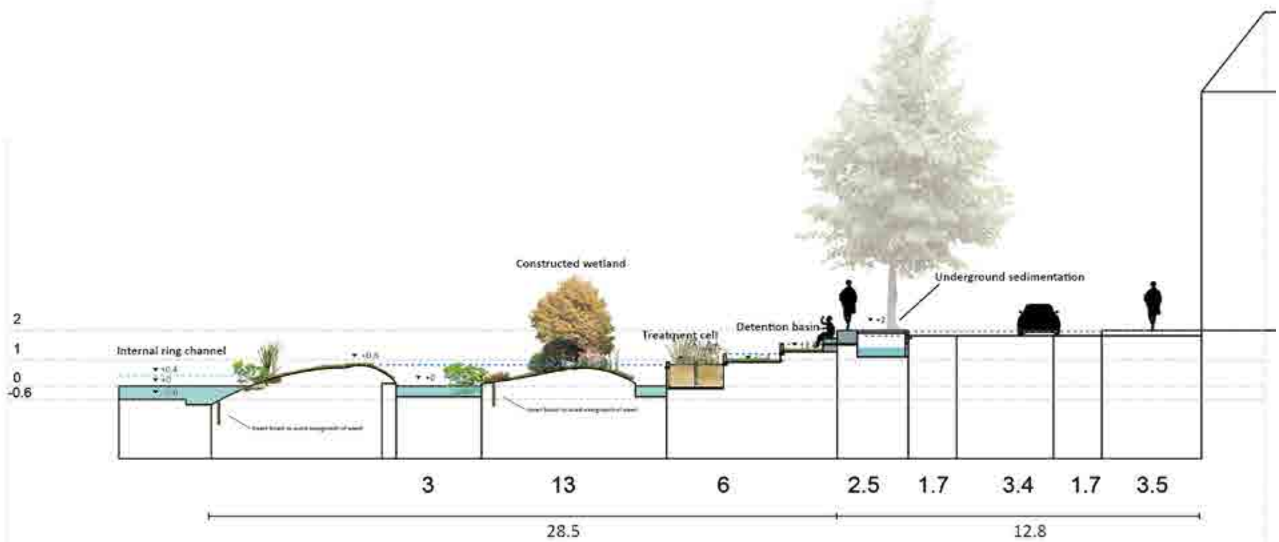


Figure 98 Cross-section 1-1

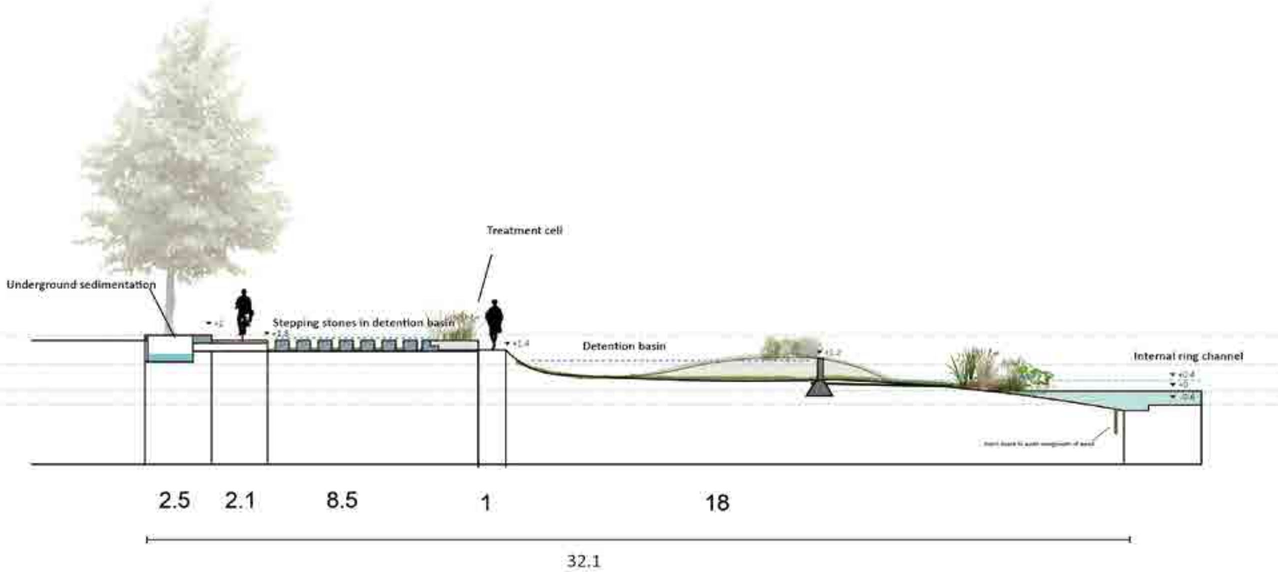


Figure 99 Cross-section 2-2 People can walk on the stepping stone to have interesting experience. a dam is created here with terrains to create integrative natural and artfical landscape.

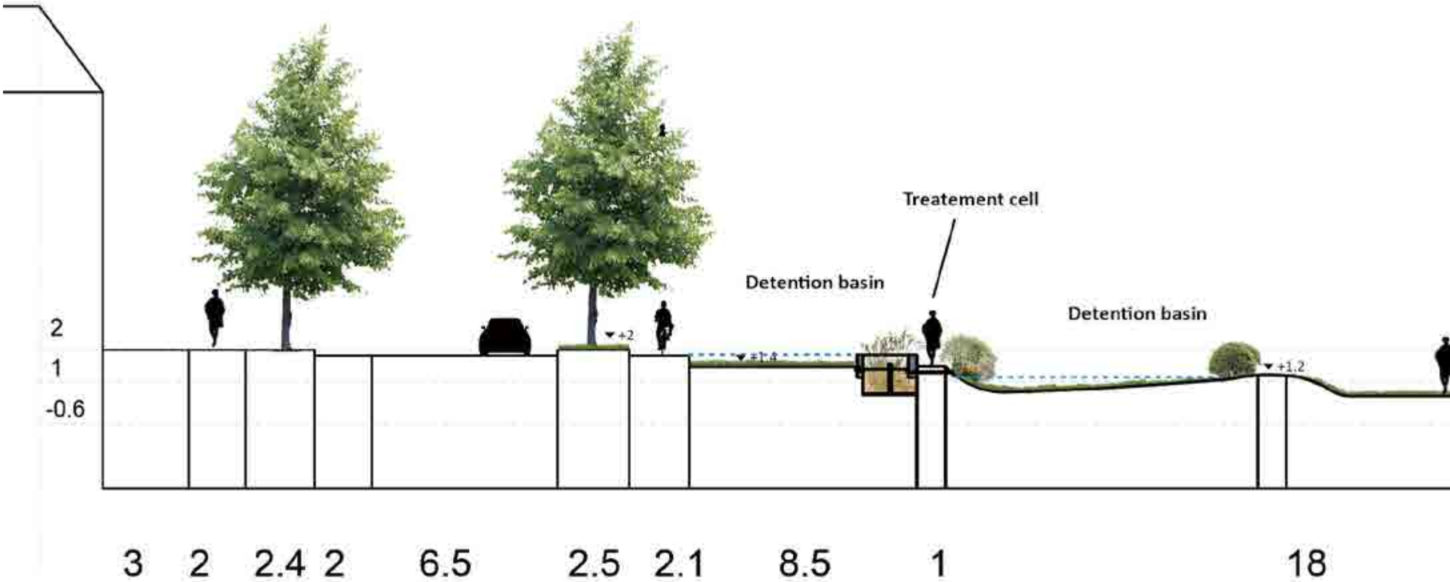


Figure 100 Cross-section 3-3 there is a bridge help people to access the water, the flat area in right side can provide space for people activity during the dry time

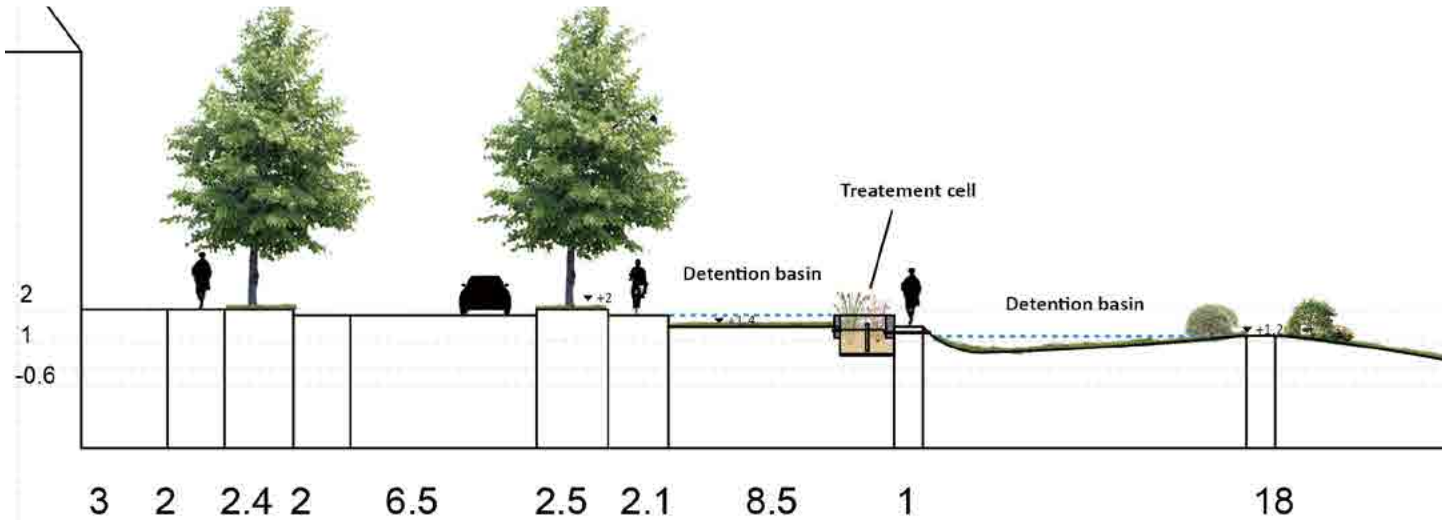
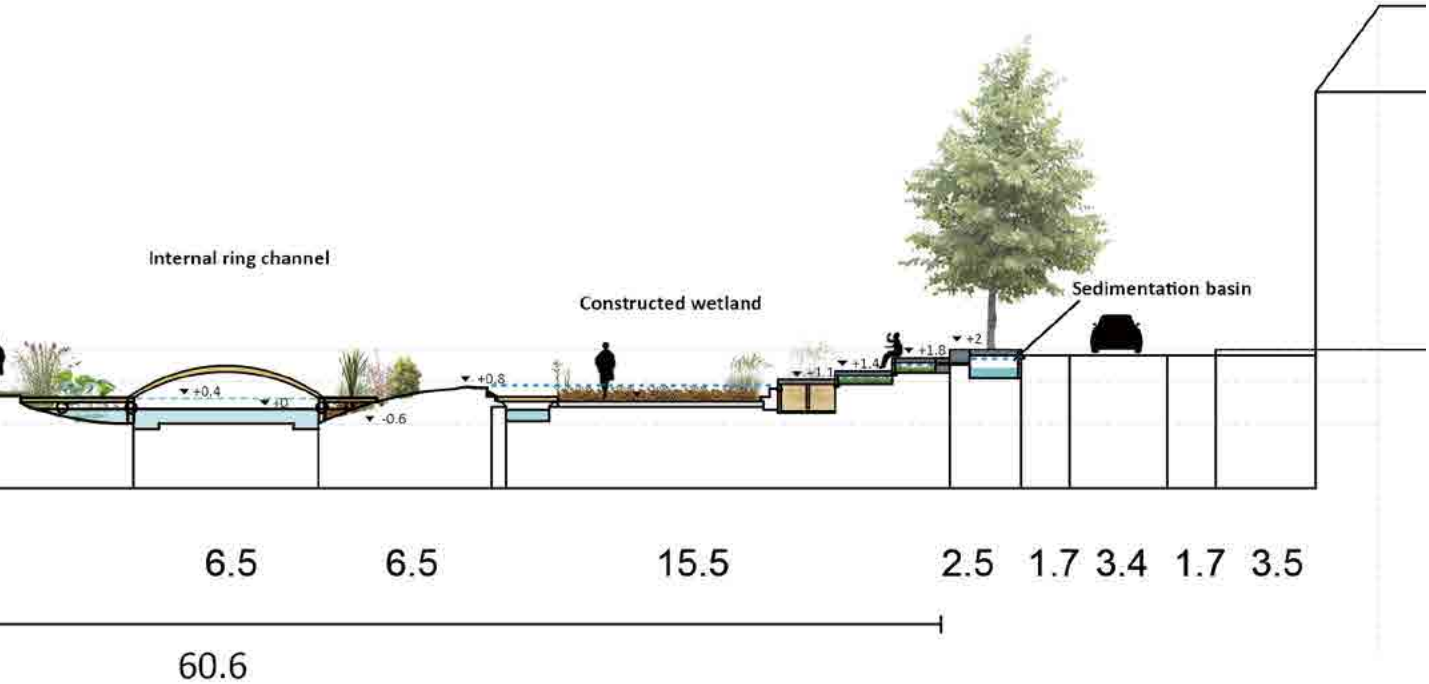


Figure 101 Cross-section 4-4, the ecological quiteness area provide ecological friendly transitions



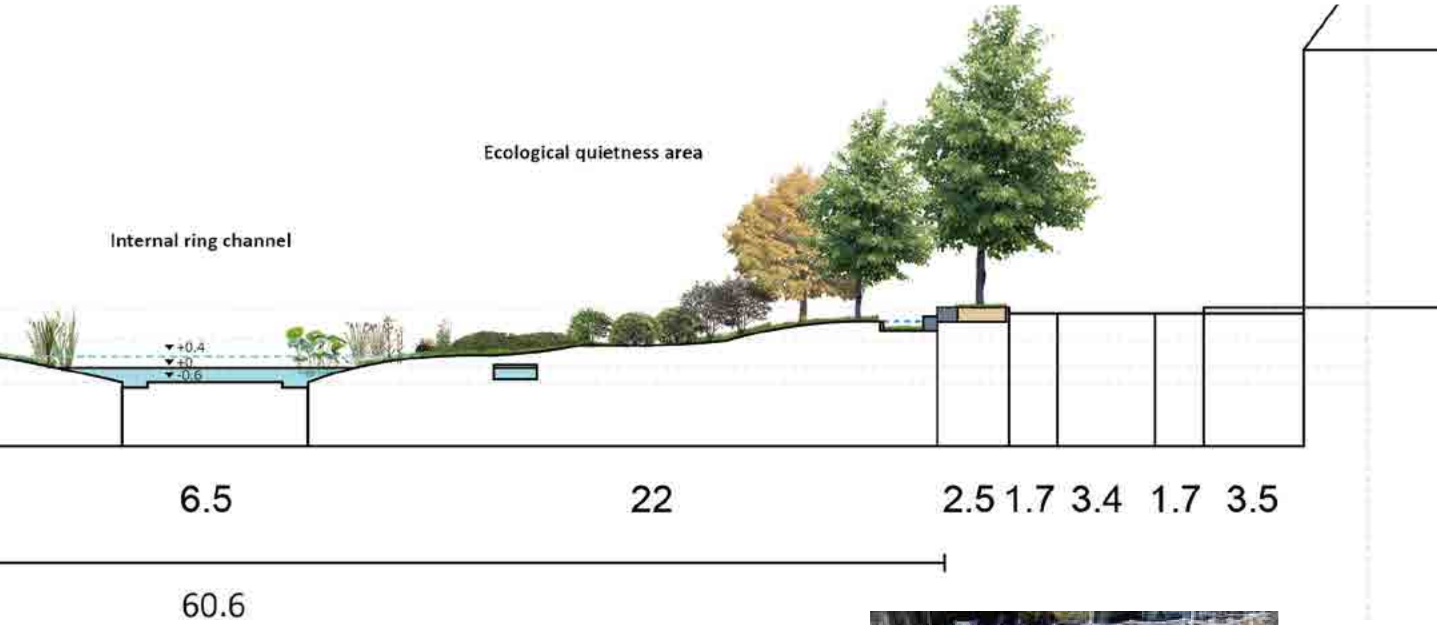


Figure 102 Reference to make the wetland cells, the bridge is in Amsterdam School. It uses red brick, detailed edge

Figure 103 Detailing of constructed wetland cells in Amsterdam School , people can sit on it

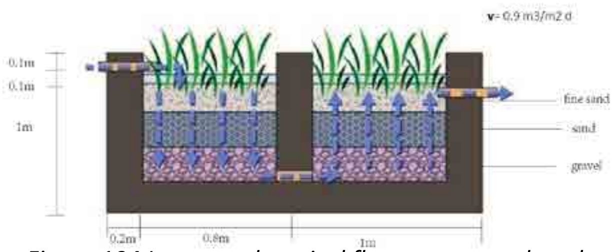


Figure 104 Integrated vertical flow constructed wetland

Figure 105 The design impression A in dry situation, people can sit on the designed constructed wetland cells, walking path is access to the water, dam and terrains help to create the integrative artificial and natural visionary

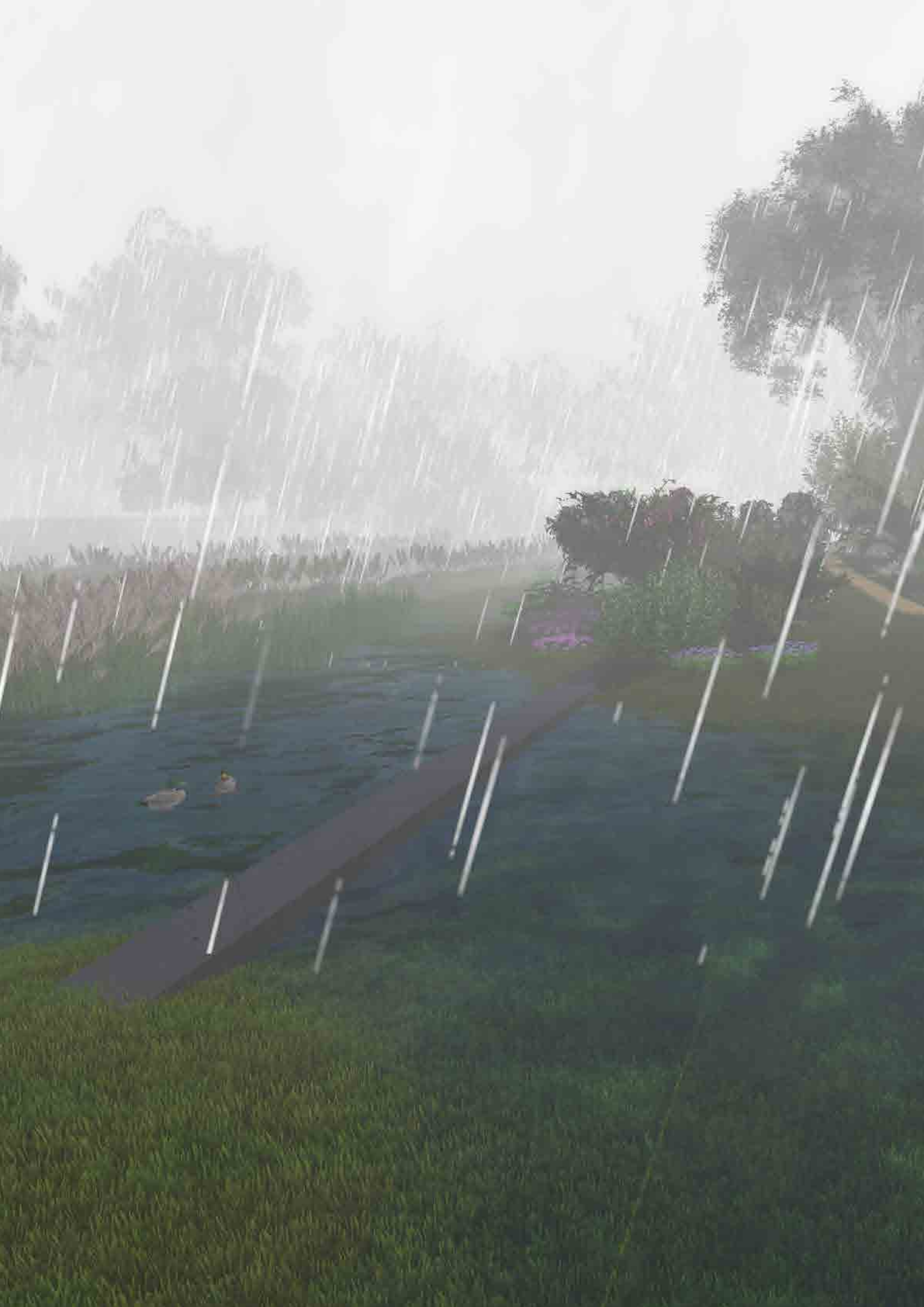


Figure 106 The design imperssion A in extreme rain situatin, the dam can block the water

Figure 107 The design impression B in dry situation, people can have activities in the flat area of the wetland area to enjoy the voice and smell of nature

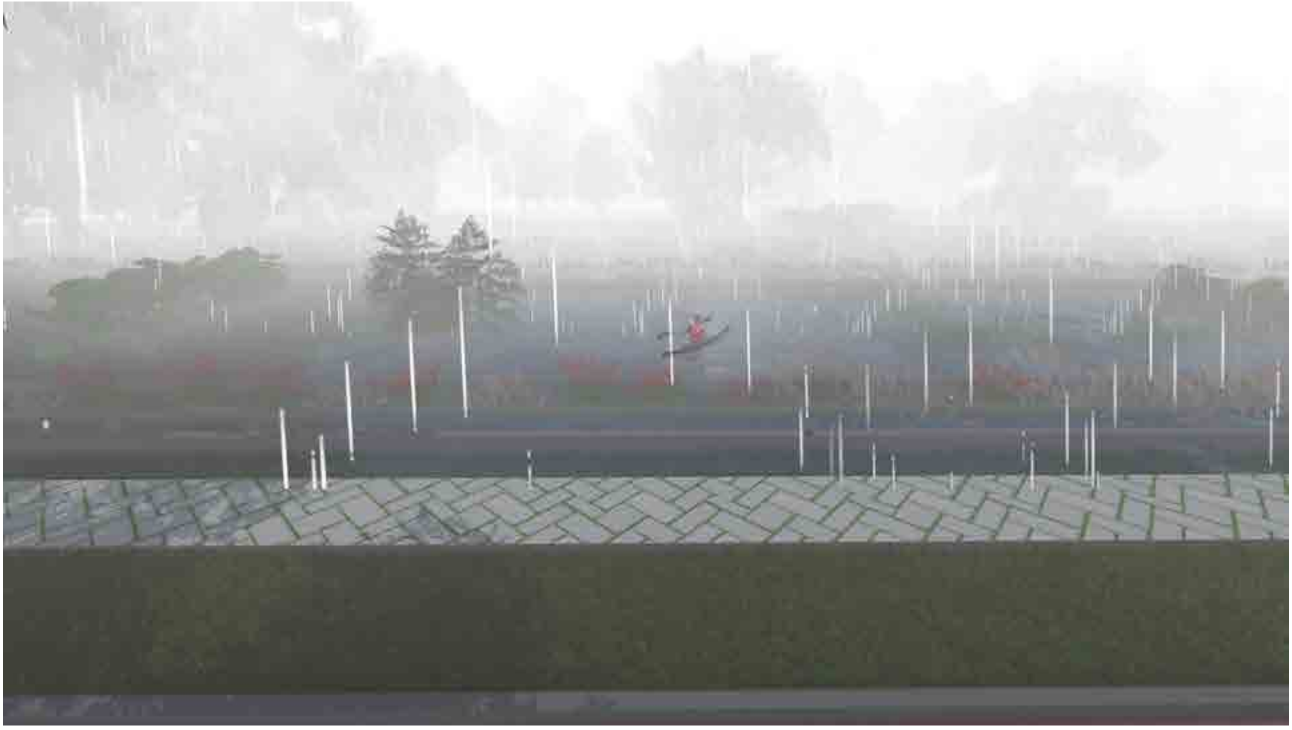


Figure 108 The design impression B in extreme rain situation

Evaluation on water assignment of Galilei

Water assignment
- Constructed wetland: 640*0.4= 256m3
- Detention basin1: 1840*0.3= 736m3
- Detention basin2 : 2080*0.4= 832 m3
- Detention basin behind dam:
1440*0.4=576m3

Total: 2400 m3

Figure 109 The current situation

Figure 110 Proposed dry situation

Chapter 7 - Conclusionand Discussion

Discussion

I spent almost one year finishing this study. The assignment of Watergraafsmeer is more complicated than what I expected previously. With the cooperation of Planning and Sustainability Department in Waternet and Amsterdam, the project is conducted based on practical demands. The design has a lot of limitations, such as high groundwater level, and emergence outlet of wastewater sewage system. Some technical interventions for infiltration listed in literature do not work here. As a student majored in landscape architecture, I am lack of relevant knowledge of water management at the beginning. In order to find out possible solutions, the study creates quantified storage scenarios based on technical toolbox. It comes to my mind that Galilei Park and Copernicusstraat can be better places to solve water issues.

In addition to the complicated water assignment, the integral part is also a challenging task to me. At first, the design shifts into decorating technical interventions, with the focus on designing technical components to improve landscape quality on a detailing scale. When I recognize this problem, I begin to conduct the design from a landscape perspective. Another issue is that the design becomes comprehensive and complex without points of focus. During the process, I am aware that water is the core media of the research, as it can connect all elements and work together to create an integral rainproof landscape system.

Although I find out the solutions for water assignment and the integral part of the system, it is still difficult for me to make the integral landscape system, especially for Galiei Park. There are only a few technical intervention measures available for making a retention park with ponds, wetland and etc. There are rare reference materials and literatures dealing with similar limitations and problems in Galiel Park. Another problem is that the water assignment is quite stable after water retention study, but the design becomes complex and dynamic. After an in-depth site analysis, I learn that I need to incorporate ecological connection, treatment of contamination and architectural element, such as Amsterdam School. The integral solution emerges when I have learned all spatial requirements and solutions, such as water quantity, water quality, ecology and human demands. Besides, I have established new interventions, like dam with terrains into the toolbox to create an integrated landscape.

Finally, the design for street, park and neighbourhood are created and evaluated. The toolbox with water integrative approach is suitable for Amsterdam Municipality to create multifunctional integral rainproof system.

In terms of design itself, it is not precise for the percentage of contamination, as this research is focused more on rainproof. To remove contamination, it needs to collect types and quantity of pollution and the size of treatment cell, which could be another research method.

Green and Blue infrastructure is generally used in terms of application. The relation between G&B Infrastructure and landscape architecture still needs to be researched. G&B Infrastructure is more like connecting green and making the green area like parks functions. The knowledge of application is selected from the domain of landscape architecture.

In current concepts of sustainable

stormwater urban design, there is a lack of integration strategy between spatial types and storm water management. It might be the reason that landscape design is site-specific, thus it is difficult to summarize types of landscape. The approach is useful in application of green engineering intervention, especially in street level. Green engineering interventions are generally used. For example, swale replaces engineering facilities, like pipes. However, when the interventions come to surface or natural environment, it is not 'engineering' anymore.

Engineering approach is man-controlled. In the past, the approach is believed to be against nature due to people's misunderstanding. Water is hidden in pipes, and the influence factor is measured by humans. Pipes are replaced by swale, which is the so-called sustainable approach. Soil, water, and species can influence each other. In Watergraafsmeer, high groundwater level results in low infiltration during storm event and some plants cannot grow here due to the pollution of seepage. Many factors need to be considered in terms of creating a real sustainable storm water management. It is only on the side of natural organisations, when we need to consider human organisations as extra, the assignment would be more complex.

When considering sustainable, the time scale is always important, the landscape system take consider the influence of long-term and short term. In this case is long-term demands of water safety, natural process, and the demand of leisure activities with water. The design tries to incorbrate these long-term demands into the robust landscape framework that can support a beautiful and sustainable future.

For landscape architecture, as a systematic thinker, we have a big opportunity to make big contributions to cross-discipline projects. We are scientists and also craftsmen. Accordingly, it need to know how different layers work, what are their interrelations and translate scientific results to spatial requirements.

Landscape-based approach can provide a durable system to incorporate different dynamic process and recover the interrelation, as it is strong in time scale and interrelation. The approach is heavily based on its own way in the analysis of landscape system, which is essential in designing a sustainable integral rainproof system.

Conclusion

Research question:
What are suitable technical interventions for to address the quantified water problems in Middernmeer-Nord, Watergraafsmeer?

Design Question
How to integrate these interventions for designing an integral rainproof system for Middernmeer-Nord, Watergraafsmeer to meet the future needs?

The assignment is quite complicated. The groundwater level is very high, thus it is almost impossible for infiltration in storms. At first, I research all principles involves based on literature, all technical retaining interventions and the storapge alternative. As a result, I get the maximum amount of water for retention or detention. However, the results from water technical approach serve as scientific basis for integrative approach. In addition, understanding of landscape system provides ecological, leisure and historical sides. And this landscape system can incorporate long-term demands.Thus, the integrated robust design is generated accordingly.

After these interventions, the capacity of rainproof is much improved on the level of streets and neighbourhood. It also makes contribution ion district level. In terms of biodiversity, it is also helpful in neighbourhood and district level. For leisure, it helps in street level and neighbourhood level.

In this research, the result of research provide the spatial requirements for designing. And the design help to define the assignment and seek for alternative solutions. During the process of depth understanding all different layers, landscape architecture can integrate them together and make the creative step to design.

The relation between research and design is explicit. Based on site analysis, water technical study and integrative principle, the design of Galilei Park can provide multifunctional treatment, rainproof, ecological connection, attractive human experience and historical architectural elements. The terrace and dams can be the extension of toolbox. The dams, especially those with terrains, are suitable for creating semi-nature landscape.

The design and its approach are well developed with theory. However, it still need practice and management to see what will be happened. Especially it is a small natural area in a densely neighbourhood. It would be interesting to manage a lliving lab with local neighbourhood especially with the school. It can be managed by implementation of habitat requirements for species. The process can increase of public awareness about the nature and water in the urban area.

Suggestions for further research:
In spite of the biodiversity with water, this approach is mainly applied in Galilee Park in terms of Riparian area. It is still interesting to discuss how to make the water related biodiversity design on rainproof network, such as retention road. The special wet dynamic conditions could make an interesting landscape design.

I have done the Galilei Park in Ecolint. This approach is assumed to be adaptable in Ecolint and Watergraafsmeer. However, I do not work in Ecolint level a lot, because it is only a Master student Thesis. The study of Ecolint could be a topic for other students. It is interesting to make the systematic approach more completed in district level.

Reference

ASLA (2013). Ningbo Eco-Corridor [online Available online at http://www.asla.org/2013wards/253.html Accessed at 21.08.2016]

Armstrong, H. (1999). Design studios as research: an emerging paradigm for landscape architecture. Landscape Review, 5(2), 5-25.

Berkt and Francis, 2014 Performing Urban Landscapes. Wageningen University, The Netherlands.

Bijlsma(2013) Designing with the aesthetics of water. Wageningen University, The Netherlands.

BMPs, R. T. (2005). Stormwater Management Manual for Western Washington. Washington DC: Washington State Depart ment of Ecology, 2005: 1 13.

Boyce, C., & Neale, P. (2006). Conducting in-depth interviews: A guide for designing and conducting in-depth interviews for evaluation input (pp. 3-7). Watertown, MA: Pathfinder International.

Chui, T. F. M., Liu, X., & Zhan, W. (2016). Assessing cost-effectiveness of specific LID practice designs in response to large storm events. Journal of Hydrology, 533, 353-364.

CIRA (2007). The SUDS manual (Vol. 697). London: Ciria.

Claasen, Uittenbroek and et,al. (2013) [online [Available online at < https://www.amsterdam.nl/publish/pages/557233/planam-06-2013-www.pdf>. Accessed at 10.04.2016]

Creswell, J.W. (2014) Research design: Qualitative, Quantitative, and Mixed Methods Approaches. International student edition, Thousand Oaks, CA: SAGE.

Cresswell, J. W. (2007). Qualitative inquiry and research design: choosing among five perspectives. London: Sage. London, the Britain.

Dekker,K., Valentjn, L.,Verhelst,M. (2011). Natuurvriendelijk beheer- en onderhoudsplan sportparken stadsdeel oost [online Available online at http://www.landschapnoordholland.nl/sites/default/files/upload/natuurvriendelijk%20beheer%20en%20onderhoudsplan%20definitief%20website.pdf Accessed at 21.08.2016]

Deming, M. E., & Swaffield, S. (2011) Landscape architectural research: inquiry, strategy, design. John Wiley & Sons.

Dickhaut, W., Kronawitter, L., & Weber, B. (2011). Water sensitive urban design: principles and inspiration for sustainable stormwater management in the city of the future. Jovis.

Dijk,P.van and Veul, J.(2010) Water-ways to climate adaptation : a landscape-based design approach for sustainable urban water system. Wageningen University, The Netherlands.

Doren, D., Glucker,A. Heijman,S. Kruif,S. Luijk,R. Versteegde, L. &Visser, R. (2010). The Ecolint in the Watergraafsmeer [Available online at http://www.watergraafsmeer.org/images/sitedocuments/partners/universiteit_utrecht/case%207%20ecolint.pdf Accessed at 21.08.2016]

DRO (n.d.) [online [Available online at <www.amsterdam,nl>. Accessed at

10.04.2016]

Duchhart, I. (2007). Designing Sustainable Landscapes From Experience to Theory. A Process of Reflective Learning from Case-study Projects in Kenya, Wageningen University, Ponsen en Looyen, Wageningen, 224 pg.

Dutch Water Authorities (n.d.). Dutch Water Authorities: [online Available online at http://www.dutchwaterauthorities.com/ Accessed at 21.08.2016]

Faase, M. (2011). Ecolint WATERgraafsmeer [Available online at http://www.watergraafsmeer.org/images/sitedocuments/publicaties/studenten/msc_thesis_maartje_def.pdf Accessed at 21.08.2016]

Fletcher, T. D., Andrieu, H., & Hamel, P. (2013). Understanding, management and modelling of urban hydrology and its consequences for receiving waters: A state of the art. Advances in Water Resources, 51, 261-279.

FOSTER, J., LOWE, A. & WINKELMAN, S. (2011). The value of green infrastructure for urban climate adaptation. Center for Clean Air
Geography. 35 (5) (2011), pp. 653–669.

France, R. L. (2003). Wetland design: Principles and practices for landscape architects and land-use planners. WW Norton & Company.

Graaf, E. (2008) Water in de stelijke omgeving. Technology University Eindhoven, the Netherlands.

Handbook, C. B. R. (1997). A Guide for Establishing and Maintaining Riparian Forest Buffers".

Hanington, B., & Martin, B. (2012). Universal methods of design: 100 ways to research complex problems, develop innovative ideas, and design effective solutions. Rockport Publishers.

Hooimeijer, F., & Vrijthoff, W. T. (2008). More urban water: Design and management of Dutch water cities (Vol. 10). CRC Press.

Huang, Carol (July 25, 2012). "Beijing floods caused 'significant losses': official". Agence Presse-France. Retrieved 25 July 2012

Ibrahim, N. L. N., & Utaberta, N. (2012). Learning in Architecture Design Studio. Procedia-Social and Behavioral Sciences, 60, 30-35.

Jongman, R. H., & Pungetti, G. (2004). Ecological networks and greenways: concept, design, implementation. Cambridge University Press.

Kellagher, R., Martin, P., Jefferies, C., Bray, R., & Shaffer, P. (2007). The SUDS manual (Vol. 697). London: Ciria.

Klijn, F., de Bruin, D., de Hoog, M. C., Jansen, S., & Sijmons, D. F. (2013). Design quality of room-for-the-river measures in the Netherlands: role and assessment of the quality team (Q-team). International journal of river basin management, 11(3), 287-299.

Koh, J. (2013) On a Landscape Approach to Design: An Eco-poetic Interpretation of Landscape. Wagenin¬gen: Landscape Architecture Group of Wageningen University.

Loehrlein, M. (2013). Sustainable landscaping: principles and practices. CRC Press.

Lundy, L. and Wade, R. (2011) Integrating sciences to sustain urban ecosystem services. Progress in Physical

Lloyd, S. D., Wong, T. H., & Chesterfield, C. J. (2002). Water sensitive urban design: a stormwater management perspective.

Meijer, M., Adriaens, F., van der Linden, O., & Schik, W. (2011). A next step for sustainable urban design in the Netherlands. Cities, 28(6), 536-544.

Meyer, E. K. (2008). Sustaining beauty. The performance of appearance: A manifesto in three parts. Journal of Landscape Architecture, 3(1), 6-23.

Milburn, L. S. and Brown, R.D. (2003) 'The relationship between research and design in landscape architecture', Landscape and Urban Planning, 64(2003), pp. 47–66.

Morison, P., Brown, R., & Cocklin, C. (2010). Transitioning to a waterways city: Municipal context, capacity and commitment.
Policy, February.

Municipality of Rotterdam (2016) Waterplan 2: [online [Available online at <http://www.rotterdam.nl/Clusters/Stadsbeheer/Document%202013/Waterloket/Herijking%20Waterplan2.pdf) Accessed at 21.09.2016]

Pötz, H., & Bleuzé, P. (2012). Urban green-blue grids for sustainable and dynamic cities. Coop for Life, Delft, the Netherlands.

Rainproof Amsterdam. (n.d.) [online [Available online at <rainproof.nl>. Accessed at 10.04.2016]

Winder, R (2013). Dry Water-scapes. Wageningen University, The Netherlands.

Wu, Z., Cheng, S., He, F., Fu, G., Jin, J., & Chen, H. (2002). [Design and purification performance of vertical flow constructed wetland]. Ying yong sheng tai xue bao= The journal of applied ecology/Zhongguo sheng tai xue xue hui, Zhongguo ke xue yuan Shenyang ying yong sheng tai yan jiu suo zhu ban, 13(6), 715-718.

Rijkswaterstaat (2011) Water Management in the Netherlands: [online Available online at https://staticresources.rijkswaterstaat.nl/binaries/Water%20Management%20in%20the%20Netherlands_tcm21-37646.pdf Accessed at 21.08.2016]

Rijkswaterstaat (n.d.). Responsibility: [online Available online at http://www.rijkswaterstaat.nl/english/index.aspx Accessed at 21.08.2016]

Rooij, S., Sluis, T. and Steingrover, E (2003). Networks for LIFE Development of an ecological network for Persicetor. [Available online at http://library.wur.nl/WebQuery/wurpubs/fulltext/22450 Accessed at 21.09.2016].

Rozos, E., Makropoulos, C., Maksimović, Č. (2012) Rethinking urban areas: An example of an integrated bluegreen approach. Water Science and Technology: Water Supply. 13 (6) p.1534–1542.

Thompson, I. H. (2000). Ecology, Community and Delight: Sources of values in landscape architecture. Taylor & Francis.

Tjallingii, S. (2008). The water issues in the existing city. More urban water: design and management of dutch water cities, 240.

Tjallingii, S. (2012). Water flows and urban planning. In Sustainable Urban Environments (pp. 91-111). Springer Netherlands.

UNESCO (2006) Water, a shared responsibility. The UN world water development report 2. www. unesco.org/water/wwap

U.S Environmental Protection Agency (2009) Polymet Draft Environmental Impact Steatement: [Available online at https://yosemite.epa.gov/r5/r5ard.nsf/0/0535ab8c1e24b3a3862576900057b14a/$FILE/MesbaiNugget_Att2.pdf Accessed at 21.09.2016].

Van der Vlies, A., Stoutjesdijk, K., & Waals, H. (2006). Effects of climate change on water management in the Netherlands. Proceedings of the Water Environment Federation, 2006(5), 7213-7232.

van den Hurk, B., Tank, A. K., Lenderink, G., & van Ulden, A. (2006). KNMI Climate Change Scenarios 2006 for the Netherlands.

Van der Velde, J. R. T., & De Wit, S. I. (2015). Representing nature: Late twentieth century green infrastructures in Paris. Delft University of Technology.

Vroom, M.J. (2005), Lexicon van de tuin- en landschaparchitectuur, Uitgeverij Blauwdruk, Wageningen

Waldheim, C. (Ed.). (2006) The landscape urbanism reader. Princeton Architectural Press.

Waternet (n.d.) [online [Available online at <www.waternet.nl>. Accessed at 10.04.2016]

Waternet (2016) Municipal Sewage Plan Amsterdam: [online [Available online at <https://www.waternet.nl/siteassets/pdf/ons-water/rioolwater/gemeentelijk-rioleringsplan-amsterdam-2016-2021.pdf.) Accessed at 21.09.2016]

Winter, H (2014). Urban and ecological ambitions unified in a waterproof environment. Wageningen University, the Netherlands.

World Commission on Environment and Development. (1987). From One Earth to One World: An Overview. Oxford University Press.

Wiki. (n.d.). [Available online at https://en.wikipedia.org/wiki/July_2012_Beijing_flood. Accessed at 10.04.2016]

Wiki. (n.d.). [Available online at https://nl.wikipedia.org/wiki/Galile%C3%AFplantsoen#cite_ref-1 Accessed at 10.04.2016]

Wenger, S. J., & Fowler, L. (2000). Protecting stream and river corridors. Creating Effective Local Riparian Buffer Ordinances. Carl Vinson Institute of Government, The University of Georgia, Athens.

Woods-Ballard, B., Kellagher, R., Martin, P., Jefferies, C., Bray, R., & Shaffer, P. (2007). The SUDS manual (Vol. 697). London: Ciria.

Woods-Ballard, B., Wilson,S., Udale-Clark, H., IIlman, S., Scott, T., Ashley, R., & Kellager, R. (2015). The SUDS manual . London: Ciria.

Yang, X (2015). Enquiry into the Application of Wageningen Landscape Analysis. Wageningen University, The Netherlands.

Ya-Ping Chang, Yinan Ji. (2010) Urban Green-Waterscape on street level. Wageningen University, The Netherlands.

Yin, R. K. (2009). Case study research: Design and methods 4th ed. In United States: Library of Congress Cataloguing-in-Publication Data.

Zavrl, M.S., Zeren, M.T. (2010) Sustainability of Urban Infrastructures. Sustainability, 2, 2950–2964.

Reference of Figures

Below are the reference of figures. Figures are not here are my personal

Figure 1: https://liliendahl.com/2011/07/11/when-a-cloudburst-hit/

Figure 2: https://www.rainproof.nl/nieuws/wolkbreuk-boven-amsterdam

Figure 3-5: www.blueplanet.nsw.edu.au

Figure 6: http://www.rotterdam.nl/Clusters/Stadsbeheer/Document%202013/Waterloket/Herijking%20Waterplan2.pdf

Figure 7: http://www.landezine.com/index.php/2015/05/copenhagen-strategic-flood-masterplan-by-atelier-dreiseitl/

Figure 8: http://www.landezine.com/index.php/2013/03/tanner-springs-park-by-atelier-dreiseitl/

Figure 9: https://www.amsterdam.nl/publish/pages/557233/planam-06-2013-www.pdf

Figure 10 : www.gelderlander.nl/thema/Location/alphen

Figure 11 : https://www.amsterdam.nl/publish/pages/504121/planam-07-2012-07web.pdf

Figure 12 : Tjallingii, S. (2012). Water flows and urban planning. In Sustainable Urban Environments (pp. 91-111). Springer Netherlands.

Figure 13 : Tjallingii, S. (2012). Water flows and urban planning. In Sustainable Urban Environments (pp. 91-111). Springer Netherlands.

Figure 14 : Van der Vlies, A., Stoutjesdijk, K., & Waals, H. (2006). Effects of climate change on water management in the Netherlands. Proceedings of the Water Environment Federation, 2006(5), 7213-7232.

Figure 17: ex25.hyperbody.nl

Figure 18: http://www.urbanisten.nl/wp/wp-content/uploads/UB_RAS_EN_lr.pdf

Figure 19: http://home.online.nl/sic/maps/kaart1575.html

Figure 20: http://beeldbank.amsterdam.nl/beeldbank/indeling/detail/start/164?q_searchfield=Watergraafsmeer&q_sk_datering_van=1000-1950

Figure 21: http://beeldbank.amsterdam.nl/beeldbank/indeling/detail/start/33?q_searchfield=Watergraafsmeer&q_sk_datering_van=1000-1950

Figure 22: http://beeldbank.amsterdam.nl/beeldbank/indeling/detail/start/104?q_searchfield=Watergraafsmeer&q_sk_datering_van=1000-1980

Figure 33-37: http://www.landschapnoordholland.nl/sites/default/files/upload/natuurvriendelijk%20

beheer%20en%20onderhoudsplan%20
definitief%20website.pdf

Figure 54: https://nl.pinterest.com/pin/366199013432549979/

Figure 74: www.inoudeansichten.nl

Figure 84: http://westwoodps.com/about-us/media/topics/saga-wetland-underappreciated-and-misunderstood

Figure 85: Wu, Z., Cheng, S., He, F., Fu, G., Jin, J., & Chen, H. (2002). [Design and purification performance of vertical flow constructed wetland]. Ying yong sheng tai xue bao= The journal of applied ecology/ Zhongguo sheng tai xue xue hui, Zhongguo ke xue yuan Shenyang ying yong sheng tai yan jiu suo zhu ban, 13(6), 715-718.

Figure 86: Woods-Ballard, B., Wilson,S., Udale-Clark, H., IIlman, S., Scott, T., Ashley, R., & Kellager, R. (2015). The SUDS manual . London: Ciria.

Figure 88: http://www.asla.org/2013wards/253.html

Figure 89-92: Wikipedia.org

Figure 93-96: http://www.landschapnoordholland.nl/sites/default/files/upload/natuurvriendelijk%20beheer%20en%20onderhoudsplan%20definitief%20website.pdf

Figure 104: Wu, Z., Cheng, S., He, F., Fu, G., Jin, J., & Chen, H. (2002). [Design and purification performance of vertical flow constructed wetland]. Ying yong sheng tai xue bao= The journal of applied ecology/ Zhongguo sheng tai xue xue hui, Zhongguo ke xue yuan Shenyang ying yong sheng tai yan jiu suo zhu ban, 13(6), 715-718.

Figure 111 : https://www.waternet.nl/media/164375/amsterdam%20waterbestendig.pdf

Figure of Olympic size swimming pool: https://www.theodysseyonline.com/15-thoughts-every-swimmer-has-during-practice

Appendix - A: Precedent Study

The precedent study is largely based on the source of landscape practice website of Landezine, dreiseitl, de urbanisten and the work of Hoyer et al.(2011)

And for the case of Benthemplein, Bellamyplein, Roombeek. I have done the site visit.

1. Benthemplein
Location: Rotterdam, NL
Type of project: water square / storm water detention
Constructed time: 2014
Context: Urban/ campus
Size of area:
Other functions: playground

Sustainability
Built in 2012, the water square is located in Rotterdam. By combining water storage and good quality urban public space, it can retain the water during peak rainfall to prevent floods in highly urbanised area. However, it is difficult to learn what extent rain event it can adapt to.

Water management
The water infrastructure is visible in this case. Water is collected from roofs or surrounding areas before being transported to the basin via visible large steel gutters. There are three basins in the area, and two are undeep basins, which can hold temporary rains. The deep basin will collect water when it rains consistently. After the rain, the water in undeep basins will flow into an underground infiltration device, so that underground water could be recharged. The water in the deep basin will be transported into canal. During dry time, the two undeep basins can be the places for wheel and dancing.

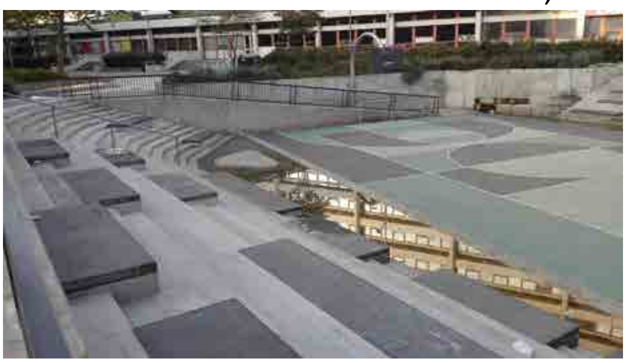


Figure: Benthemplein after rain, a playground for dry situation. Source: author

Functionality
The deep basin is the sports basin where people can play football, volleyball and basketball. In addition, there are also several planting places where people can relax themselves.
The water is dirty after rain, thus making some parts unpopular for users. The design tries to preserve the existing trees. The green is mainly focused on leisure functions, such as ornament and rest for people, which can be improved in terms of ecosystem service, such as water cleaning.

Aesthetics
In terms of aesthetics, there is water wall to show the water fall. The surface of basin expected covered of water during the rain time is painted by blue. The infrastructures for water flow and water storage can be distinguished by material, shape and colour. A small water fountain sculpture is established near the church to present the meaning of water square. There are some ornamental plants.

Figure: Detailing the designed gutter. Source: author

Lessons learned
The technical intervention of detention basin can be resilient in different weathers. In dry situation, it can be a playground, while in rain event, it can store water. It shows an example that delays the runoff for the peak time. The water management is integrated with detailing elements, such as the transport of metal gutter.

2 Bellamyplein
Location: Rotterdam, NL
Type of project: water square/ detention
Constructed time: 2012
Context: Urban/ residential area
Size of area: 0.55ha
Other functions: playground, urban farming

Sustainability
The place can detain water during rain events. There are many green areas in the site. However, they are not integrated with the water system.

Water management
The storm water is collected from surroundings. There are several levels of surface on the water square, with 750 m3 of water. The water pipelines frame the ring of the square. Water can enter low basin with hard surface.

Functionality
There is a sport field, leisure area and urban farm near the water basin. The water basin has some benches and stepping stones.

Figure: Bellamyplein in dry situation, there are a lot of residuce on the pavement. Source: author

However, people like to have activities in recreational areas or grass fields rather than in the basin, as there is much garbage and bad smell. The maintenance is bad. Many grasses are on the plaza.

Aesthetics
It is a simple design. There are some stepping stones which are used to stimulate people with interactions of water. The pavement of the water basin makes many remain left on the surface. Some details of the water square imply the direction of water flows.

Lessons learned
Similar to Benthemplein, The technical interventions of detention basin are resilient in different weathers. It shows an example that delays the runoff for the peak time. However, there are many residues on the pavement, due to the bad maintenance of the plaza. The pavement should be smooth for easy cleaning.

3 Tanner Spring Park
Location: Portland, USA
Type of project: Park/ retention
Constructed time: 2010
Context: Urban/ residential area
Size of area: 0.4 ha
Other functions: recreation
Annual rainfall: 940mm

Figure: Tanner Spring Park. Source: Landezine

Sustainability

A previously industrial area has been transformed into a green area with sustainable storm water management and natural wetland. The place can collect storm water, which is then cleaned by the biotope. The material of artwork is reused from the site. The wetland habitat is restored. The new marsh, pond, and meadowland are combined to form a diverse habitat for original inhabitants of the area (animals and plants of the marshes). There are three different methods for maintenances. The lawn needs to be maintained regularly. The plants along the water need to be cleaned and trimmed, while waste in the pond sometimes needs to be removed.

Water management

Originally, the place is a wetland. The tanner creek was channelled underground, and flowed openly through this area. Water is collected to the pond from the sidewalk, as underground conditions do not allow water infiltration. During the extreme rainfall events, excess runoff overflows into the sewer system. In normal time, the water could be pumped to create the flow water of spring. Water can be absorbed by the soil and make plants flourish.

Functionality

The place provides cultural and recreational activities, as people can enjoy the view at designed seeing points. There are some crafts on the art wall which presents some nature images.

Aesthetics

The bridge is close to the water in diverse directions. People can experience the scenery by walking on the bridge. The water in pond and stream are both visually and physically accessible for people. The pond is border by a 60-metre-long artwork, the art wall, which is made by the rails. There is the contrast between the static strength of the rail tracks and the lithe and flowing movement of the wall. There are some images on the rail tracks. The seating steps can be the formal frame to the wetland park, where glass, concrete, and metal are designed to fit into surrounding context of modern mixed use buildings. The design integrates the modern and natural design elements.

Lessons learned

It shows how to incorporate biodiversity with water by transition wetland. The detailing design is from history to create identity.

4 Zollhallen plaza

Location: Freiburg, Germany
Type of project: Park/ detention, infiltration
Constructed time: 2011
Context: Urban
Size of area: 5600 m2
Other functions: meeting
Annual rainfall: 940mm

Sustainability

The historic customs hall on the plaza was restored. The plaza was built for environmental and water friendly plaza that can infiltrate water. The design reuses material from the previous site. In the

Figure: Zollhallen Plaza. Source: Landezine infiltrate zone, some plants are used to clean the water. The groundwater can be recharged by the infiltration of water.

Water management
It is a water sensitive urban design. The plaza disconnects the local sewage system, and storm water can be infiltrated into the subsoil. The plaza is divided into three zones, with the first one for regular rain, the second one for the 1/10 year rain event, and the third one for the 1/100 year flood. The water will be directed to the lower part, which is a water-permeable zone covered with plantings. In the regular rain event, the water will be guided in the infiltration zone. It is a resting place decorated with a lot of plants. In the 1/10 year event, the overflow water will flow into a cistern via a drainage gradient. The overflow will be stored in a water storage boxes under the plaza. During the 1/100 year event, water will be controlled in the safety zone by height difference.

Functionality
It can be a meeting place and provide space for cultural event.

Aesthetics
There are many detailing designs showing historical characteristics, such as the slab made by old rail tracks. The perennials and ornamental grasses
Lessons learned
The technical intervention of detention basin can be resilient in different weathers. It shows an example of underground storage and discharge.

5 Potsdamer Platz
Location: Berlin, German
Type of project: Water square/ water retention
Constructed time: 1998
Context: Urban/ commercial area
Size of area: 1.3 ha
Other functions: recreation
Annual rainfall: 556mm

Sustainability
The plaza can collect and clean the storm water. Rain water can be reused for toilets and plants. The cleaning biotope is helophytes, and ecological treatment.
10-year rainfall event

Water management
The water collected on roof will flow into the cisterns, and some water will be pumped to the biotope to clean. The water on the surface will flow into the centre of the plaza and return to the cisterns. The cistern and pond will store the water during some extreme rainfall events.

High underground water level, an artificial water table, cycle via biotopes, cascades and technical filters, underground storage cisterns, lake and canals can ensure the storage of 13649 m3. The circulation patterns are affected by temperature changes, wind patterns, and water volume.

Functionality
The artificial dynamic waterflow and plants help maintain ecological balance. The recreation is made by access to water,

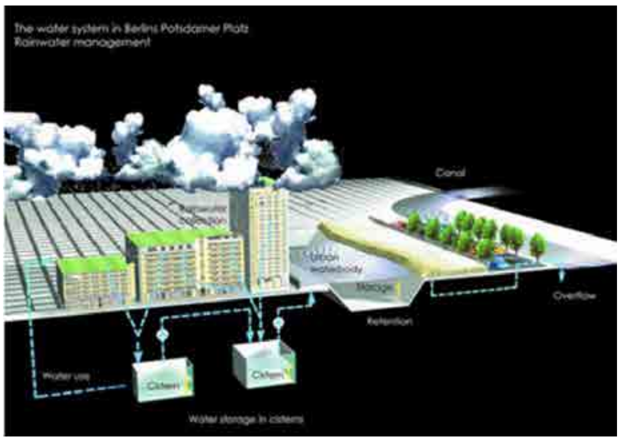


Figure: Potsdamer Platz. Source: dreiseitl and stepping stones are helpful to attract people. The construction cost is roughly 9 million euro.

Aesthetics
It uses the components of the cascades, art work, mix natural and artificial elements, gravel beach among the reeds and stony embankment.

Lessons learned
It provides a good example to create water aesthetics and cleaning water.

6 Roombeek
Location: Enschede, Netherlands
Type of project:
Constructed time: 2005
Context: Urban/ commercial area
Size of area: 70ha
Other functions:
Annual rainfall: 784

Sustainability
The ponds in Stroinksbleekpark can clear the water with the plants, as there are some ducks. The north part can store water during extreme rainfall events.

Water management
The place was a creek before the urbanisation. There is a wetland in the upstream, which is not accessible for people. After the stream flows into the

Figure: Roombeek, the stepping stone on the designed stream. Source: author

urbanized part, some parts flow into underground areas, thus it is visualised in the blue pavement. Some parts can be visualized into the green grass area in the meander patterns. The roombeek can reduce the speed of water flow, while the underground pipes are used to control the water to avoid the water nuisance. The north part can store water in terms of extreme rainfall event.

Functionality
The limited precipitation in summer leads to the problem of water quality -- the algae. It costs 1000 euro to clean the water every time. Water flow and ecosystem service can help deal with the problem.

The roombeek is situated in the commercial and cultural area. The landscape attracts many people to stay, walk and play especially children. It becomes their living environment. According to the survey (2012), many residents come here frequently. Some people come here for fishing, and running.

Aesthetics
The gutter presents historical and geographical elements. For example, the stepping stones are used to attract people. It creates wave, and water fall. People can easily access to water. The blue pavement informs the underground water flow in pipes.

Lessons learned
It shows an example with stepping stone and detailing the gutter of transporting water.

7 Rotterdam water plan2
Location: Rotterdam, Netherlands
Type of project: integrated water management and spatial planning

Design time: 2007
Context: urban
Size of area: city level
Other functions: comprehensive
Annual rainfall: 816mm

Sustainability
The plan is in inter-grade that can enhance urban quality, and provide plant bank, and green roof. Various site specific strategies are applied in the different situations to clean water by ecosystem service. This plan integrates the green area.

Water management
The Rotterdam is vulnerable in climate changes. In the future, water level will be higher, flooding occurs due to the increase if rainfall (shortage of around 600000m3 of storage, at least 80 hectares of extra lakes and canals), and people have stringent demands for quality of water. In order to realize the goals, the plan makes an analysis of flood patterns (shortage of water storage), analysis of urban structure types and category of measures for urban structure types

The plan is divided into three principle areas. The river city mainly reinforces the dyke, with the north shore of 193000 m3 water storage. The south shore integrates water system.

Besides the three principle areas, the plan distinguishes seven spatial types. Besides, it makes categories of measures for urban structure types. The distinguishing of the measurements for different spatial types is based on the goal and availability of space. The measurements include green roof, water square and water gardens. For each catchment area, it identifies where water squares should be located ideally. The general measurements are drainage units with collecting basin, retention square, border of catchment area, drainage into the river, infiltration area/park, retention pond, wet neighbourhood, and dyke.

Functionality
In the plan, the public space is used for

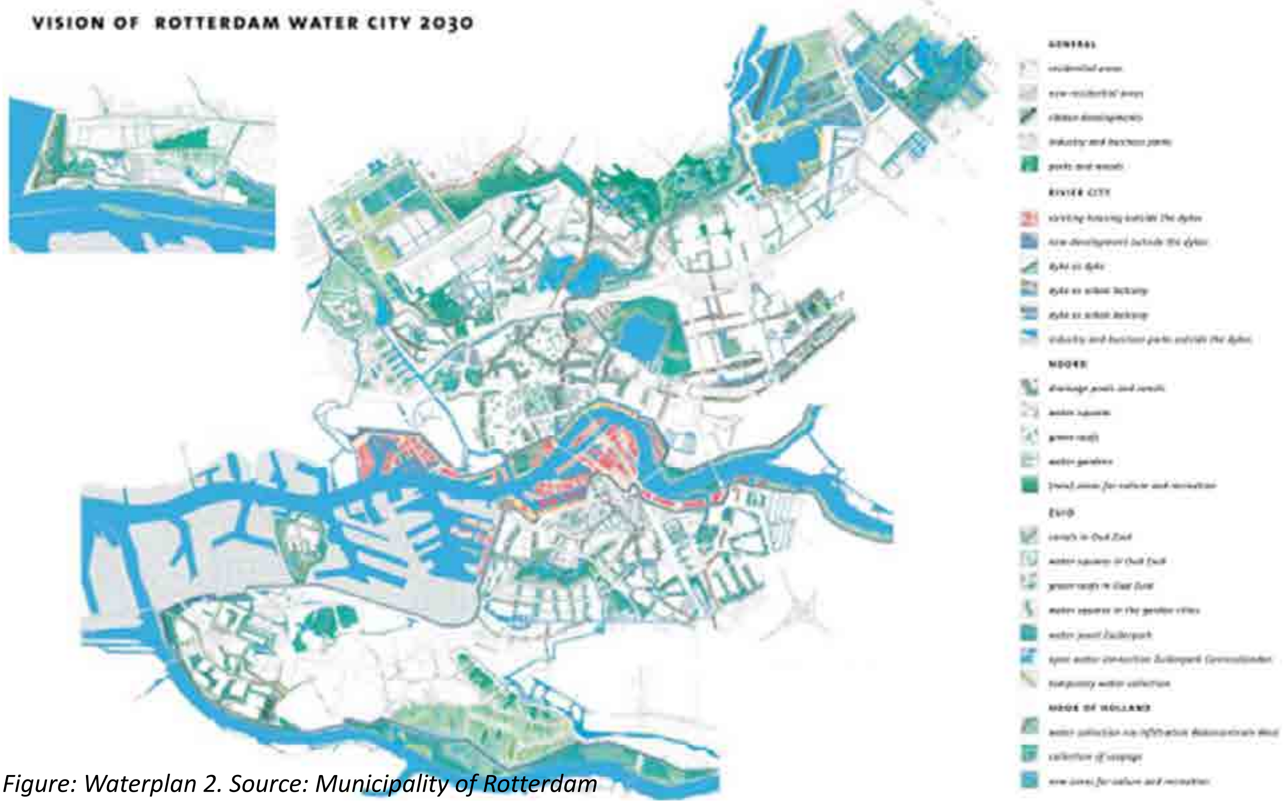


Figure: Waterplan 2. Source: Municipality of Rotterdam water storage, and they can be used for other functions during dry time. For example, the water square is a good place for recreation activities, while the water street can be used for transport in most time. In the south shore, the waterways are connected and the surface water bodies are expended to make recreational values.

Aesthetics
The plan points out that Rotterdam becomes an attractive city by urban planning. It uses different urban types to improve spatial qualities.

Lessons learned
It provides a good example using integrated approach on city scale in the Netherlands. It provides the methods to divide different water catchments and spatial types. But how to make them work together in terms of integration is still not explicit.

8 Copenhagen
Location: Copenhagen, Denmark
Type of project: flood resilient strategic urban flood plan
Design time: 2013
Context: Urban
Size of area: 34km2 district level
Other functions: comprehensive plan
Annual rainfall: 613

Sustainability
The plan takes account of the current park structure, to connect and activate existing park structure. The green street consists of the decentralised cloudburst network. The plan respects the natural topography of the city and tries to create habitat by planting native plants.

Water management
The plan creates a risk map to show the risk level in the scenario of 2112 and makes the stimulation of water accumulation to know where the vulnerable place is. The water catchments of Copenhagen is analysed to connect different scales
.
The concept of water strategic plan is cloudburst fingers based on urban structure, which is mainly not on primary traffic routes. It connects and activates existing park structures.

It takes the decentralised cloudburst storage strategy, the green streets and pocket parks are the main interventions for the strategy. The plan creates toolbox of interventions for different spatial types, such as lake, creeks, Retention Boulevard, green streets, park and plaza etc.

Functionality
The plan is comprehensive in integrating different disciplines. It considers the function of mobility for cars and addresses cycling and walking. It addressed the shared space in different levels. The road profiles are redesigned for specific uses, such as meeting places and play areas for children. What is more, the plan seriously considers its own economic value. It calculates the result of the investments of green blue city, thus saving great spending compared with conventional approaches. It can even add real estate value based on the data provided by the government, thus the city can gain a benefit of 23.8 million euros yearly.

Aesthetics
The plan creates a green and blue city, which is attractive to people. In human scale, the plants are well designed, and trees are preserved to make an island-like pattern.

Lessons learned
It provides the knowledge of water management in terms of watershed,

which is a multifunctional landscape plan with consideration of biodiversity, human comfort and water management. Besides, it shows how to make integrated design on district, street and park level. It is strong in water management and need more as to how to integrate other functions

9 Portland
Location: Portland, Oregon, USA
Type of project: Sustainable stormwater management programmes
Design time: 2008
Context: city
Size of area: 376.5 km2 city level
Other functions: comprehensive
Annual rainfall: 940mm

Sustainability
The programme takes decentralised strategies, and green is applied in streets and private areas. There are a lot of green street projects, to increase biodiversity. Government purchase nearly 45000 hectares of land to protect sensitive habitats and ensure water quality. A total of five different planting strategies are designed for residents to choose from participation and making their own identity.

Water management
The overflow takes place an average of 100 days each year. Although it does not have overall city-wide plan for decentralized storm water management, it works well in combining other types of planning.

The strategy is to apply the intervention close to the source as much as possible. It uses vegetation to slow, retain and filter stormwater, with various methods for decentralised stormwater. It identifies the areas in need of measurements, and provides financial and information support to private.

It is a valuable project showing individual site specific decentralised measure to make huge contributions on district even on urban level. The plan can avoid sewer flooding, reduce pollutants in rainwater, and protect and enhance groundwater quality.

Functionality
The plan is integrated into urban infrastructures. Residents can access all kind of places and services by walking or biking within 20 minutes. In 3 years, 32000 jobs have been created in green businesses.

Aesthetics
The city becomes more attractive with more green elements. It brings urban space closer to nature. The roof and street consists of various plants.

Lessons learned
It shows how to conduct different intervention measures and get people involved in the creation of a green and blue city.

Reference
Bijlsma(2013) Designing with the aesthetics of water. Wageningen University, The Netherlands.

Dickhaut, W., Kronawitter, L., & Weber, B. (2011). Water sensitive urban design: principles and inspiration for sustainable stormwater management in the city of the future. Jovis.

Dreiseitl (n.d.). Portfolio. [Available online at www.dreiseitl.com Accessed at 21.09.2016].

Landezine (n.d.). Projects. [Available online at < www.landezine.com/ Accessed at 21.09.2016].

Municipality of Rotterdam (2016) Waterplan 2: [Available online at http://www.rotterdam.nl/Clusters/Stadsbeheer/Document%202013/Waterloket/Herijking%20Waterplan2.pdf Accessed at 21.09.2016]

Pötz, H., & Bleuzé, P. (2012). Urban green-blue grids for sustainable and dynamic cities. Coop for Life, Delft, the Netherlands.

Winter, H (2014). Urban and ecological ambitions unified in a waterproof environment. Wageningen University, the Netherlands.

Appendix - B: Manual of Technical Intervention

	name	description	average depth (m) or volume	photo
1	Water square/garden	Landscaped depressions that are normally dry except during and immediately following storm events	0.3	 (Kellagher, et.al, 2007)
3	Speed pit	The speed pit can temporary store the water	0.15	
4	Speed bump	The speed bump can delay or direct the water	0.1	 https://www.rainproof.nl/toolbox/maatregelen/drempels-voor-watersturing
5	Temporary water storage road	Temporary store the water	0.1	 http://www.urbanisten.nl/wp/?portfolio=waterpleinen
6	Attenuation storage tank	Used to create a below-ground void space for the temporary storage of surface water before infiltration, controlled release or use	0.5	 https://www.rainproof.nl/toolbox/maatregelen/infiltratiekratten
7	gutter		0.1	 https://www.rainproof.nl/toolbox/maatregelen/open-goten
8	wales	Shallow, flat bottomed, vegetated open channels designed to convey, treat and often attenuate surface water runoff	0.3	 (Kellagher, et.al, 2007)
9	Storm water tree trench	A subsurface trench installed in the sidewalk area that includes a series of street trees along a section or the total length of the subsurface trench	0.3	 http://www.phillywatersheds.org/img/GSDM/GSDM_FINAL_20140211.pdf

10	Corner bump-out	A landscape curb extension that extends the existing curb line into the cart way	0.3	
11	Pervious pavements	Allowing rainwater to infiltrate through the surface and into the underlying structural layers		
12	Harvesting tank		0.224L per tank	
14	Green/water roof	Areas of living vegetation, installed on the top of buildings	About 0.15	

Calculation formula

*Water storage capacity = Area*average depth*porosity*

Normally a value of 30% is assumed for the porosity of most aggregates used to store water in SUDS.

Geocellular sub-base storage capacity generally > 90 porosity

Reference

Kellagher, R., Martin, P., Jefferies, C., Bray, R., & Shaffer, P. (2007). The SUDS manual (Vol. 697). London: Ciria.

Pötz, H., & Bleuzé, P. (2012). Urban green-blue grids for sustainable and dynamic cities. Coop for Life, Delft, the Netherlands.