Open to water

A search towards an integral approach to live in areas that are allowed to flood on the southern side of Dordrecht

Jelle van Gogh
December, 2017

Faculty of Architecture and the Built Environment
Delft University of Technology

AR3U100 Urban Transformations & Sustainability
Thesis

J.J. (Jelle) van Gogh
1355147
j.j.vangogh@student.tudelft.nl

Graduation Studio:
Delta Interventions

Main mentor:
Prof. dr. ir. Han Meyer (Urban Design)

Second mentor:
Dr. ir. René van der Velde (Landscape Design)

External examiner:
Dr. ir. Willemijn Wilms Floet (Architecture)
Dr. ir. Wido Quist (Architectual Engineering)
Januari, 2018

1 Intro

1.1 Introduction

With climate change and rising sea levels flood protection has become more and more relevant. With the new Deltaplan 2015 new standards have been set concerning flooding and risk management. That means the current water protection systems that we use will not suffice in the future. Large investments and plans are made to cope with these changing dynamics.

This thesis will focus on the concept of adaptive planning in different areas. These two areas both determined by uncertainty are on the one hand the threat of water and on the other hand the uncertainty in development process of cities. The research will be aimed at the island of Dordrecht.

The municipality of Dordrecht is seen as one of the leaders in research to water safety and planning related to these issues. They profile themselves with the ideal of a self-sufficient island in terms of water safety. This location gives the opportunity to integrate different issues regarding water safety, uncertainty in planning and a diverse landscape with history and character.

This research will revolve around how a landscape can be prepared for different dynamics. How to prepare an area for unknown water safety related developments and how can a landscape be prepared for unknown future use. A search will be done towards a flexible delta landscape.

1.2 Personal motivation

Since the moment of when I can recall memories I have always lived in places where I was close to water. I grew up in a place where I could just see a glimpse of the Rhine from my house. To me water has a mysterious attribute. Since I started my studies in Delft and got in touch with the more urbanism related courses this mysterious attribute of water started to intrigue me. Water always has a defining influence on its surroundings. Then i moved to The Hague, the city behind the dunes, next to the sea. The water is much further away than it was in my hometown Alphen aan den Rijn but water is still characteristic for the location, the sea in proximity in this case.

For some reason water in an environment most of the time is seen as something positive, something desirable. But it is difficult to grasp what exactly this desirability is because the experience of water comes in many different forms. Sometimes it presents an open water landscape, a subtle line through a landscape, it can be recreational or of ecological value. Sometimes the water doesn't even have to be visible to experience it.

My interest in dynamic water landscapes grew mostly during the MSc Urbanism in Delft but already started earlier there in the BSc courses. This was a project site in Delft itself where upwelling water played a major role in designing a neighborhood. If this was paired with heavy rainfall the area would slightly flood. This project in the bachelor started a fascination. Along other urban design related courses it becomes quickly clear that within the Netherlands almost all urban design tasks strongly feature water problematics in them.

In the MSc 2 project I came across a potential the room for the river project near Zwolle. Within this project I found it very difficult to design the in between zone where the transition between land and water is made. What can this area be used for? Recreational or even residential use? That is what I want to develop further on for this thesis. What are the possibilities in the transition zone between water and land for creating spatial quality and multifunctional use.

By coincidence just before I had the opportunity to start this project I had to move to the city of Dordrecht. I always liked the old inner city itself with its peculiar typology and form. This project gives me the chance to explore the rest of city I just moved to and its surroundings to see what the city is like and what the area has to offer.

"'Start with water, the rest comes later'. With this slogan is the leading function of water for the spatial quality of the area emphasized. A system approach for water is necessary to get water in balance. This approach refers to the whole river system and not only the polder. Ecological structures in the area show great resilience and diversity of ecosystems. The area can be seen as one large robust ecosystem which functions as an ecological source for the adjoining urban area(s)." (Alkema, van der Veen, 2004)

2 Framework

2.1 Problem Field

Water

The main contributer to the problematics presented in delta planning is climate change. While climate change covers multiple aspects of the changing climate this project will focus on the effects on water related issues. These issues can be broken down to three categories or sources of an increasing water threat, water at sea, rain and river discharge.

Sea

Rising sea levels are an increasing threat to the Netherlands. Measures to keep the water out of our polders therefor need to be adapted to accomodate this increasing pressure. While this problem is a worldwide problem the Netherlands has the extra disadvantage that more than half of the country is vulnerable to flooding (PBL, 2014). This is in particular the case for the island of Dordrecht as the majority of it is located at least half a meter under the sea level.

While Dordrecht is not directly located along the coastline the current of the sea can be noticed around the island. With the projections of the sea continuing to rise the threat of the sea will keep increasing as well.

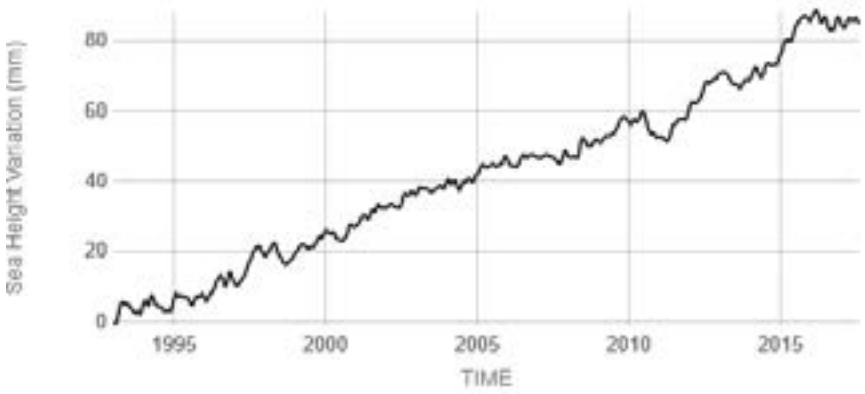


Figure 1. Rising sealevels. FROM: climate.nasa.gov

Rain

Due to climate change the weather will bring more extremes. For rainfall this means periods of drought and periods of heavy downpours. The rainfall effects river levels but can also cause flooding directly in areas where it falls. In general the drainage system of the city works well enough to deal with heavy downpours. The surrounding rivers make it easier to release excess rainwater out of the city when needed. The old city centers structure also has no need for additional rainwater mitigation measurements.

However the southern edge of the city can be partly flooded by rainwater alone. The agricultural areas do not have sufficient means to get rid of the water during heavy rain showers. The trenches cannot cope with excess water and a small film of water raises just over the land.

River

The river problematics around the island of Dordrecht are influenced by the rain as well as by the sea. The island is positioned on the end of the Rhine delta where it starts transitioning into the northsea. Over 70% of the water that flows through the Rhine is passing around Dordrecht. The amount of water is affected by rainfall, the more water has fallen in the delta area the higher the rivers flux will be. That means more rain means more pressure on the water defense systems. The opposite is true as well where periods of low rainfall cause the river levels to be critically low. The research will focus however on high water levels as drought that can

be found in the Netherlands is easier to overcome than flooding.

Rising sea levels play their part in the rivers water problematics due to Dordrechts position. Sea tide can be experienced around the island. On high tides the sea makes it more difficult for the river to release its water into the open waters outside the delta.

These three sources of water influenced by climate change pose the main problematics for safety on the island of Dordrecht. The sea, rain and the river each contribute to pressuring the dikes. In the future with the prospect of the sea levels continuing to rise and period of rainfall or drought being more extreme these problems will become more threatening by time.

Figure 2. Sources of water around Dordrecht.

Urban development

Besides the looming threat of water the city brings in its own problematics as well. The city of Dordrecht being located on an island means there is water all around the city. Water defenses are integrated within the city structure and can make upgrading or strengthening these defenses difficult. Being an island also limits the options to handle water safety and sets strong limits to the available space for the city.

Spatial urban limitations - Voorstraat

With the rising water levels around the island the water defense system is in need for upgrades to withstand the increased threats. Upgrading the water defense infrastructures typically means strengthening the surrounding dikes and make them higher. For Dordrecht this may run into some difficulties since the dikes are on some places strongly integrated within the urban structures. The most pressing location where the city is limiting the redevelopment of the water safety infrastructures is the Voorstraat in the city center. The Voorstraat has strong cultural values being the one of the main streets of the city center for centuries with housing, shops and incorporates the old squares in the center that had functions for markets and provides space for the city hall. In addition to its cultural value the Voorstraat functions as the primary dike for the northern side of the island.

Figure 3. View along the backside of the Voorstraat. BY: Karel Klinkenberg

Space for development

The city as an island has a limited amount of space as it is bound by the surrounding rivers. Over the last years the city recognized that the city is nearing its limit of citizens. There are open green spaces left in the city in the form of parks, agriculture and protected nature under the natura 2000 and EHS (national and european network of protected ecological and nature areas). City policy makers have concluded with the research on the latest city structure vision that the green that is left over within the city parameters is too valuable to give up. City expansion will mainly sought in small redevelopment projects. Two locations are appointed to actual expansion, the bovenpolder and an area along the main road that crosses Dordrecht, the N3.

Stagnating growth

Related to the limited space for development is the stagnating growth of Dordrecht's number of inhabitants. In general in the Netherlands over the past years a migration can be seen by younger generations that move from the outer areas of the Netherlands towards the Randstad. Dordrecht being located on the edge of the Randstad was an attractive city to live as it has a nice location at the edge of the Randstad. Travel times to the Randstad are low while nature for leisure is located at the edge of the city. Added to this is the nicely preserved cultural old citycenter that attracts not only tourists but houses various leasure facilities for Dordrecht. However due to the limited space for expansion and the national housing market crisis not many people made the choice to move to Dordrecht. Now the market is getting back towards normal again new projections are made. By 2030 the city would have grown by 5000 inhabitants. This is a relatively low growth and is not a certainty. The slow growth would mean a need for around 150 homes a year to be built.

Independancy

One of the unique features of the Dordrecht is the fact that the city is an island in between a landscape full of rivers. That means in contrast to the rest of the country the municipality of Dordrecht is an entity on its own in relation water safety. The city has its own Ringdike with smaller older dikes that create compartments within this ring. For comparison the entire Randstad also is protected by one main ringdike. This means that when the ringdike of Dordrecht breaks in a disaster scenario the entire island can flood. Added to this to evacuate to safety at least one river needs to be crossed to get to safer main land. The city of Dordrecht therefor thrives to be as independant as possible and mitigate different means to guarantee safety within its own borders.

2.2 Problem analysis

The problematics revolving water safety around dordrecht can divided as seen before into two main categories. On the one hand there is the threat of the water. Being situated on a location that is effected by as well the sea currents as the river runoff interventions to water safety measures are needed.

MIRT

Plans to adapt the current water defenses are being made. The suggestions made by the government in the Deltaprogramma to upgrade and heighten the entire dike ring were deemed by the municipality to not be optimal for the city. Interventions would be too expensive and cultural icons as the Voorstraat may not be able to transform to the needed safety qualifications stated in the Deltaprogramma.

As reaction to these plans the municipality of Dordrecht started up the MIRT research where within a collaboration of the government, the province, the municipality and other stakeholders try to find different ways to deal with the future flooding scenarios.

Spatial quality

Water safety and adapting the current water safety infrastructues is the main task to prepare the city for the effects of climate change. The city itself ofcourse also plays a role within this scope.

The growth of the city has stagnated over the last few years.

Some growth is still projected for the future but it is not certain to be there. Spatial quality of the city as well as nature around the entire island that is experienced should be preserved. To be a thriving attractive city cultural elements as the dikes throughout the city and the Voorstraat are important to maintain. While not growing it is still important to compete as a city with other cities in the Randstad not only for maintaining its own inhabitants but for sectors as tourism as well. The identity of Dordrecht is what makes the city unique and should be diminished by implementations of water safety measures.

Design shift

The water defense solutions that are still built upon and guarantee our safety today stem from a time where the mindset of engineering was that we as people can control the water to our own wishes. The Delta works are the greatest example of how the water can be tamed by engineering solutions. However now we realize that human interventions in the natural delta system can be a threat to the ecosystem and may not be the best solution for a sustainable water safety system (Meyer et al., 2010).

A shift can be seen from controlling to water towards Design with Nature solutions. Prime examples can be found within the Room for the River projects spread throught the entire Rhine delta in the Netherlands.

2.3 Project goal

The goal of this research will be to search for the possibilities to create a solution that can be adaptive to the different possible water problematics that may present itself in the future as well as to create a framework that is prepared to deal with the issues related to maintaining spatial quality, possible growth and where developments can be self reliant in terms of water safety.

Water safety measures should be presented along different scales. They can be applied on a larger scale to address general safety, for instance on city level. On a smaller scale, block or residence level, other strategies to address water safety can be applied.

In the final design the goal is to find a solution between the requirements that urban adaptation present and the requirements that climate change related adaptation present, and how these can be integrated. The input given from both smaller and larger scale should be combined into an integral design.

The research will search explicitly for the confrontation of possible flooding of an area and how an area that can be flooded is still able to incorporate a form of residential development. Research on this confrontation hopefully can add towards the discussion on how floodable areas or areas susceptible to being flooded in the future can still be used other than be natural or ecological preserves.

The developments around Dordrecht and the MIRT research make the island of Dordrecht an appropriate location to pursue this goal.

Proposed case

Potential locations that are in need for new plans or strategies concerning flood defense measures are abundant. As Meyer and Nijhuis state:

"The Dutch river- and delta landscapes are an important laboratory for experiments of new approaches, which try to take into account the different dynamics of the different layers." 2014

The case of Dordrecht especially where different water dynamics can be found, tidal and river dynamics, is an interesting location.

This research will be done partly in cooperation with the municipality of Dordrecht. Information brought forward by the municipality but also instances as the province and water boards will be used as context for the research.

One of the main contributors for the context is a research done on what the effects will be of compartimentation of the island. What damages will occur when a flood occurs and how much investment these compartimentation will cost. One option was presented as the most promising in the tested models. This was option IRV6. In short the compartimentation is made in such a way that when the

weakest part of the main water defense ring will collapse the water will be directed ztowards the agricultural land on the southern side of the island. This is done by strengthening an old inner dike towards the city side and perforating another one towards the open landscape. By doing this all the water that comes through the most likely breach location will flow through a fairly narrow piece of land between two dikes before flowing into the larger open fields. For this research chances of flooding will be set higher than they would be with current plans to support the idea of finding alternative forms and typologies to work with adaptive planning.

This small strip of land is also on the agenda for redevelopment. The location can offer several development options that benefit the adjacent neighborhoods and areas. Several plans had already been made by different parties varying from conventional development up to building a golf course with small residential blocks scattered through the course. However these plans have been rejected due changing demands. At this point in time the municipality does know they want to redevelop the area but does not know what kind of programme to plan here. Considering the location of the area in context to the larger water system and the uncertain demands from the municipality makes this an excellent location to test for an integration of a floodable landscape combined with residential functionality.

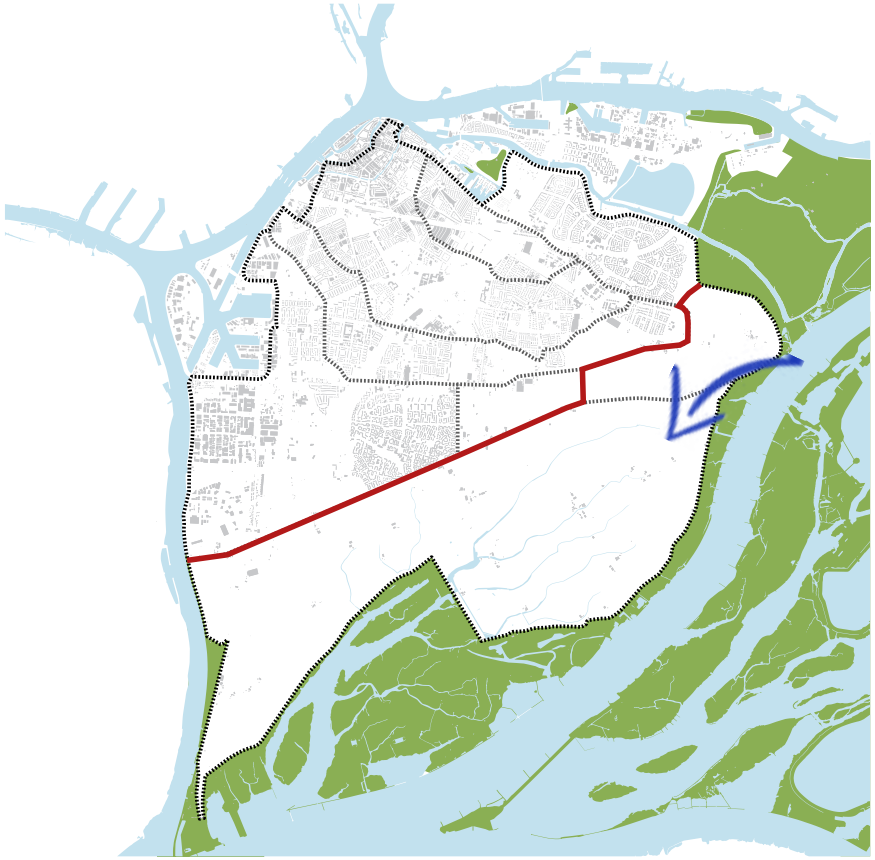


Figure 4. MIRT proposition IRV6.

2.4 Research questions

The research question is supported by several sub questions. Due to the nature of the research, the intertwining water safety and the urban form, the sub questions have been divided in different categories to maintain overview on the different types of information.

Main question:
- How can possible flooding be combined with urban expansion while maintaining spatial quality?

Historic:
- How did nature and culture form the area around the island of Dordrecht?
- How does the history of Dordrecht reflect in its current cultural identity?

Water:
- How can the southern edge improve water safety conditions for the island?

Urban spatial:
- What is the urban structure of Dordrecht?
- How can occasional flooding be accounted for in spatial design?
- What characteristics of the landscape can be found on the southern edge of the city of Dordrecht?

Key words:
- Adaptive delta design
- Self Sustainability
- Scenario building
- Dynamic water levels

2.5 Initial methodology

As a basis for the research methodology a basic four step approach will be used. Within these steps different research methods can be used to gather or find out information for the project. These four steps are the following:

1. Site analyses.

As first step the site analyses will contain a part of historic analyses and inventory of the area. Analyses methods can be used such as landscape as a 3d construction, landscape as history, landscape as scale continuum and landscape as a process (Nijhuis, 2013)
Techniques: Literature research, site visits and mapping.

2. Comparative study

After the initial research to get a better grip on the area comparative studies can be done to see what kind of spatial solution were used or designed in similar cases. Also literature to typologies can be used.
Techniques: Case studies, literature research.

3. Implementation

The third step will focus on trying to fit in the found forms and principles on the chosen location. This step is the main factor in searching for typologies and forms that could work with dynamic water around the island of Dordrecht.
Techniques: Design based research (elaborated later)

4. Reflection

When the implementation is finished the results of this step can be reflected to see if found forms and typologies work or do not work in the area of Dordrecht.
Techniques: Mapping, 3d impressions, expert consults

These steps will not be a continuous process but it will be a circular repeating process where the different steps can run parallel. When the project progresses the first steps will take a less prominent role and make place for the latter steps.

The main techniques used within the four steps will be executed as followed:

Literature research - The literature research will consist of various different media including books, articles, online publications, journals, research reports and previous student graduation work. The main search parameters being Sustainable Flood Defense, Water and urban quality and Dynamic urban water landscape.

Site visit - Because the proposed locatclose there is the luxury of venturing into the chosen project site a few times. Considering the length of the total project this opportunity should be taken advantage of. A first visit will be used for general mapping of impressions and there will be looked at the integration of current water defense structures within the chosen project site. When more questions come forward that

ask for returning to the area for more information additional visits can be planned.

Mapping - Mapping shall be used as a tool for analyses as well as structuring findings that have been done that have a spatial impact in a plan. This should help organize data and visualize ideas spatially to get a better grasp on the progress of the project and how different findings relate to each other.

Case studies - Case studies are important for this research because an inventory of both innovative and robust more traditional projects is desired to compare one's own findings and get a better indication on how to evaluate them. Within the area of case studies traditional approaches can be found in already developed projects while for innovative projects competition entries might be interesting to analyze. What also is interesting to go back to the basics how people adjusted their living environments to dynamic water levels before we had our current modern civil engineering techniques.

'Design based research' - The reintroduction of dynamic water levels have consequences for the built environment and its relation to the water. Design based research will be in the form of a variety of scenarios based on different levels of water. These designs will be explorative and search for different solutions integrating dynamic water into the urban form.

The planned methodology divides the research in two different areas. Site specific research and general research on a subject. As connector and overlapping theme the processes and developments are placed. The site specific research should give insight in the history, the form and typology of the landscape and the area. The general research will focus on what the research will try to implement in a design for the location. In this case a flexible adaptive landscape that could accommodate different water safety scenarios as well as different urban developments. This general research should result in an overview of typologies that can deal with the problematics of the adaptive landscape.

The information found in this inventory research will be used to together with different scenarios that were derived from ongoing processes in the landscape and different types of programme to add to different designs. The result of these design can give new ideas or feedback to earlier findings in the initial research.

In the end an attempt will be made to derive a landscape that could work for the different designs. Then a reflection will be given to what extent the flexible landscape actually works and if this type of landscape can bring added value to an area.

As a final product a framework will be given that could adapt to the urban spatial needs, water safety needs while maintaining spatial quality.

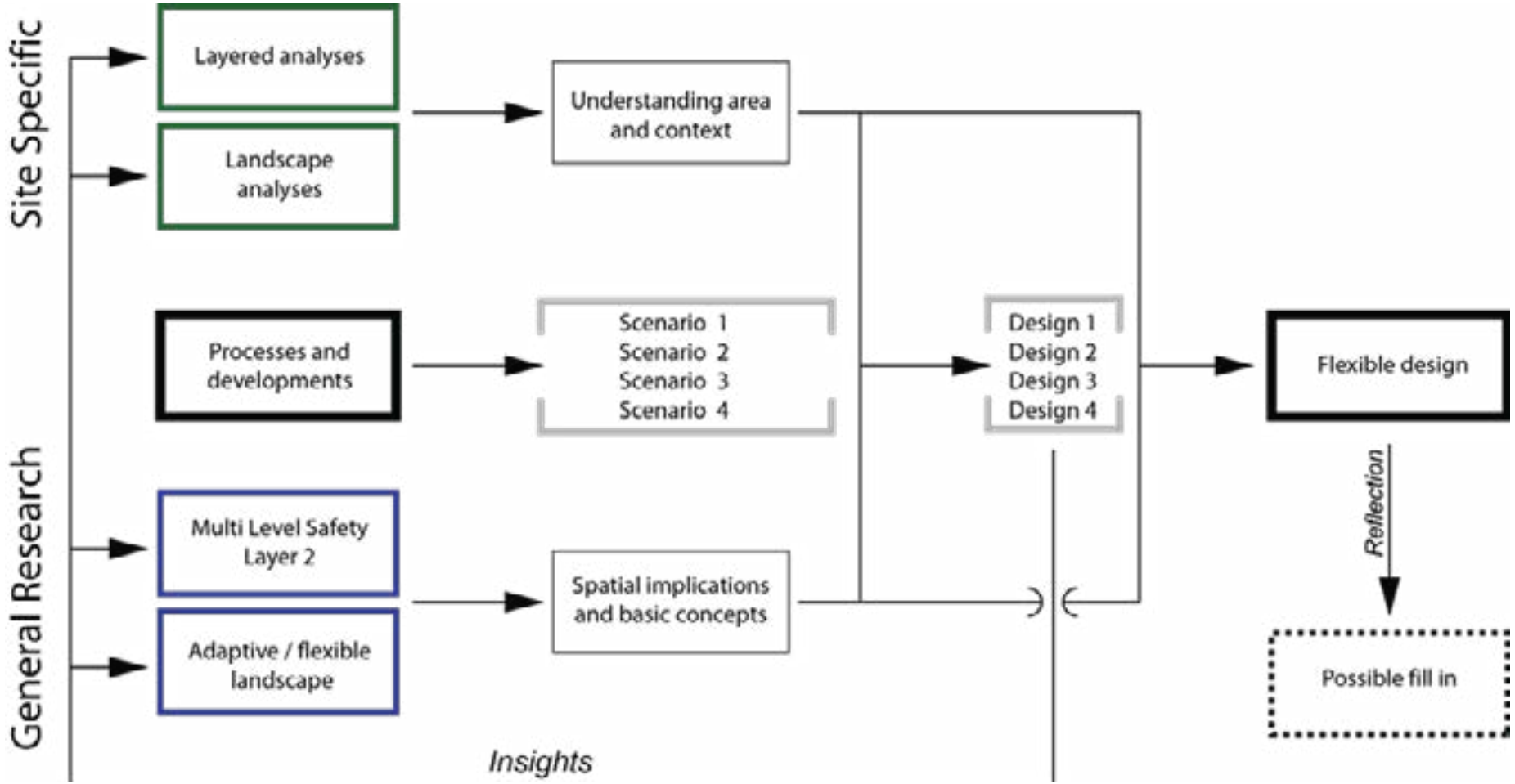


Figure 5. Initial methodology.

2.6 Theoretical framework

Throughout the research the use of scenarios to explore the location and its possible outcomes will take a central role in the process. The scenarios that will be used to create a range of possible futures are derived from the delta scenarios in the Deltaprogramma 2050 and 2100 (Deltares et al, 2013).
The scenarios are divided along two axis. These axis represent the two variable that will determine the cases in the four different scenarios. The vertical axis represents urban growth (50%) to urban shrinkage (20%) for the region around Dordrecht and its accommodating socio-economic growth or shrinkage and the horizontal axis represents a proposed flood risk for the island of Dordrecht. This model leaves four scenarios where scenario two and three are strongest opposites and scenario one and four are variants between the former two.

Scenario 1: This scenario has a low flood risk combined with an urban growth. In this scenario there is a need for space for expansion as well as a need for densification. The threat of the water will be low but because of the increased densification in case of a flood damages will be high so some measures should be planned.

Scenario 2: This scenario has a high flood risk combined with urban growth. This scenario has the highest demands for available space. Besides the space need for urban expansion and densification as in scenario one extra space has to be reserved for water safety measures. High threats combined with a dense built environment need extensive water safety management. Often sustainable solutions ask for more space than conventional ones, this scenario should explore multifunctional use along densification opportunities.

Scenario 3: This scenario has a low flood risk combined with urban shrinkage. This scenario leaves space for natural dynamics to be reintroduced, space for extensive sustainable solutions.

Scenario 4: This scenario has a high flood risk combined with urban shrinkage. In this scenario one of the design problems is the shrinking city and how to respond to that. The shrinking city however may generate space to manage the high flood risks that this scenario imposes. Sustainable water safety solutions could be integrated with reintroducing the natural environment.

Figure 6. Proposed scenarios.

At the heart of the research lies the definition of adaptive planning what this means for the urban designer. Different ideas and concepts are presented around these subjects.
Since the 60's the notion of spatial planning as a system was seen as something that could be adapted and regulated as a mechanical system by controlling how different elements communicate and relate to each other, planning was managing society and aimed at creating a definite end product. (Meyer, Bregt, Dammers & Edelenbos, 2014). They state that through time this idea has developed and influences of other disciplines such as natural and social sciences have taken a foothold in the profession of the urban planner and designer. More acknowledgement is given to concepts that relate to complexity chaos and uncertainty in long term design tasks. As well in natural and social sciences as in the planning profession focus is transitioning to design a system that leaves as much space as possible for further evolution of this system influenced by large dynamics.

The term adaptation arises mainly in the biological scope as a trial to study the relationship between the characteristics (anatomic structure, physiological processes or behavior) of living beings and their environments (Martín, de Lope & Maravall, 2009). To translate this to a model with human input they made a model consisting of adaptation, anticipation and rationality and intelligence. Where to adapt a system to changed or new dynamics one needs to understand the system, be able to make a prediction and implement changes to address these changes.

To this model was made in context of computer science and creating models that mimic nature. If this could be translated towards planning and urbanism one could say that the designer needs comprehensive understanding through analysis of a proposed project area (rationality and intelligence) and needs to be able to project this knowledge to future developments (anticipation). In planning future developments bring forward uncertainties. These uncertainties could be addressed by creating a range of anticipations in the form of scenarios. Where the adaption would mean a design that allows, in continuance of Meyer et al., a plan that could work with these different anticipations.

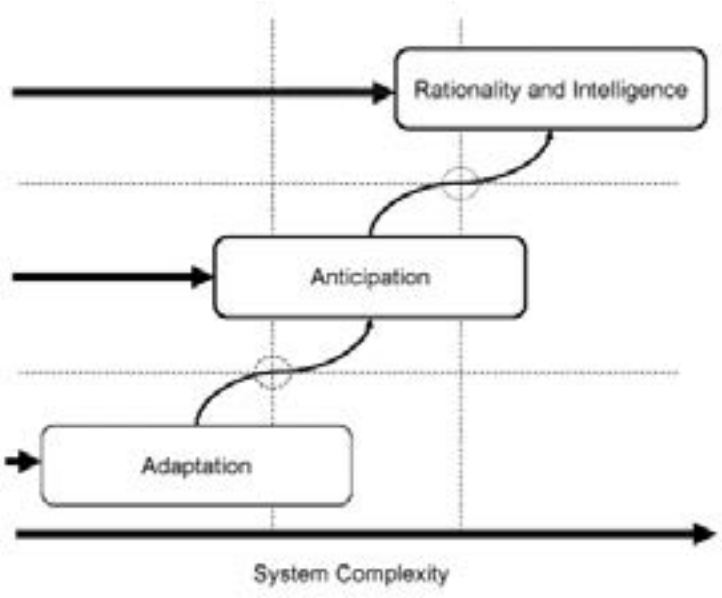


Figure 7. Logical adaptation. (MARTÍN, DE LOPE & MARAVALL, 2009)

Plans that should accommodate this adaptivity rely on robust interventions. These interventions are on the one hand robust enough to react decisively and accurately to serious climate challenges. On the other hand these interventions must be flexible enough to enable tailor-made interventions and creative innovations to achieve adaptation solutions that generate added value, and meet the ambitions of the various stakeholders. (van Buuren et al, 2013) Thus the robust interventions should work in multiple conditions or scenarios while they are the pillars for further development.

Another concept that aims at creating adaptive and sustainable environments concepts is the casco concept (Sijmons). This concept is a planning concept that supports the development of low dynamic, slow functions in a framework (the casco) that directs the higher dynamic faster processes. The open

spaces in the framework that offer space for these faster processes provide flexibility and freedom that is needed to accommodate new developments (Leinfelder,2007)

This principle of leading slow natural processes and faster processes are also supported by Meyer and Nijhuis that translate these processes to existing theories such as the layer approach of McHarg. The layers that are derived to relate different slow to fast processes to are from slow to fast, the substratum, infrastructures and land use patterns. (Meyer & Nijhuis, 2015)

As notion towards adaptive urbanism, within literature often is referred to the general concept of densification and multifunctional use (de Graaf, 2012) This idea of adaptivity focuses on how denser and multifunctional spaces are better tailored to survive change in demands.

Another idea of adaptive design that is brought forward is the multi layered safety approach, this approach is focused at water safety. This concept revolves around a backup scenario in case of a flood. The model consists of three layers where the first is the main flood protection ring of an area, the second layer should account flooding in smart sustainable planning that reduces the amount of damage done and victims in case of when a flood occurs and the third layer is a evacuation plan in case when the first two layers do not suffice.

Figure 8. Multilayer safety approach. FROM www.wrij.nl

Theory continued

In the initial methodology of the project was driven by scenario planning based on the Deltascenarios 2050 & 2100. While providing a starting platform towards a plan that can manage different future problematics if they present themselves, the scenarios on its own would not suffice for an engaging design or for a design that handles different dynamics.

When looking at contemporary methodologies that are being used for tackling adaptive or sustainable planning and future uncertainties such as the Room for the River approach, three basic principles can be deducted. These basic principles or approaches would be the Design with Nature approach by Mc Harg, scenario planning and the No Regrets approach.

Design with nature

In origin McHarg's approach, to include several structural layers of the landscape in the design process, was aimed at taking advantage of ecosystem services and promote environmental and public health. The ecological science that is used to dissect different layers into comprehendible data functions as base input for a design and can play a leading role in the decision making process of a project. (Yang, Li & Li, 2013) In the approach it is concluded that people are holistically connected to the environment. To attain a resilient and adaptive society it is needed to benefit from the protection and enhancement of the environment. Accepting and strengthening the environment integrated into an urban plan would benefit both. (Roös, 2014)

To continue on this idea Roös suggests that combining the theory of McHarg with the methodology of pattern language by Alexander offers a basis for adaptive design. The layered approach of McHarg where different dynamics are visualized can be further specified into design principles formulated through patterns that can be found within those layers. In the goal to create an adaptive design it is key to grasp an understanding of the natural dynamics and what they may be in the future. And find solutions to how patterns in infrastructural and cultural layers can be integrated in those natural dynamics. (Roös, 2014) The difficulty lies in combining the dynamics of these different layers and find appropriate solutions. Short term solutions might not be beneficial to long term safety. Local short term measures often reside to 'hold the line' measures that focus on strengthening current solutions or creating new dikes to keep the water out. In the long term the effort and resources spent on these solutions are gone to waste and may be contra productive towards the initial goal of keeping people safe. (IPCC, 2012)

The approach is adaptive in identifying the leading dynamics that are least flexible and using these dynamics to be a guide for the design of an area. This should lead to sustainable or durable solutions in relation to the changing environment while integrating cultural components. (Roös, 2014)

Scenario based research

"Scenario planning techniques are increasingly gaining attention in the process of spatial and urban planning because of their usefulness in times of uncertainty and complexity. Scenario planning encourages strategic thinking and helps to overcome thinking limitations by creating multiple futures. In this way, it can help to shape the future according to the values and desires of society." (Stojanović, Mitković & Mitković, 2014)

Ducot & Lubben (1980) propose a model differentiating four kinds of scenarios divided in two categories of two types. The first distinction made is between descriptive and normative scenarios where descriptive scenarios are an objective depiction of events where normative scenarios are set up to incorporate preferred variables. The second distinction is between explorative and anticipative scenarios. Explorative scenarios use the current situation as a starting point and aim to see how to continue from there where anticipative scenarios set an end result and question how to get to that result.

Scenario	Explorative	Anticipative
Descriptive	For the given causes – What can be the next results (effects)?	For the given results (effects) – what could be their causes?
Normative	For the given measures – What can be the goals achieved?	To achieve given goals – what measures could be taken?

Table 1. Scenario types. (Ducot & Lubben, 1980)

When looking at planning for future uncertainties normative anticipative scenarios are most interesting to work with. While explorative descriptive scenarios are more suited for exploring a given short term design task or researching options.

Scenarios can be used for different purposes and work on a multitude of scales from local neighborhoods to mondial settings. The thematic and scale of the scenario is based on the research goal or what subject is being explored. It is of importance that the delineation of a scenario based research is done extensively to ensure relevance of the outcome of the research. (PBL, 2013) The better we can map what the future might bring the better we can prepare for one of its pathways. The most resilient designs or developments are the ones that would serve a goal in multiple scenario's.

No regrets approach

Urban planning that has to deal with climate change is about taking future uncertainties into account. The effects of climate change are still predictions and come in the form of a range of possible change in water levels, whether it be rainfall, river flow or sea levels.

"Unforeseen events, natural and human-induced, will occur. For these reasons, the best insurance policy is one that improves society's generalized ability to cope with disasters, environmental and otherwise, not simply to mitigate one potential disaster scenario that may or may not occur" (Adler et al., 2000) The no regrets approach, in relation to climate change, is based on combining urban development with the uncertainties of climate change. No regrets policies and actions are those that are beneficial to implement whether or not the consequences of climate change or a disaster turn out as expected. (UNISDR & UNDP, 2012)

The UK Environment Agency (2015) lists the following key characteristics for decision making to comply with a no regret vision:

" *- No-regret actions are cost-effective under current climate conditions and beneficial whatever the out come in terms of climate or sea level.*
- Low-regret actions are relatively low cost and are likely to be beneficial under predicted future climate or sea level scenarios.
- Win-win actions contribute to adaptation and provide other social, economic and environmental policy benefits.
- Major policy changes or investment decisions have significant, long-term consequences and costs associated with them, and require considerable analysis and public debate before a decision is made "

The no regrets approach is not only applicable to urban planning but as well for the integration of communitiy to be an integral part of making cities more resilient at different scales. (Siegel, n.d.) This could help strengthen communities and local ownership. (Siegel & Jorgensen, 2011). However it is essential that the given communities and local residents are engaged in the process and planning of creating said adaptive plans to help them understand the context and local policies. (UNISDR, UNDP, 2012)

Mapping the uncertainties of climate change and developing a long term plan to cope with the given problematics may set boundaries on the possibilities within a project plan. However it can also be used to inform short term planning and create better integral solutions. (UNISDR & UNDP, 2012)

Methodologies compared

When looking at these approaches, and their ability to tackling uncertainties of climate change, some differences, similarities and compatibilities can be seen.

The three approaches are different in the in their main characteristics. They all use different starting points from where the design originates. Design with nature is using slow natural dynamics as a basis for a design to create a resilient plan. The no regrets approach attempts to increase the value of a plan with short term benefits integrated in long term measures. And scenario based design uses a wide range of predictions to grasp an understanding of an area and form the puzzle of how to prepare for its future.

While being different from each other the approaches consensus can be seen when looking at the basis of different dynamics as described by McHarg. When the goal is to be adaptive determined should be what to be adaptive for. The three approaches all base their findings on a problem statement in the slow changing natural layer and what its effect could be in the future. The design with nature approach uses it as a guide to base a resilient design on. The scenarios approach uses a scope of predictions of changes in the natural layer to attain an understanding of the possibilities what could be considered in a design. And the no regrets approach uses the measures needed to cope with climate change as inspiration for integration of short term plans to create more value.

The different methods do not exclude one another to be used within a design process. They each have their own qualities. The scenario approach adepts more at being a tool for analysis of the problematic and attain a wide comprehensive view on design goals and possibilities. The design with nature is an approach that excels at long term resilience and sustainability of a plan. And the no regrets approach is most useful as a tool to integrate long term plans to integrate with short term projects or benefits. Combined together this could lead to a resilient adaptive design.

Floodings might be one of the most damaging occurances nature can present. In the Netherlands we have defied nature for a long time by building dikes. We have become so adapt at building water defense systems, maintaining polders and controlling the rivers, entire cities were built under the sea level.

We now however found out that the solutions that were made in the past are not as sustainable as they seemed. Climate change driven increasing water threats show the limits of our water defense system year by year and forces new solutions to keep our cities safe and dry.

In case of Dordrecht this process of the defense systems limits showing itself is a relatively common occurence. Houses along the Voorstraat where the built environment is part of a dike has its lower floors flooded when the river levels become too high.

The Netherlands itself is located for 26% under sea level and 59% of the country is vulnerable for flooding and 55% of the country is protected by dikes, dunes and dams. Alongside most of the Dutch population lives in areas that a sensitive to flooding. (PBL, 2014) Water safety in the Netherlands is treated as common good people that people have a right to enjoy. With 4 million people live under the sea level millions are being spent every year to preserve the safety that is enjoyed today.

While climate change is progressing new solutions to adapt to increased threats become more and more important. These solutions can be used for in the search for how to manage water safety in a sustainable way. Solutions found may be of use for locations outside of Dordrecht and in a more general way of how living with the threat of flooding can be dealt with in a built environment.

2.7 Methodology revised

Starting to work on the project it was soon clear that the earlier mentioned methodology was not sufficient to reach the goal of a design that could work for multiple futures. Extra layers of theory introduced themselves along the way when the design process had started. The results of the scenario based planning method did bring forward some designs and added some scope the project but were too banal because the terms of the set scenarios (presented in deltascenarios 2050 and 2100) being so extreme they did not leave a workable base to continue on.

During the project new information presented itself following interviews, mentioring or additional literature review. The project itself was by far not a linear process. Different setbacks were taken when new information was needed to proceed with the design or when different opportunities showed themselves.

From a design perspective a gradual iterative process was the baseline. The major setbacks in the project came from the research side where new information sometimes threw off the entire design. This may have been from the lack of

The methodology shown here is more a representation of the actual project than it is the prefered process that one would like in a project. As per illustration of this report the methodology explained within a plan should be aimed at making the reader understand how the project is done so it can be understood how the results have come to be.

With this project many things have gone wrong. Therefor it is difficult to retrace the exact stepts taken to recreate the same project. This representation is here to show that the initial proposed methodology is not representative for how the project is done.

Despite being not ideal and having caused many hurdles from a theoretical perspective it could be said that design tasks within adaptable and sustainable design in the delta present themselves in such different ways that an approach to a project should be adaptable in itself and should be able to make place for new ideas or methods to tackle the presented problematics.

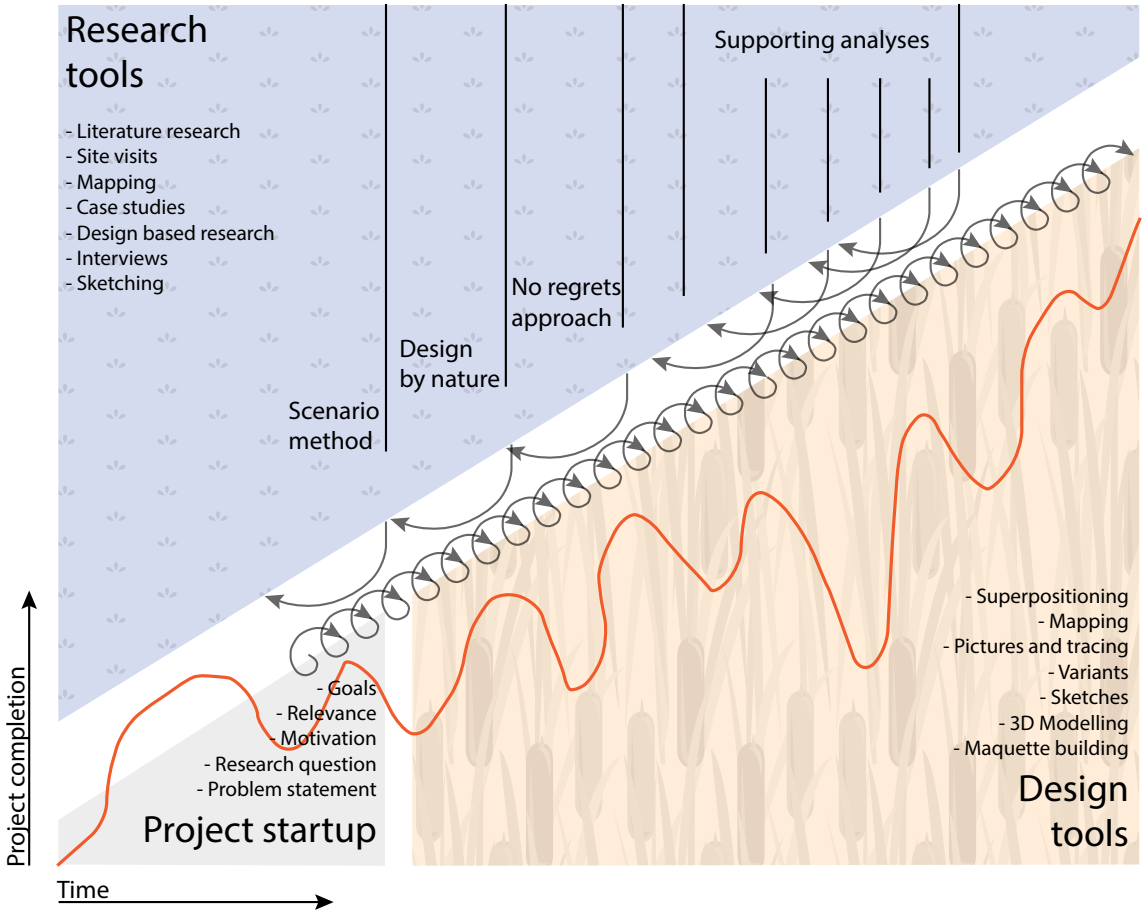


Figure 9. Revised methodology.

2.8 Project goals extended

With the redefinition of the methodology the scope towards the initial project goal of creating an adaptive landscape had need for some addendum as well.

Within the theoretical framework one of the main methodologies that is used through various projects in practice was mentioned, the Room for the River approach. The room for the river approach is a continuation on the design with nature principles defined by McHarg.

Different projects have been executed with this approach as a basis and more are to come. In short the methodology in practice aims at finding more space for rivers to flow so to lower water levels and promote a more regular discharge.This is mostly achieved by two different types of interventions. Moving the main dikes that bind the river more landinwards or lowering the grooves along the river. These project have one strong identifier in common, their locations are in primarily agricultural landscapes.

The project with intruducing Room for the River near the city of Dordrecht provided a different parameter for this methodology, a built environment. By introducing water at the southern side of the city a new temporary waterfront can be present. This brings forth a situation not often seen within the room for the river projects plans.

The built environment that can be found within the projects often has the form of a single farm. Potential flooding for these farms is solved by putting them on a individual mound to protect them from the water.

Despite being design by nature in principle Room for the River in practice the offers a more technical solution to water problematics. The input of the city is a rather non defined territory in the approach.

Within this project the goal will be set to find out what influences the city may bring towards its border when a Room for the River type intervention presents itself adjacent to the city. City dynamics, structures and spatial quality that attach or play a role on the borders could be an integral part of the design solution within the Room for the River plan.

Figures 10-13. Typical Room for the River locations and solitaire mound for a single farmhouse. FROM: www.ruimtevoorderivier.nl

2.9 Societal relevance

Floodings might be one of the most damaging occurances nature can present. In the Netherlands we have defied nature for a long time by building dikes. We have become so adapt at building water defense systems, maintaining polders and controlling the rivers, entire cities were built under the sea level.

We now however found out that the solutions that were made in the past are not as sustainable as they seemed. Climate change driven increasing water threats show the limits of our water defense system year by year and forces new solutions to keep our cities safe and dry.

In case of Dordrecht this process of the defense systems limits showing itself is a relatively common occurence. Houses along the Voorstraat where the built environment is part of a dike has its lower floors flooded when the river levels become too high.

The Netherlands itself is located for 26% under sea level and 59% of the country is vulnerable for flooding and 55% of the country is protected by dikes, dunes and dams. Alongside most of the Dutch population lives in areas that a sensitive to flooding. (PBL, 2014) Water safety in the Netherlands is treated as common good people that people have a right to enjoy. With 4 million people live under the sea level millions are being spent every year to preserve the safety that is enjoyed today.

While climate change is progressing new solutions to adapt to increased threats become more and more important. These solutions can be used for in the search for how to manage water safety in a sustainable way. Solutions found may be of use for locations outside of Dordrecht and in a more general way of how living with the threat of flooding can be dealt with in a built environment.

Figure 14. A man behind his window with high water levels. BY: Rinie Boon

2.10 Scientific relevance

Climate change is an ongoing process proving itself to present new challenges along its way. Delta areas around the work are under threat of the rising water. The discussion around how to deal with the threat of water in delta areas is still an ongoing discussion. In this process there is still demand and room for new concepts and ideas on different scales.

Urbanized deltas over the world provide attractive locations to live to work and are prime locations for trade. The desire to maintain these cities is therefor a logical foundation to drive the research in how to preserve them under the threat of rising water.

The design task at hand is on of the most complex problems that present themselves with the area of urban design. A combination of different processes being urban, ecological, water related or economical all come together and must transform to withstand the projected rise of the water under climate change.

This makes the problem multidisciplinary and difficult to tread against as an individual. Workgroups, discussion board and experimental design lead the way in developing an approach on how to tackle the threat of water in different circumstances.

With this research I hope to bring forward spatial forms that can maintain value under different future scenarios be it flooded or not while maintaining or strengthening spatial quality of an area. However the design will be limited. The design will be made for an area that is already planned to be redeveloped and the current landscape is rather empty. In a situation where there already is a lot of built environment already present the design task of transforming a whole area to an adaptive plan will be much harder.

3 Project context

3.1 Dordrecht

As earlier stated the project will be taking place in the city of Dordrecht. Located in South Holland in the Netherlands Dordrecht is a city on an island in between the rivers the Nieuwe-Merwede, Beneden Merwede, Dordtsche Kil and the Oude maas. The city is a mid sized city of almost 120.000 inhabitants. Most typical that the city is known for is it old cultural center on the northern side of the city and the natural areas on the south side of the city.

What is less well known about Dordrecht is the unique spatial configuration that has formed the island over time. In 1421 Dordrecht was hit by a large flood that was away most of the land. The city center of Dordrecht managed to stay strong and slowly reclaim the land bit by bit. This process was paired with creating a series of dikes. This series of dikes is still present in the current urbant spatial structure and will play a major role within this project.

Figure 15. Project location.

Being an island the area around Dordrecht has an abudance of water. Flanked on all sides by rivers the island always had to deal with the pressure of the water.

Being located at the end of the Rhine and Meuse rivers water can be a problem from time to time around the city. Adding to this is the location of the city within the delta still is under the effect of the tide of the sea. When it is high tide the sea makes it more difficult for the rivers to flow into the open waters of the sea. Added to this are periods of rainfall the by themselves can cause nuisances on the island for the amount of water can be too much for the present systems to rapidly disperse.

While the island at this moment in time is relatively safe the threat of climate change may bring change to that. Climate change will cause the sea level to rise and for rain to turn into periods of more extreme downpours or drought.

Extremes in downpours within the entire Rhinedelta can cause Dordrecht which is located at the end of the river to deal with excess water. When these extremes get larger under the effect of climate change and sea levels make it harder for the river to get rid of its water the water safety infrastructures around the island of Dordrecht are in need for a change.

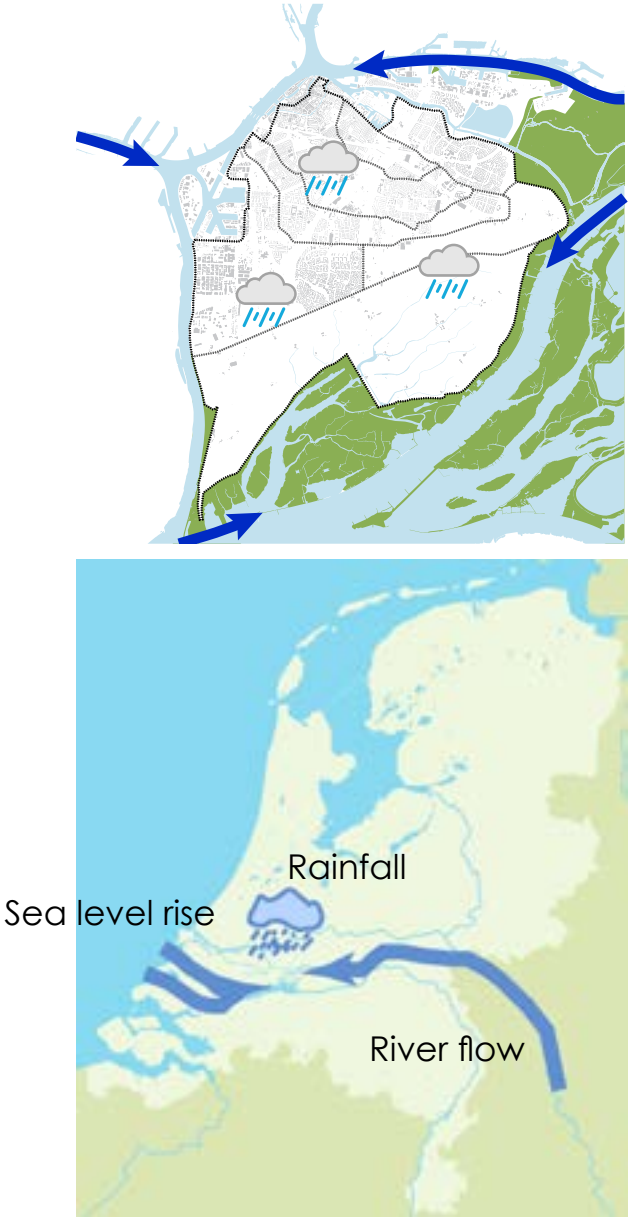


Figure 16. Three types of water threats.

Dordrecht has a love/hate relationship with the water. In the past the city prospered due to its strategic position at a crossing of multiple rivers. Today Dordrechts cultural center still has the spatial configuration as it did in the middle ages in relation to the river making it one of the most attractive city centers in the country.

But the threat of the water looms and the city fears to be flooded. The most feared scenario for the city is for the dikes to fail at the Kop van 't Land. When this happens one of the the largets of the compartment dikes, the Wieldrechtse Zeedijk, will force the excess water to flow into the city causing a dangerous flooding and extreme damages throughout the city.

As measure to prevent the flooding the government provided a solution in the Deltaplan. The entire northern half of the outer ring dike around Dordrecht should be heightened to prevent floodings with a change of failure only once in ten thousand years.

These are heavy measures and to comply with them could be detrimental for some of the cultural relics that the city is able to offer.

Figure 17. Most feared flooding scenario.

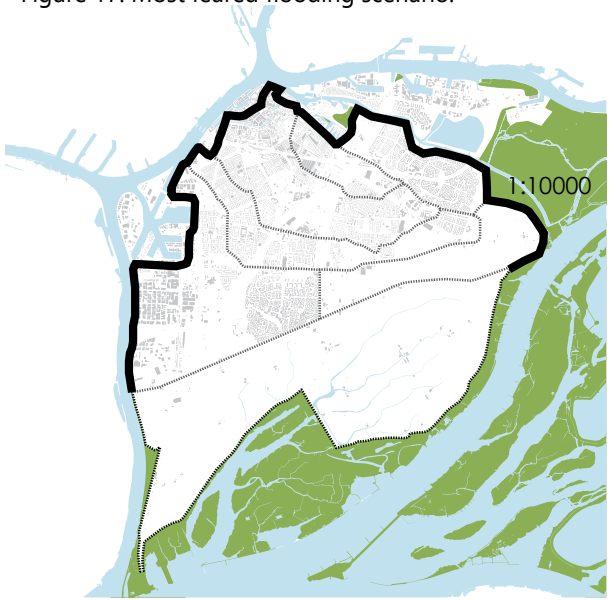


Figure 18. Projected Delta Plan measures.

That is why the city came up with a counter proposal. Alternative solutions should be researched and if these had desireable results they could serve a substitution for the plans made in the Deltaprogramma.

A research group was set up as a collaboration between different parties including the municipality of Dordrecht, the government, the province, Waterschap Hollandse Delta, environmental orginizations and other stakeholders. They worked together on the MIRT research, focussing on a plan for a multilayer safety design for the island of Dordrecht.

One of the most promising solutions was to strenghthen a secondary dike so that instead when the primary dike fails the water wouldnt flow towards the city but into the open agricultural landscape on the south end of the island.

This would mean that the dikes on the south side of the island would not need as much strengthening as what was stated in the works of the Deltaplan since it now would have a backup dike to support it.

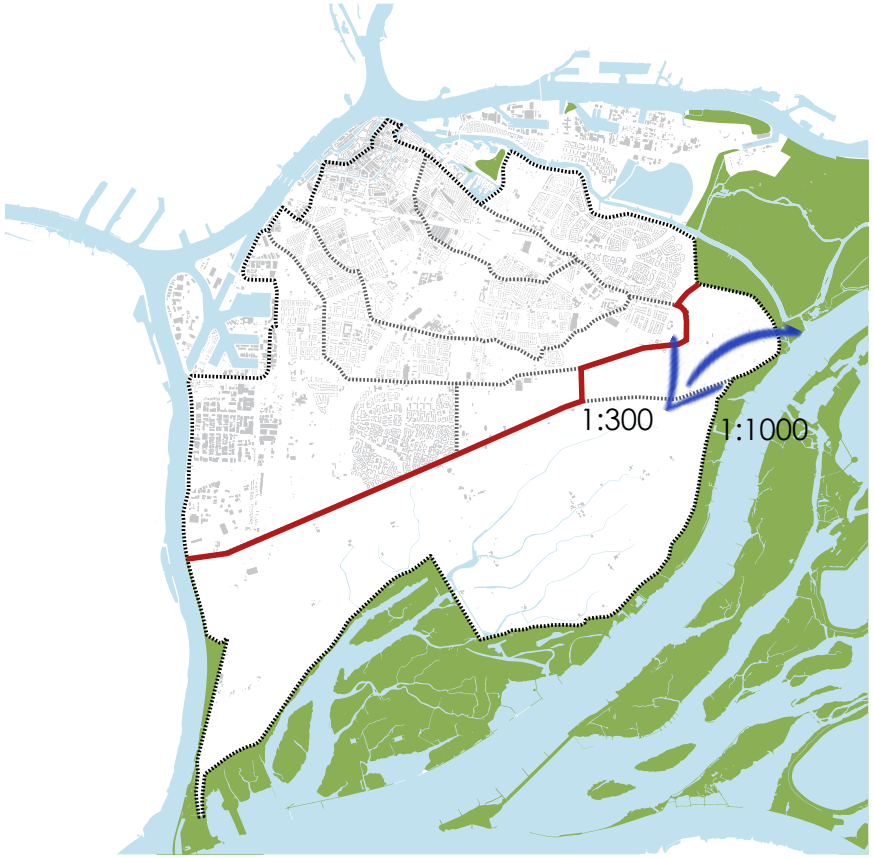


Figure 19. Municipality research MIRT proposition.

Three variations of the plan were made. All of them follow the path of the the Wieldrechtse zeedijk in the west and differ from when they would move upwards in its trajectory to form a secondary dike.

The first variant would go up along the schenkeldijk. This dike was not sufficient to function as base for a new secondary dike and had to be fully redeveloped. In addition the first part of the Zuidendijk where the Schenkeldijk would connect to is richly built with dike houses.

The second variant made the step northwards in the middle of the Aloysenbovenpolder, this skipped the dike houses mentioned earlier and had the benefit of being combined with a new recreational route.

The last variant used the stronger Zeedijk for as long as possible before bending northwards to form the secondary dike.

Preference of the research group went to the middle option. Forming the basis of the continuing discussion how this will work for the different layers in the multilayer safety model.

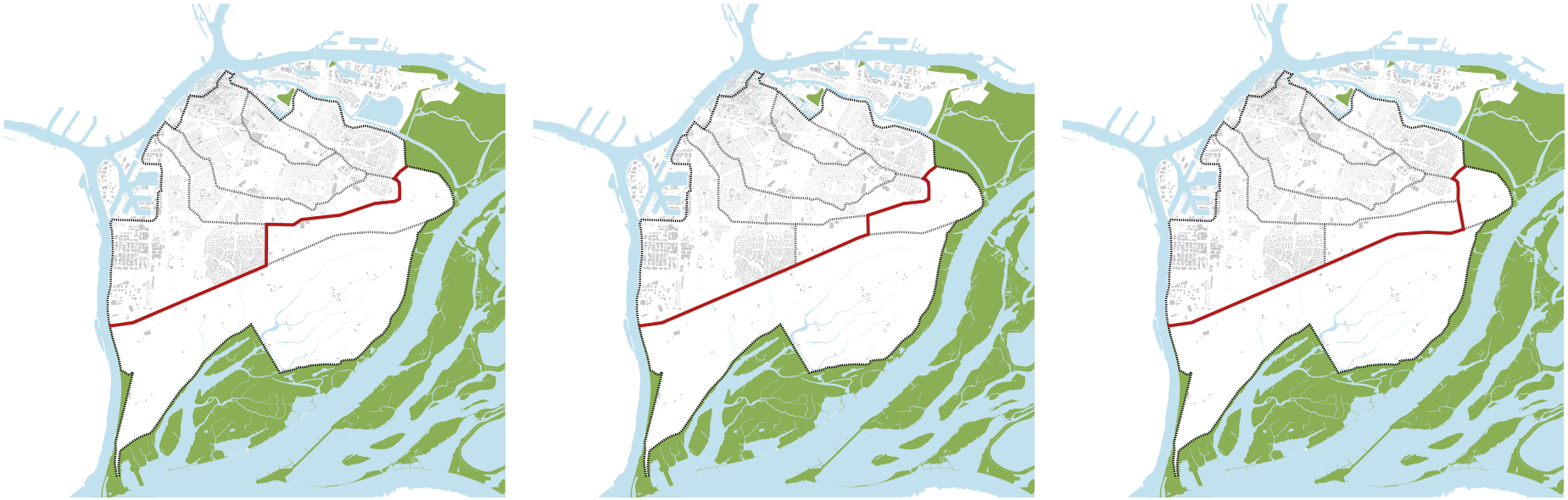


Figure 20. Variants within the MIRT project scope.

HKV

Through interviews with HKV a different approach was established for this project. The new approach uses the findings of the MIRT research of using the Polder the Biesbosch as buffer body to prevent the city from flooding as a basis to elaborate and improve on.

The first difference is to acknowledge that the river that feeds the water to the southern side of the city is the same river that flows along the northern side of the city as well. That would mean if the river causes problems of the south side the north side of the side has to deal with the same problematics.

The question became if an intervention for water safety on the southern side of the island could benefit the northern side as well. This question was raised because the northern branch of the river passed along solutions and locations significantly less flexible in its design space than the south side of the island of Dordrecht.

One most inflexible elements in Dordrechts water defense system is the Voorstraat. The dike there is highly integrated with the urban form but redevelopment of the dike could make the street lose a lot of its cultural value.

Figure 21. The Merwede river leads water along the Northern and Southern side of the island.

When looking at the Voorstraat one can see that the dike is at its limits. In cases of extreme high water extra barriers need to be planted to guarantee safety so the hinterlands will not flood.

The Voorstraat itself is relatively high but the neighbourhoods that lie behind it are not. There is a fast drop in height leaving the city center. When the Voorstraat will give in to the pressure of the water the most densely built area of Dordrecht will be under 3.5 meters of water.

The extra dike attachments to keep the water out are already in use for a long time. Back when water levels werent as high as they are today seeing them during high tides was a common sight. These extra attachments did not receive much of an upgrade over time and it is the question for how long they will suffice to keep the city safe from the northern end.

Figure 22. Aerial picture of the dike and main street the Voorstraat.

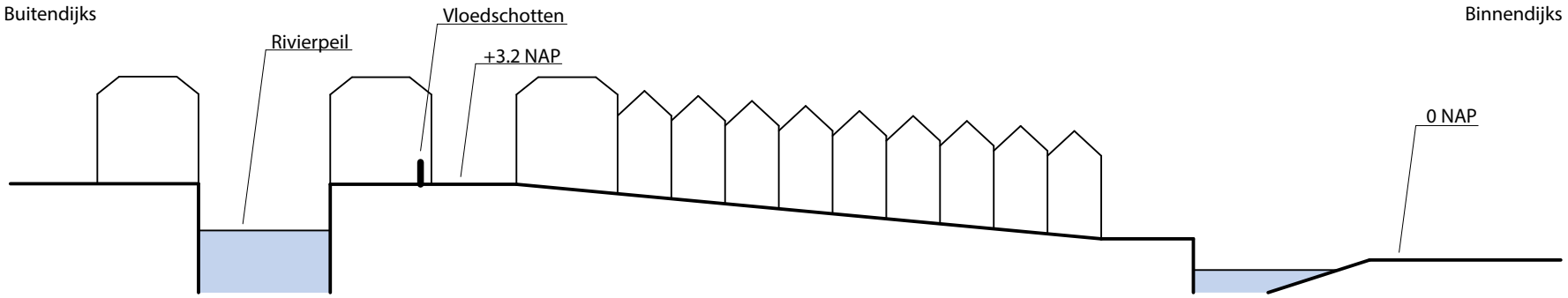


Figure 23. Representation of the dike function of the Voorstraat.

Figure 24. Flood barrier extensions on the Voorstraat. FROM: het financiele dagblad.

Figure 25 & 26. Historical pictures of flood barrier extensions on the Voorstraat. FROM: www.serc.nl

As a countersuggestion to the MIRT proposition this location could be suitable for a Room for the River concept project. The effect of such an intervention will bring substantially larger benefits to the area concerning water levels other than a simple emergency buffer. The trajectory of the dike would follow the higher Wieldrechtse Zeedijk along the southwest side of the city and bend upwards towards the Zuidendijk to offer maximum space for water as a buffer as well as space for the incoming water to flow through.

Within this plan the intake of water would be in a controlled manner as seen in other Room for the River projects where part of the outer dike is lowered so it can gradually flow into the polder when water levels become too high. The extra space for the river is that is provided this way will help reducing water levels and pressure on a larger trajectory along the riverdikes towards the east.

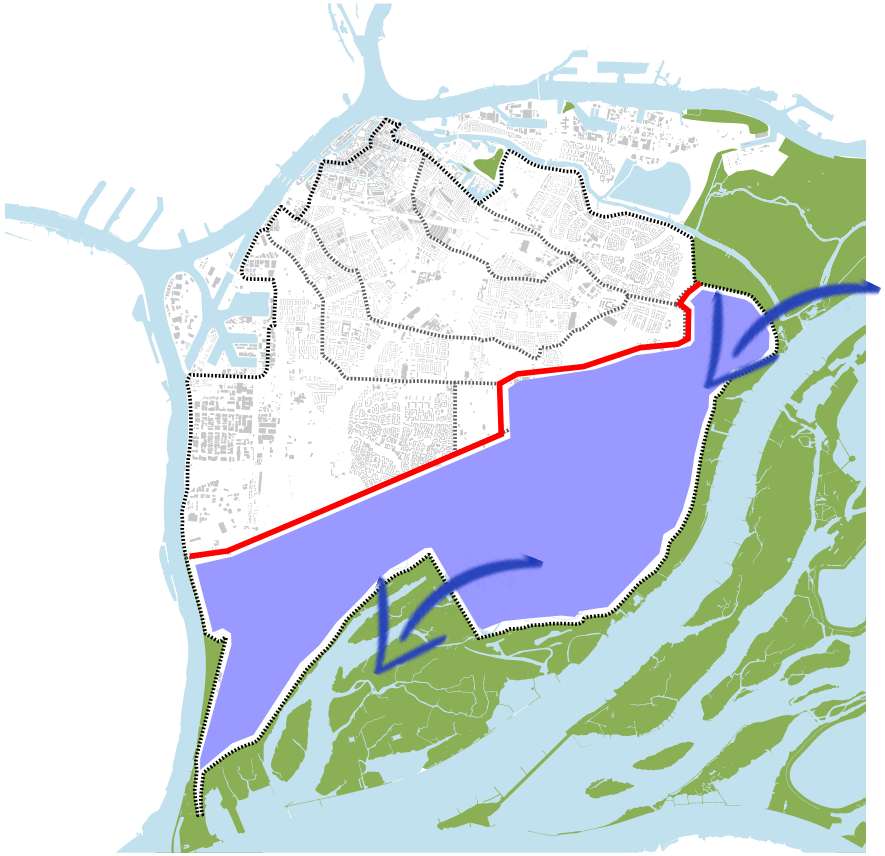


Figure 27. Proposed Room for the River plan.

To determine what could be gained with such an intervention comparisons can be made to other room for the river projects along the same river. Relatively close by the Noordwaard polder can be found this polder according to the Ministry of Infrastructure and Environment would lower the levels of the river at the point where the river splits towards north and south of the island by 30 centimeters by providing a basin and more surface for the river to flow through.

More towards the east another Room for the River project can be found. This project "Kribverlaging Waal Fort St. Andries" would lower the river levels by another 10 centimeter.

Comparing the area of the proposed Room for the River on the south end of Dordrecht to the two others in the region a conservative approximation would be a decrease of water levels at the split of the river by another 20 centimeter.

The northern end of the river is sided by highly urbanized quays that as the Voorstraat not as flexible to redevelop as a dike in an open landscape. A Room for the River solution could offer a decrease in water threats for the entire urbanised river front network on the north side of the island as well as the outerdike port areas of Dordrecht itself.

Figure 28. Room for the River type of intervention could lower water levels by 20cm for the entire waterfront of the Drechtsteden.

The proposed plan however would not directly transform the south edge of the island into a room for the river project straight away. For the coming 50 years the outerdike is still deemed to be sufficient to protect the city from the water. The first intervention will be an opening in the dike so that when the disaster scenario strikes the water can mainly flow towards to polders in the south. This opening will be beneficial in any future outcome.

When climate change proves to still be increasing the water levels and pushing extremes in rainfall upwards, change is going to be needed to adapt to the increased threats. That is when the area has to transform to offer the relief for its own location but for the rest of the region as well.

Before building all of the dikes tests can be done to see the effect of different configurations of the secondary and primary dikes.

The most extreme change being a reversal of the secondary and primary dike. Assigning the current outer dike to be a buffer for the newly appointed Primary dike that is that would be last line of defense against flooding. The new primary dike may be made less high because it is supported by the buffer dike reducing the water pressure.

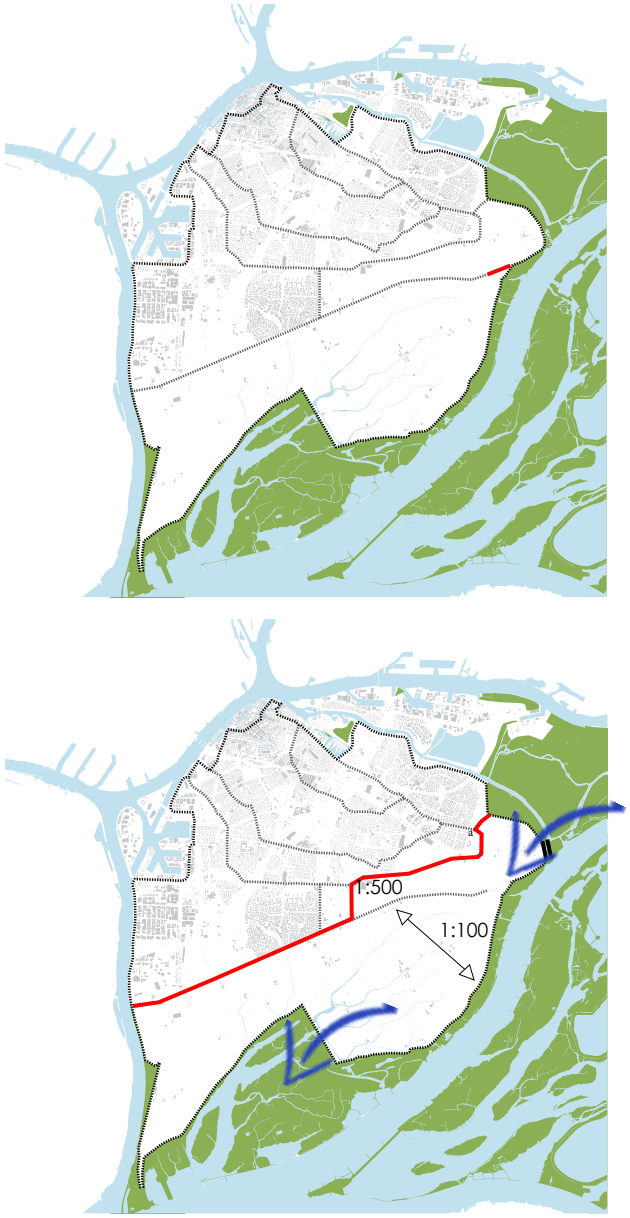


Figure 29. Switching primary and secondary dike functions.

4 Urban influences

The goal of the project shifted more towards how to improve on the current practice of the Room for the River method. Finding out what the influence of the city may contribute to the decision making and design tasks around adapting the water infrastructures towards this new water safety solution has shown itself to be answered through research by design.

The process knew two sides, the first being setting the basic principles for the water safety solution, in this projects case this was the Room for the River principle along the southern side of the city of Dordrecht. On the other hand there is the design from a city perspective.

Through starting up a design from a city perspective different parameters were set that would have meaning or contribute to the decision making for the chosen location. These parameters can be divided into categories. As means to expand on the Room for the River method this chapter will list the different categories that I have found to be a factor in shaping the southern side of the city towards an integral solution combining city dynamics with the water safety needs.

These categories could function as a starting point for discussion within future projects as basis for what to expect and what to hold into account for Room for the River type project within the urbanized delta.

Figure 30. Dordrecht around 1572. BY: Braun en Hogenberg

4.1 Historic value

During the middle ages water safety and water management was not as advanced as it is today. The system was much more dynamic as connections to the sea were still open. The tide could work its way around the estuaries and floodings occured more often than they do today. Most of the floodings happened in Zeeland which is the end of the delta and before the Delta works were built had a very open relationship to the sea.

Dordrecht located close to Zeeland at the end of multiple branches of the Rhine and Meuse and close to the open water of the sea could enjoy some of these floodings as well. The most influential floodings that Dordrecht has experienced are the series of floodings in the early 15th century called the st. Elizabethsvloed, a series of three floods in respectively 1402, 1421 and 1424. The second flood in 1421 was devastating for the area around Dordrecht completely washing away the countryside of the city.

Dordrecht was one of first cities with stature in the Netherlands. The city was built on a strategic location on higher land in the heel of a threepronged crossing of rivers and had acces to the sea making it a prime spot for trading and taxing passing ships that wanted to use the rivers to go further inlands. Trade offered Dordrecht to earn on taxes they imposed on the merchants for using the rivers they had acces to.

The higher located city center combined with a well constructed base and city walls helped the core of the city survive the disastrous flooding of 1421. In this moment in history big steps were made within techniques to create dikes to reclaim land that was once lost to the water or even create new land. In the period after the flood slowly the lost land was returned and the island of Dordrecht grew to its current form.

Figure 31. Dordrecht before the 1421 flood drawn in 1565. BY: N. Diert.

Figure 32. Dordrecht 1560. BY: Pieter Sluiter.

1421

The year of the flood. Dordrecht lost all its land on the southern side of the city. The northern side the city is located along the rivers Beneden Merwede, Oude Maas and the Noord. While the water washed away most of the land and the area turned into a new lake it was a relatively shallow lake creating with the help of the tide of the sea some marsh like areas with patches of land that show itself when the tide is low.

1600

The sedimentation process after the flood went gradually. An old stream called the Dubbel that was located south of the city still had retained a small ledge under water. The sediment that was brought along from the rivers slowly piled up on this ledge and land gradually returned.

When enough sediment washed up and the land showed itself a little above the water again around 1600 a first dikering was made. Remnants of these dikes can still clearly be found with on the west side of the newly constructed Oud Dubbeldamse polder the Brouwsdike was build, on the southern edge the Oudendijk and with a fitting name on the east side the Krommedijk.

Figure 33. Island growth after the flood 1421.

Figure 34. Island growth after the flood 1603.

1620
After the construction of the first dike ring the sedimentation process rapidly accelerated. Where it took almost 200 years for enough sedimentation to be washed up for a dike to be built the second layer of dikes was already added within the next 20 years.

With the construction of the first dikes a hard barrier was created that caused the river flow dynamics to leave more and more sedimentation along the newly built dikes. New dikes on the south, the Zuidendijk, and in the north, the Noordendijk, were built. The polders were accordingly named the Noord- and the Zuidpolder

1660
Technology advanced and the dikes that were bing built got stronger and higher. In 1659 the completion of the Wieldrechtse Zeedijk going into the Zeedijk on the east the main protection against the sea was built.

This intervention was a major step in water safety for the island and created the large Wieldrechtse- and Oostmijlpolders in the large areas in the new land on the west side and the narrow Alloijzen- of Bovenpolder towards the east.

This situation was deemed to be safe and spaceous enough for the coming years for the city to develop itself. There was space for argriculture as well as urban expansion.

Figure 35. Island growth after the flood 1620.

Figure 36. Island growth after the flood 1660.

1800
It was only until the late 18th century that there was a need for more agricultural space again. A series of small polders were build along the southern edge of the city and in the east.

In order the Oude beerpolder, the Haniapolder, the Zuidbuitenpolder on the southern side were built. Followed by the two polders in the north the Oudestadspolder and Noordbovenpolder. And finally the Louisa-of prinsenenpolder again on the south side.

1930
At the beginning of the 20th century another series of polder expansions to the island took place. The city prospered and was in need for expansion of the ports. The location chosen for this was north of the island. The strip of land called the Staart was developed, though not as a polder but the entire outerdike strip of land was heightened and transformed. Soon after to be expanded with the Staart 2 in 1916.

On the southern side of the island the most recent polders were claimed creating the largest polder of the island, Polder the Bieschbosch. Formed by the dikes called the Nieuwe Merwedeweg and the Zuidwestdijk. These dikes now overtook the function of the western part of the Zeekdijk to be the main protector against the sea.

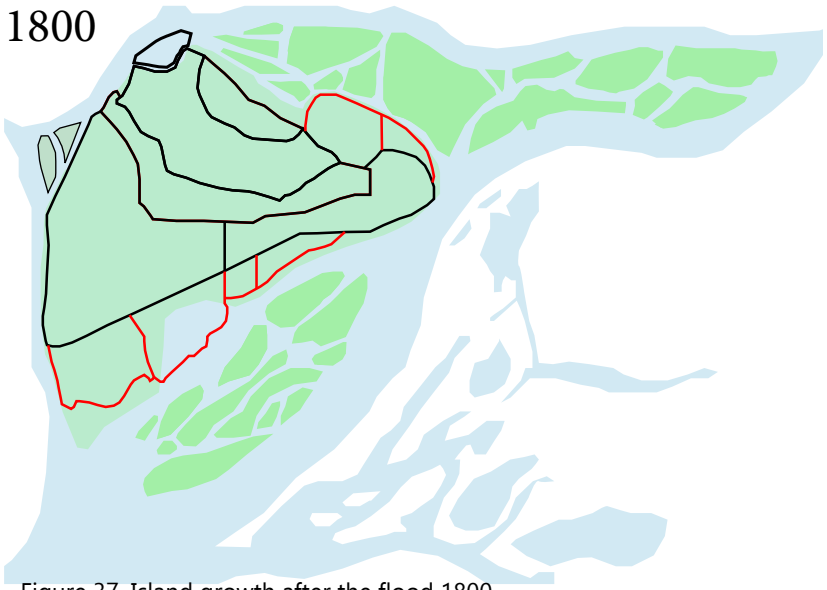


Figure 37. Island growth after the flood 1800.

Figure 38. Island growth after the flood 1930.

Urban growth

Since the construction of the Polder de Biesbosch no new land was reclaimed. The shape of the island is still rougly the same since then. The growth of the city itself to thread outside its city walls happened at a much later time than the rapid expansion of the land. Until the late 19th century no substantial attempts were made on residential or industrial developments outside of the city center. Then the industrialization offered Dordrecht the creation of a railway line and station. The station was located at the southern side of the city.

This made Dordrecht as a city more reachable for workers or for travelers making it the starting point of growth for the city. Dordrecht took down its city walls on the southern side to open the city towards the railway and possible urban expansion. The city started to grow at a steady rate up until the second world war. After the war there was a housing crisis. There was a pressing need to develop new homes. In the late 50's and 60's new large neighbourhoods known as Wielwijk en Crabbenhof started popping and gave the city large capacity for inhabitants.

After thhe housing crisis Dordrecht however kept growing at a steady rate. The city was an attractive city offering culture and nature within close proximity and the railway lines and highway made Dordrecht connectivity to Rotterdam and the rest of the Randstad outstanding.

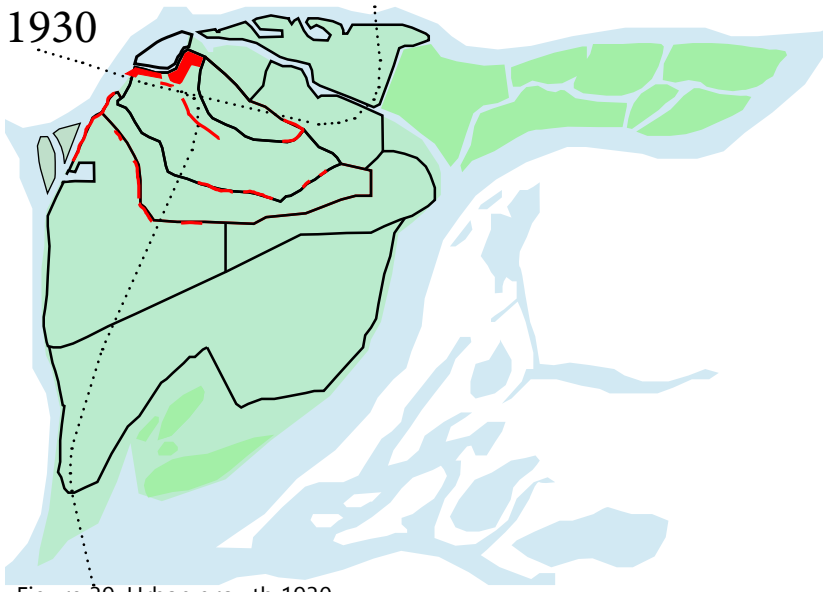


Figure 39. Urban growth 1930.

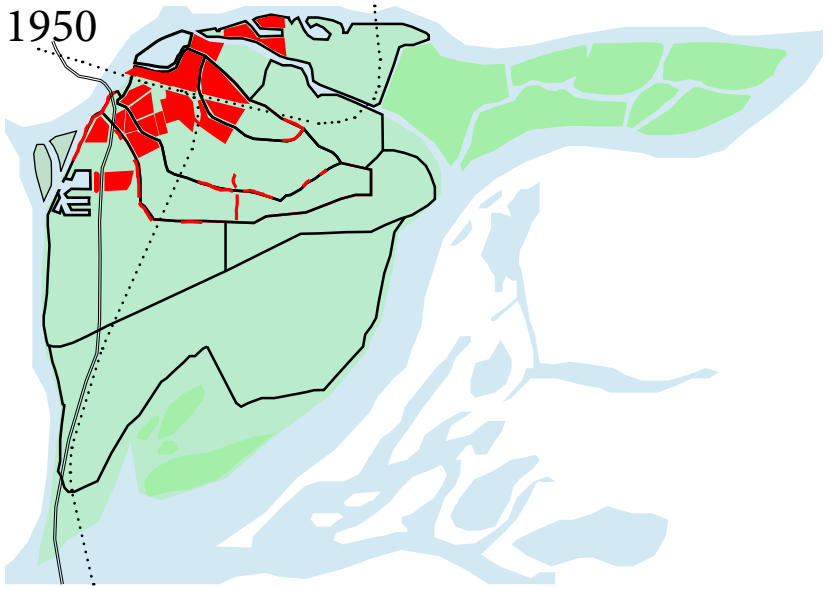


Figure 40. Urban growth 1950.

Up until the early 2000's large expansions in the form of residential areas were realized. Hoewever the growth has come to a stop. The island of Dordrecht is reaching its limits on how much built area it can incorporate.

The dikes that slowly formed the current landscape of the city are still visible in the city structure. Together with the infrastructures as the railway and the highways these lines that run through the island are the basis of the spatial configuration of the residential areas scattered in between the spaces that are left.

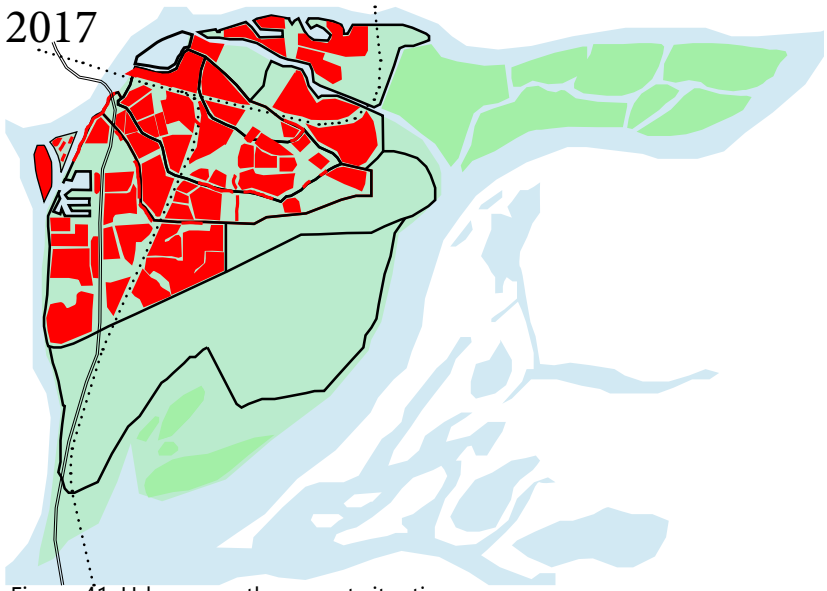


Figure 41. Urban growth, current situation.

4.2 Morphology of the dike

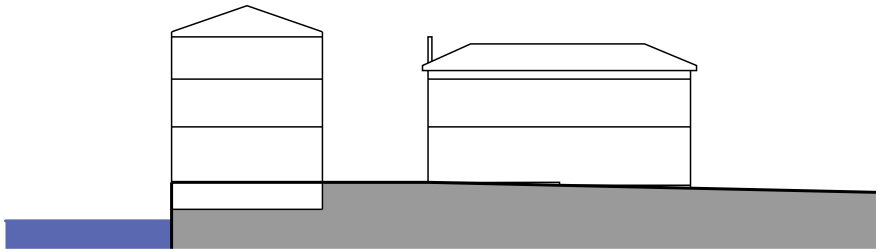
The dikes that formed the island and still are visible within the city structure are a unique feature of the city. The closeby succesion of dikes offers the city landscape a very rich amount of dikes within its borders.

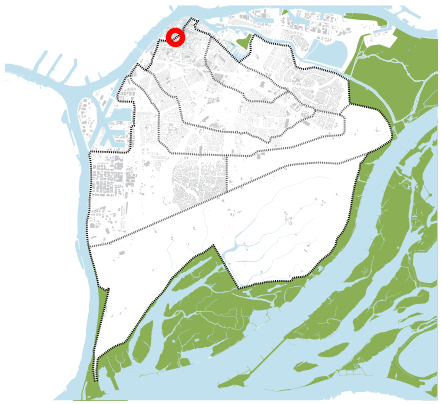
Voorstraat

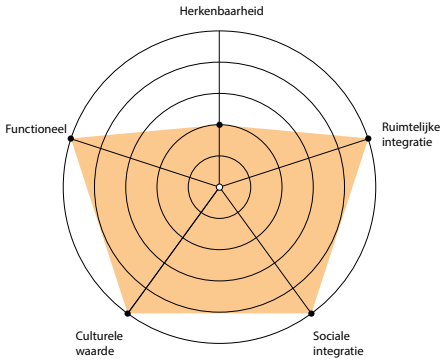
One of the most peculiar dikes in the city can be found in the city center, the Voorstraat. This street can be called the main street of Dordrechts cultural center, it is however also a dike. The oldest dike since the Elizabethflood that still has its function of being a primary dike today.

The dike is strongly integrated with the city making the houses and businesses that were built along the street part of the dike itself. The fact that this dike still functions as a barrier given its age and is still as lively in its function as a shopping and tourism location makes it a cultural attraction.

The integration of all the functions and the cultural value of the street for the city is somewhat problematic. The street still does function being a barrier but does is reaching its limits of how much further water level extremes it can manage. Redeveloping will be a difficult task without diminishing the cultural identity of the street itself.







Brouwersdijk

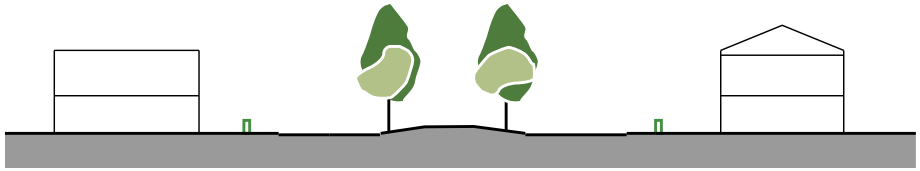
Close to the voorstraat the remains of the Brouwersdijk can be found. While not recognizable immediately as a dike upon further inspection the characteristics can be found.

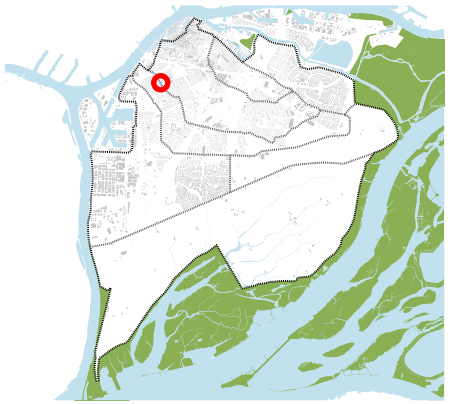
The Brouwersdijk was one of the first dikes that were built after the Elizabethflood. Given its years it has gotten a function integrated within the city structure as a main road connecting different neighbourhoods that were built in the pre war period.

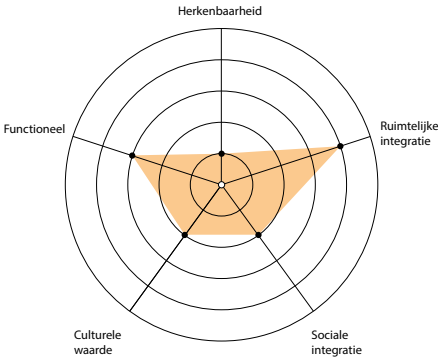
The dike through time has been reduced to a berm in between two roads that still has the form of a little hill. The brouwersdijk with its foundation as a dike is the highest road in this part of the city.

When looking at the spatial characteristics the brouwersdijk is fully integrated with the city. The profile of the street is displayed as a wide open green boulevard that gently flows in between the adjacent neighbourshoods. It has homes facing with their front towards the street and is a daily route in people travel routines.

The adjacent neighbourhoods that were built around the Brouwersdijk originated in the period between 1930 and the second world war.







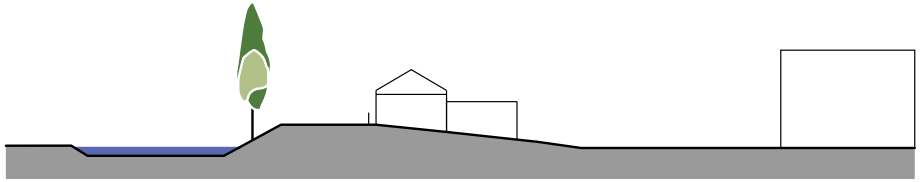
Oudendijk

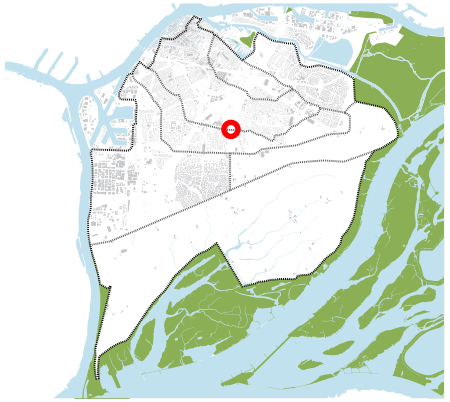
In the same dike ring as the Brouwersdijk the Oudendijk was built, the Oudendike situated a lot farther from the city center as its dike ring college.

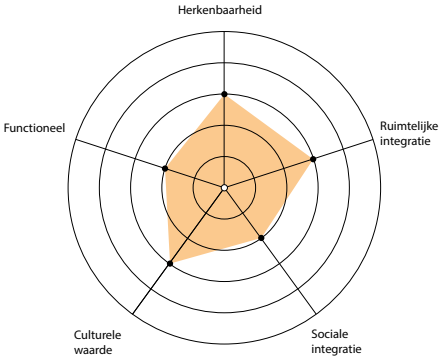
Strong differences can be seen with the two previous dikes. The most obvious difference is its form. The dike is still clearly a higher linear element that runs through the landscape. This makes the type of development along the dike also different. Along the Zuidendijk some development can be found in the form of dike houses. These homes have a front door on dike level and have on their backsides acces to the ground level.

The Zuidendijk on this location looks to offer the surrounding city function by having it integrated with green park like areas or water bodies. This gives the neighbourhoods adjacent to the Zuidendijk some space for leasure while offering a solution for the height differences and the often very variable backside of the dike houses that are placed scattered along the dike.

Where the Voorstraat and the Brouwersdike are main routes and offer space for shops and have functions that are used on a daily basis the Zuidendijk is used by the people that live on the dike and people that stroll on the dike for leisure.







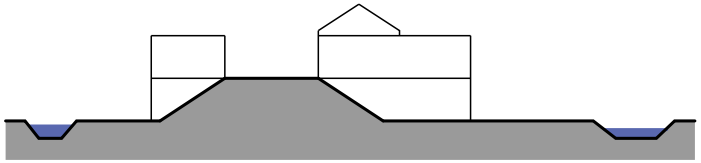
Zuidendijk 1

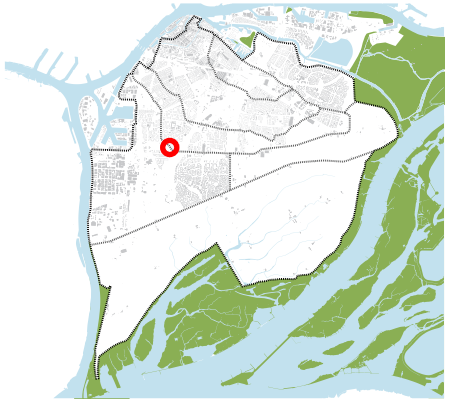
Moving on one dike ring further away from the city center the Zuidendijk can be found. This dike is a long stretched element going all around the south side of the city and therefor knows different characteristics. This particular location is situated in between the neighbourhoods built in the post war housing crisis period.

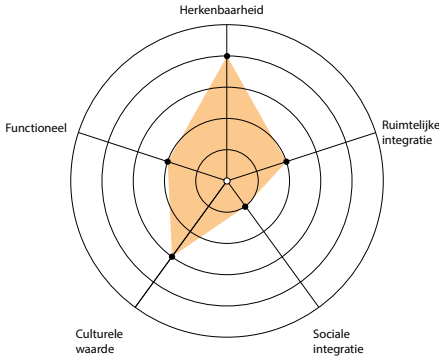
Being built in its time period there is little attempt to be observed for integration of the dike with the surrounding neighbourhoods. It is situated along backsides of adjacent developments and, can be said, is ignored in the planning process other than being a barrier. This makes the dike more clear in its shape as higher element and adjacent spaces that could serve for neighbouring areas cannot be found anymore.

In the dialy lives of Dordrechts inhabitants the dike solely functions as infrastructure for the people that live in the present dike houses and for people that use the dike as infrastructure for leisure in the form of bike rides or walks.

The character of this dike is more private when compared to the previous dikes. It is still surrounded by neighbourhoods but no attempt to integrate the dike to those neighbourhoods is made.



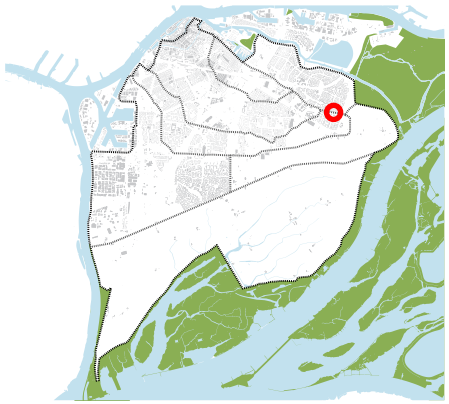


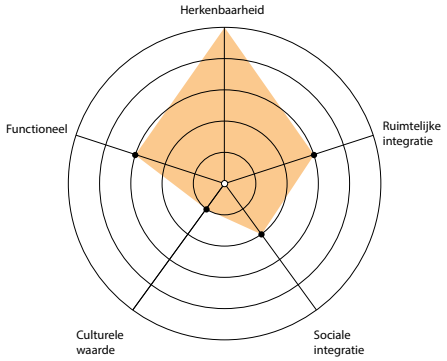


Noordendijk
This location of the web of dikes in Dordrecht is a renovated part of the Noordendijk.

One could say this dike shows some similarities to the Zuidendijk 1 in the fact that the dike is a clear barrier in between neighbourhoods and people that use the dike use it for slower transportation methods and leisure routes.

The dike is vastly different though where it is first dike when moving from the city center that does not have any built elements attached to it. The dike can be seen as a barrier between neighbourhoods but connections towards the dike to use it as slow transportation network are explicitly sought for.





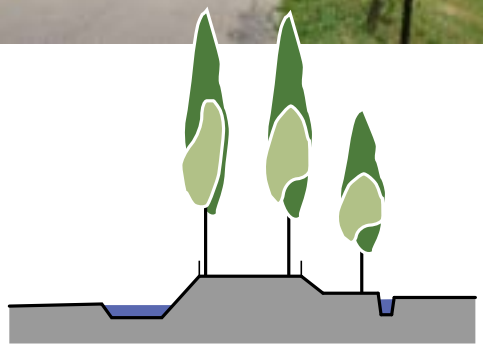
Zuidendijk 2

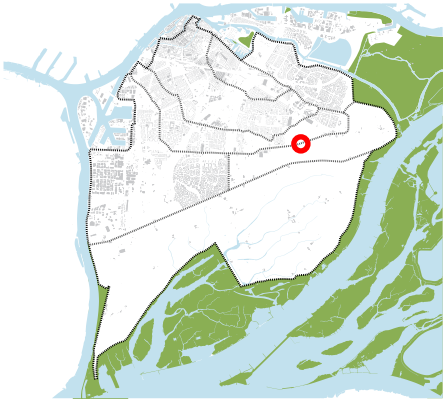
Going again further away from the city center we can find the Zuidendijk again. However with different characteristics as we have seen on the first location.

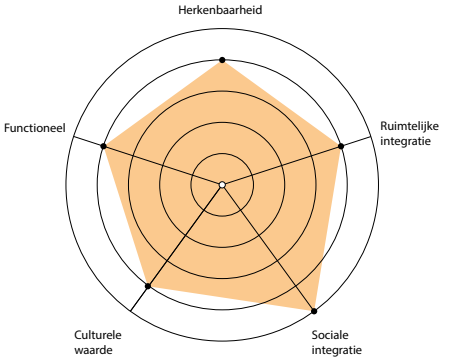
This is the first location along the different dike rings that no urban developments on either side of the dike are situated. On the southern side of the dike the view of open agricultural landscape is offered and on the other side of the dike is a variation of agricultural land and green spaces can be found.

The dike itself is a very continuous element that retains its shape along a long stretched area. Flanked by trees in the middle of a green landscape the dike is very recognizable as a dike for the people that use the road its popular function as leisure location.

Along the southern side of this dike the project will focus itself as it provides space for development as well as a situation that has a chance to be flooded within the suggested plans of water safety.







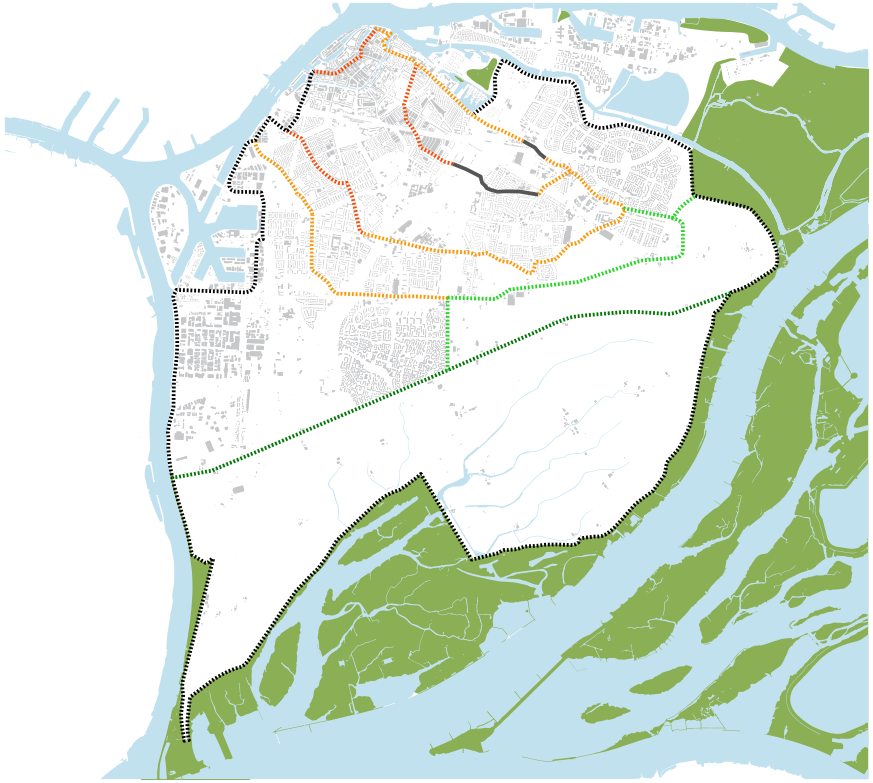
Gradient
When mapping these different locations of the mentioned dikes a pattern can be seen.

When starting in the city center going outwards to the edge of the city the spatial characteristics of the dikes gradually change. The Voorstraat in the center is heavily integrated within the city structure and it is difficult to recognize a conventional high ledge in the landscape dike in it.

Going further away towards the Brouwersdijk the dike claims its space back in the street profile. Moving further along more open functions such as green spaces or water bodies can be found gradually shifting towards the dike being an element laid out in the open landscape.

This gradient is somewhat logical. The dikes closer to the city center have had more time to be integrated within the urban structure and those dikes had lost their function as main protection against the water for a longer period of time. In addition interventions for rapid post war urban expansion did not leave space for the integration of dike elements.

The dikes towards the outer rings are still recognisable which can be related being the base for cultural and recreational experiences along the southern side of the city.



4.3 City morphology

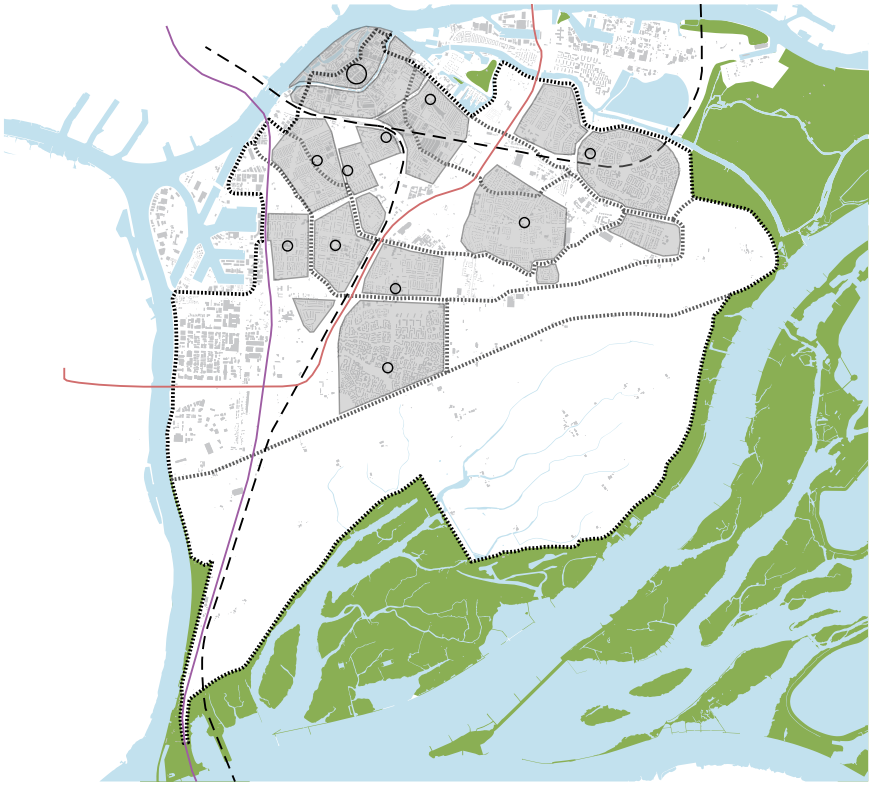
Dordrecht is a city that is built with various lines that run through the city. The most characteristic lines are of course the dikes that were built since the Elizabethflood. The rapid succesion of different dikes are a unique feature to the city but also leave their mark on the city structure.

In addition the the dikes the city has two railway lines that cross through the island, a highway and a provincial road. Where the dikes on the northern side of the city are integrated in such a way that they do not function as barriers it is not the case for the train and high speed car infrastructures.

All of the different lines through the city leave their mark for the city structure to be divided into many different smaller residential islands that flat between the dikes, roads and railways.

Added to this is the peculiar location of Dordrecht cultural center on the northern edge of the city. This center does not function for Dordrecht as a daily go to location. Every island within formed by the dikes has its own, sometimes small, shopping center. While Dordrecht is one of the larger cities in the country, the amount of centers is unusual high.

A variety of the small islands within Dordrecht will be highlighted to find how they relate to the lines that set their boundaries.



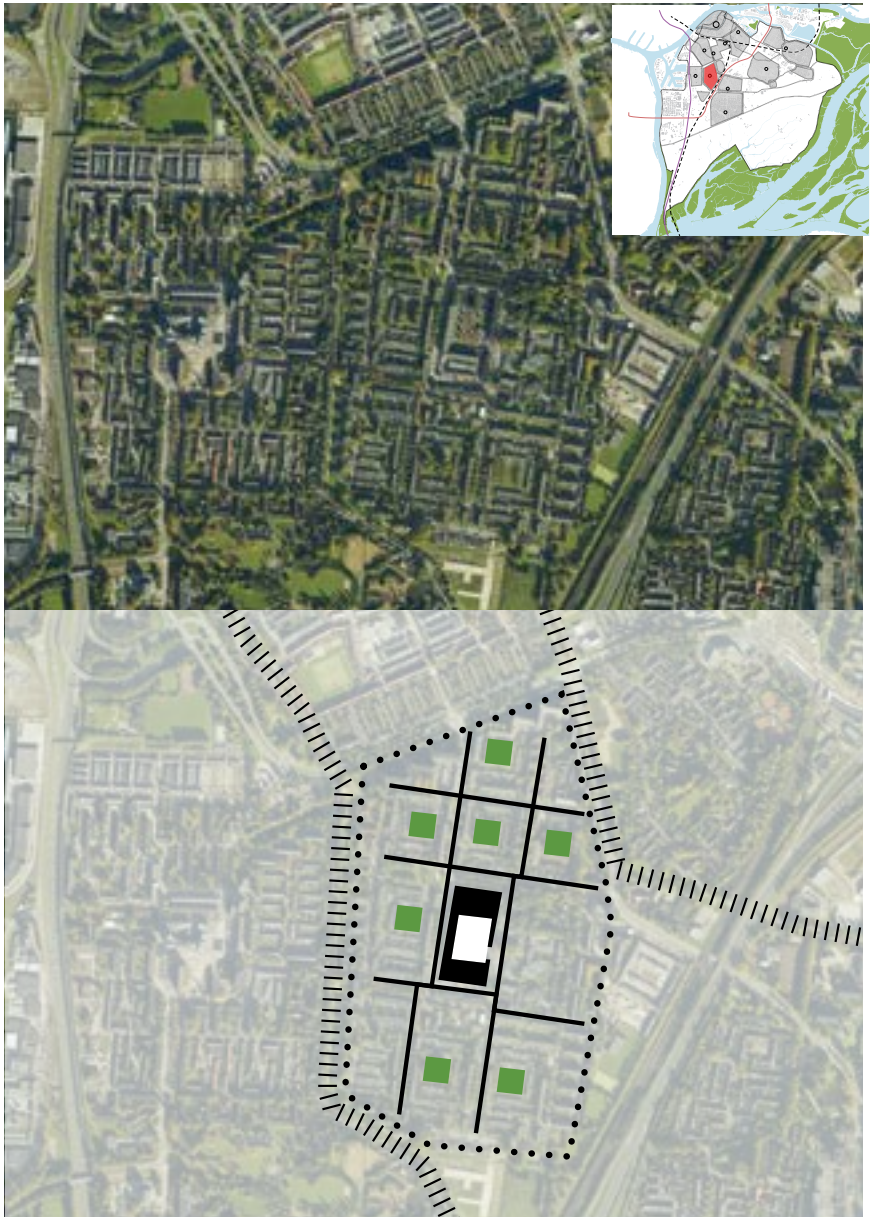
Crabbenhof
This neighbourhood is one of the larger ones in the city it is flanked by the Oudendijk and the Zuidendijk on the east and west side respectively. Crabbenhof is one of the rapidly built post war neighbourhoods from the 60's consisting of mainly appartment blocks.

The neighbourhood is built in a systemic way laying a grid in the available area with each part of the grid having its own green center. In the middle one of Dordrechts many shopping areas can be found.

While earlier was mentioned that the 60's neighbourhoods did not attempt to relate to the dikes the grid through Crabbenhof has several connections for slow traffic to use the dikes as main transport lines.

However the orientation of the appartment blocks is built with their backsides towards the dikes. Making the dike feel like a secondary space behind the welcoming fronts towards the rest of the neighbourhood.

The green courts scattered through the grid make a well placed attempt in making the area more pleasant to live in offering all inhabitants a view on a patch of nature. The typology of the buildings diminishes this quality greatly for its bland form.



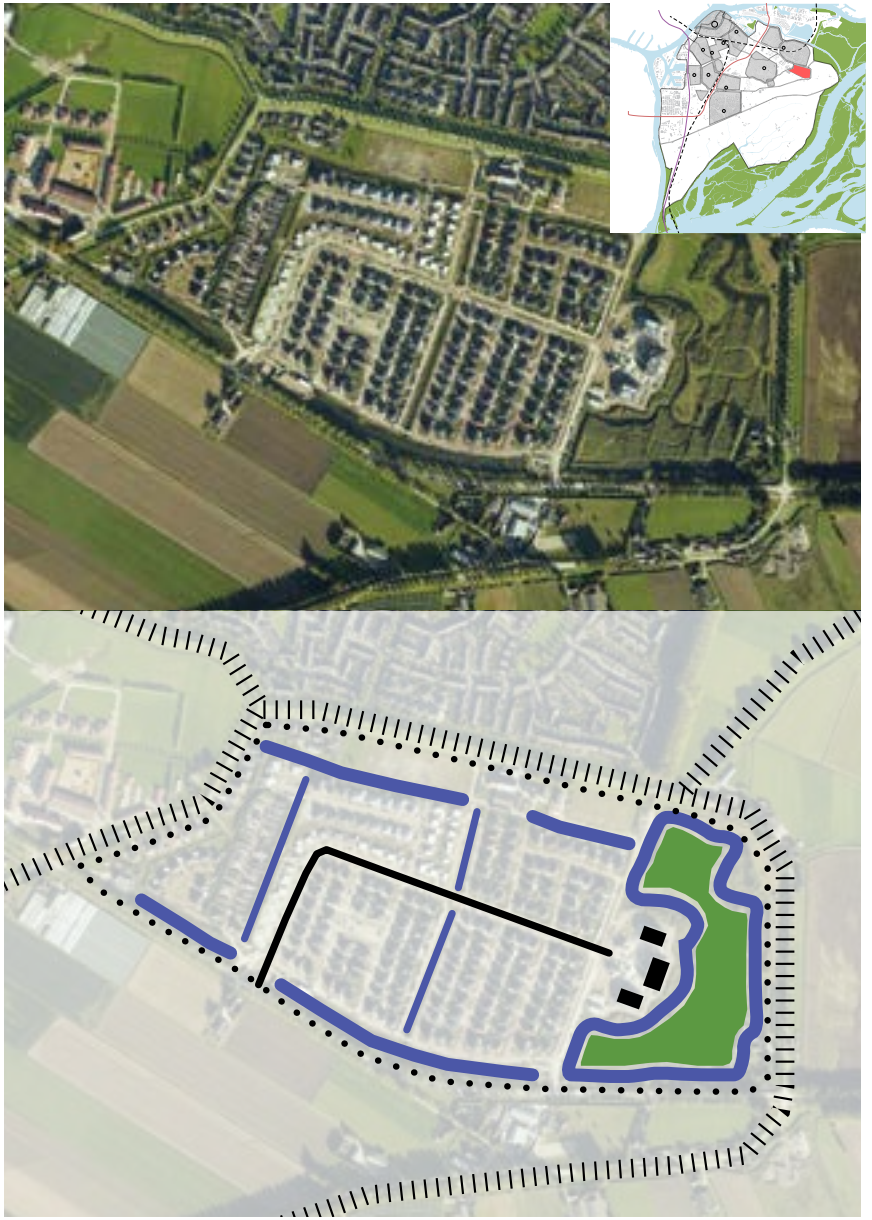
De hoven
A much more recent and also more luxurious neighbourhood can be found on the eastern edge of the city. De hoven is a single house neighbourhood built around 2007.

What makes this area pleasant is the spaceous configuration. Streets are wide with green elements in their profiles. The neighbourhood has a suprising amount of water that is reminiscent of the polder that had to make place. This water is taken fully advantage by creating a small version of a singel in the center of the plan.

For connectivity to the edges of the area where the Zuidendijk is folded around the same can be said as for Crabbenhof. The dike is used for its qualities to function as infrastructure for slow traffic but buildings are facing the dike with their backsides.

The exception can be found at the eastern edge where a park was built adjacent to the dike. While not being an integral part of the dike it has several connections to enjoy these spaces together while leasuring.

For typologies used, the uniformity of the buildings is a tad one sides. Most homes have the same form language and it may be experienced as repetitive.



Dubbeldam
This neighbourhood is a small expansion made to the district of Dubbeldam between the Oudendijk and Zuidendijk. It is built in the early 70's and consist of rows of family homes.

The first thing to notice about this neighbourhood is its clear traffic acces structure. One ringroad provides infrastructure for the entire block. In the center of this ringroad a car free series of squares is present making the neighbourhood very suitable for young families.

The relation to the dike however has been attempted to be solved by creating a strong ring with trees around the neighbourhood. Negating a view on the dike as well as limiting the options of accesing the dike from within the area. While the trees function as extra barrier towards the dike they do this as well for the view and experience of the open landscape to wards the east where a larger agricultural polder used for farming is situated.

The tree ring does however mark strong where the edges of the neighbourhood can be found.

A hoeve
Further away from the city the smallest form of island on the island of Dordrecht can be found. This is a single farm in the open agricultural landscape in the Polder de Biesbosch south of the city.

While it is not strictly connected to one of Dordrechts dikes it is connected to one of the smaller riverbanks for its infrastructure. In contrast to the other neighbourhoods the hoeve has its frontside towards its adjacent infrastructure be it the only road available.

The trees surrounding the hoeve mark its location in the landscape and provide a recognizable image for passersby. In the case of the hoeve the trees do have the function of providing a little bit of shelter against the wind and opennes that is present in the polder.

In short
All of the neighbourhoods seem to struggle in its relationship to the dike while all of them do try to make use if it for slower traffic. The islands are bound by the dikes not only because the dikes happen to be their but also due to the spatial configuarions of the neighbourhoods.

Different solutions are attempted though including building parks along the dike or solving the connection to the dike by placing trees in between building and the dike.

4.4 Densities

To further elaborate what kind of development the southern edge of the city may be fitting the tool of spacemate is used to map different locations from the center of Dordrecht towards the southern edge.

Six locations have been mapped and put in the space matrix system. The first thing that one might notice is that the placement of the six different locations for a linear line within the figure.

To produce a linear line within the space matrix one of the three values that are used to map the different areas, Floor Space Index (FSI), Ground Space Index (GSI) or Open Space Rating, needs to have a constant value. The constant value that can be found within these six blocks is a factor in the Floor Space Index. To determine the FSI one first needs to aquire the OSR. Then the OSR is multiplied by the average amount of floors of the buildings in an area.

The overlapping factor in all of the six blocks is the amount of floors, they all had between 2 or 3 floors. There are some example areas in the city where this would not apply but these can be seen as exceptions, such as the typical 60's development of 4 story apartment blocks. In general this gradient would apply.

When looking at the spatial patterns of the different blocks it can clearly be seen that the farther towards the edge of the city the block is situated the more open it becomes. Starting out as tight building blocks, to more open building blocks. to rows of houses and finally a single home configuration.

If a new area would be build another step further from the city center one would assume a fitting position would be again a little more spaceous in its composition while maintaining the general two to three floors.

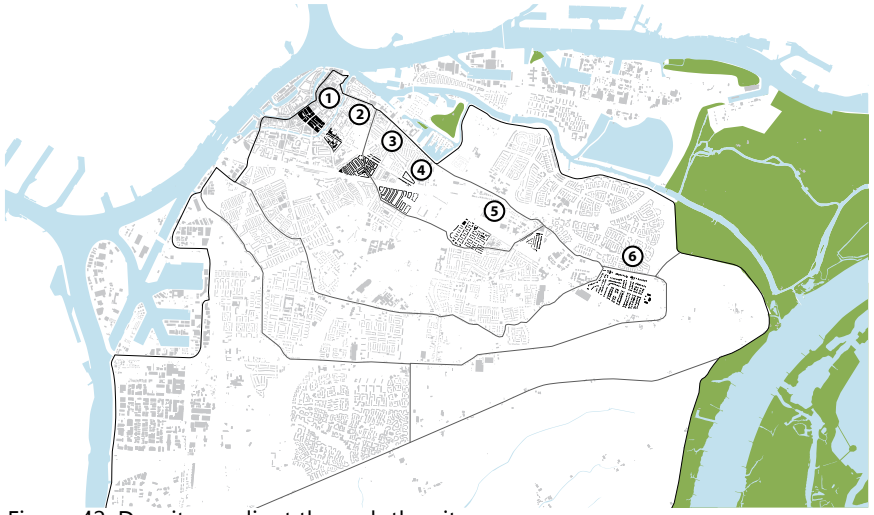


Figure 42. Density gradient through the city.

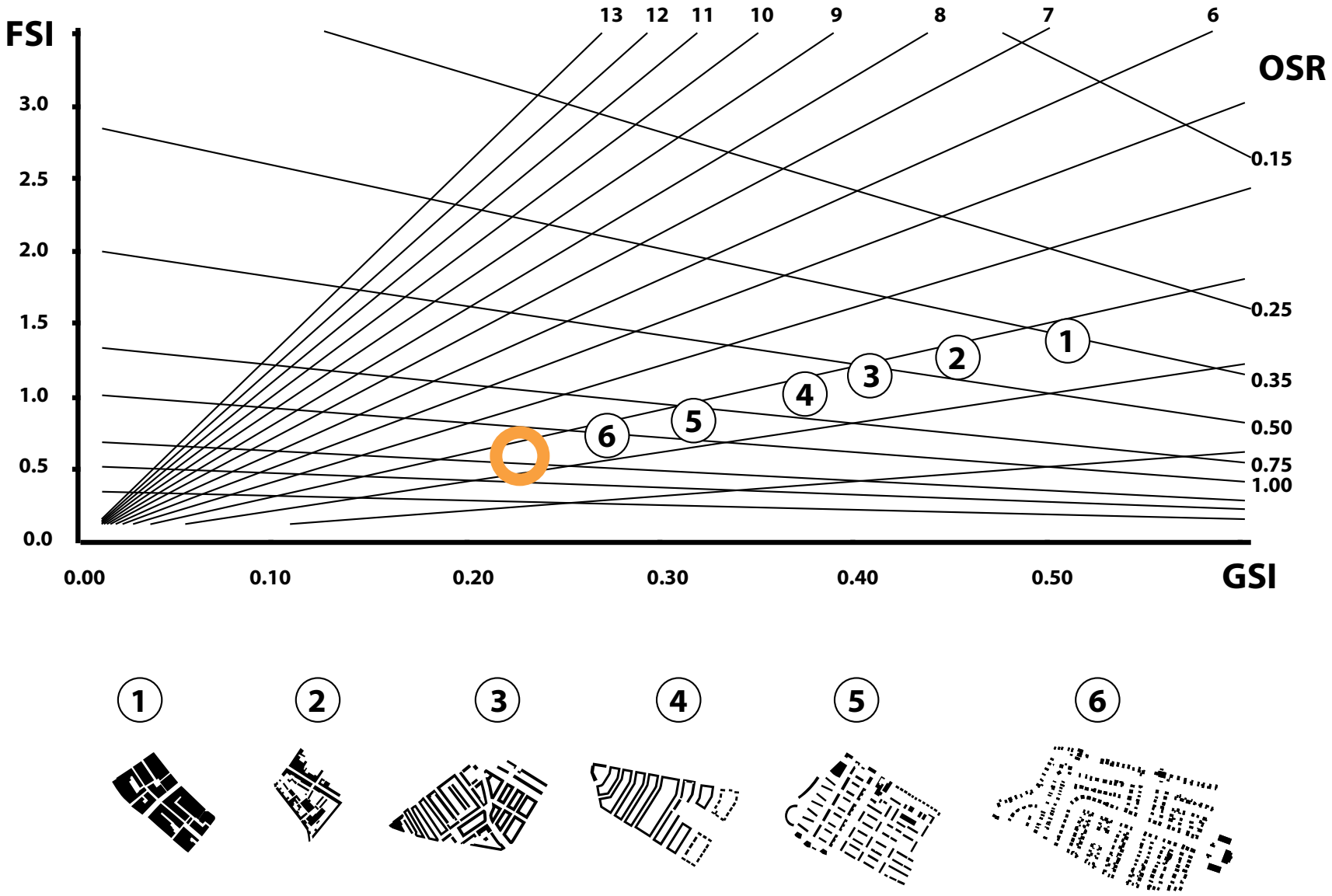


Figure 43. Densities mapped on the spacemate matrix.

4.5 Social integration

Dikes within the city have different relations to the urban spatial configurations that can be found along them. Towards the center the dikes are heavily integrated spatially with the urban form and towards the south the dikes can be seen as object that are sides by open green areas.

Both of the dikes at the northern and southern side have desirable qualities in form of cultural, recreational or functional ways. However for some dikes that can be found in the middle of the city its presence seems sometimes ignored.

While other dikes are daily experiencable these dikes that are ignored are hidden behind different kinds of development. In the illustration an example is given of the Oudendijk. One of the older dikes of the city that can be found in an area that was developed at the end of the 60s.

Alongside the dike the space is used for different purposes ranging from residential areas, sports clubs, scouting to businesses and a hospital. The dike is closely cornered by the buildings that were placed. When pointing out the entrances of these buildings another thing becomes clear. All buildings have their fronts turned away from the dike making the dike be cornering of the dike by backsides of buildings.

Being cornered in by backsides has a negative impact on the atmosphere of the dike. The once important element that still has cultural value to the city, as it is part of how the city managed to grow back to a respectable size, is now treated as a backalley.

New developments along the dike should respects is history and cultural value as well as preserve or improve on a desired atmosphere for functionality that it has today. Solely backsides towards the dike should be prohibited or a solution should be found for the problematic of backsides along a public road.

Figure 44. Backsides towards the dike.

One of the contributors to the denial of the dike is the height difference a dike brings. When the dike is used as a route such as in the design location the visitor is on a higher level than the surrounding landscape. This can cause some problems. Around Dordrecht different solutions to height difference can be found.

Most notable are residential buildings with their backside to the dike. The entrances are turned away and the social cohesion between the dike and the housing is solved through a fence or large hedge, public and private sphere are seperated rigidly and do collaborate . Within traditional dikehouses the public and private sphere are closely related, one could even say it is so close that the dike itself seems to be a part of the private sphere of the houses alongside it, as a form of front yard.

Within the city examples can be found of typologies that have a height difference within its own building. Drive-in homes and houses in the inner city often have their living rooms on the first floor while still having their front doors on ground level.

When superpositioning this concept of the duality in main occupied first floor and a connection to the ground level an encounter can be seen between how the dike functions mirror to the homes. People on the dike are now present in the habited sphere but the ground level still has its own social control.

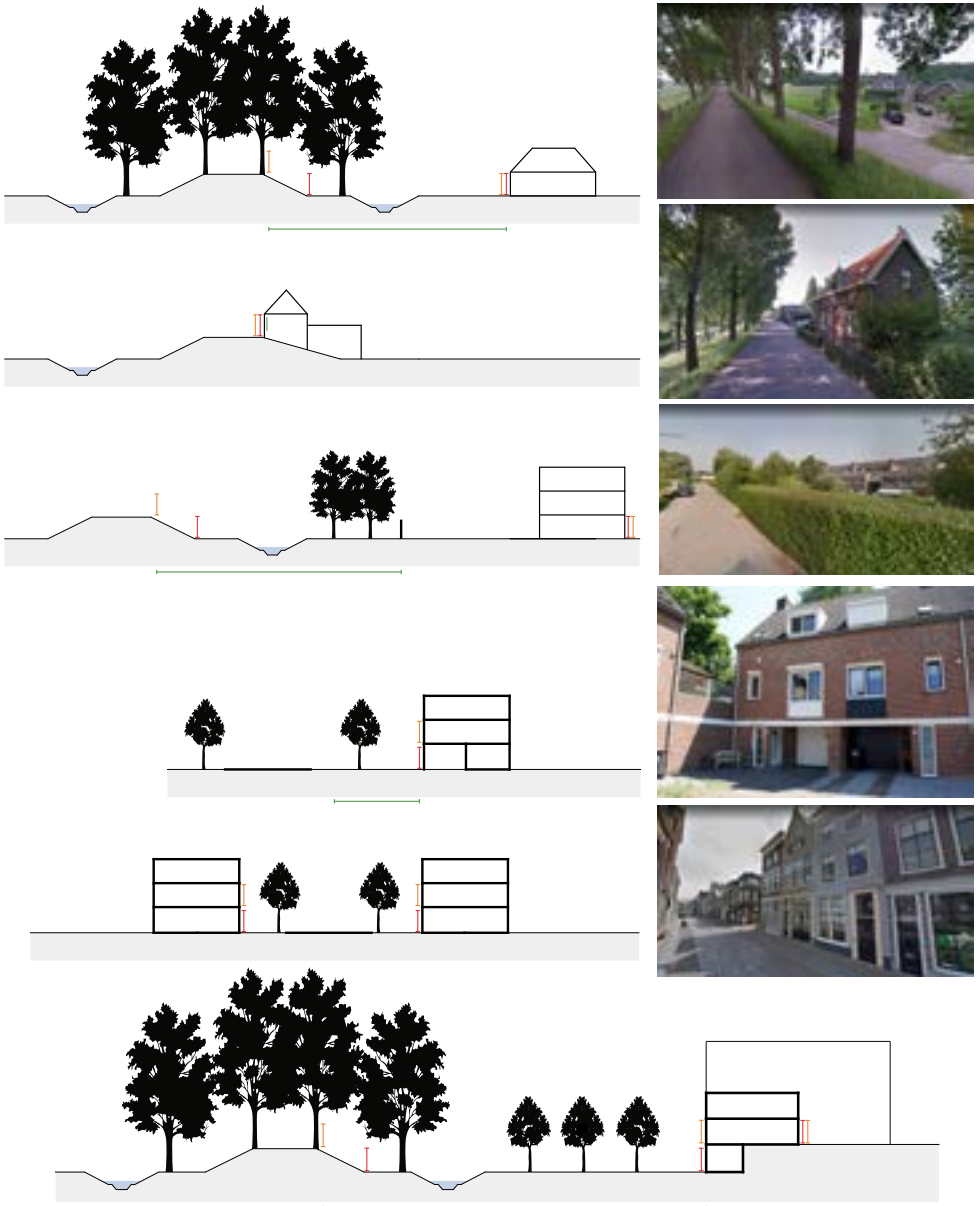


Figure 45. Social relations sections and examples. Pictures FROM: google streetview

4.6 Green structures

City to open landscape

To determine the characteristics of how newly biuld area in the Aloysen- of Bovenpolder may manifest a distinction can be made in how the space is divided between the built environment and the open green spaces.

Dordrecht is reaching its maximum capacity, this also means that the city does not have a lot of open spaces within the its structure. Parks and open green spaces are scarce and strongly lined with urban elements.

At the edge of the city a rapid turnaround can be seen where to open space is the main contributer to the landscape and the city's presence is changed more towards individual islands within this green space.

Expanding the city into these greener locations should consider that when building the leading role of the open landscape should keep its presence since it is one of the main contributors for the recreational function of the area and holds ecological functions as well.

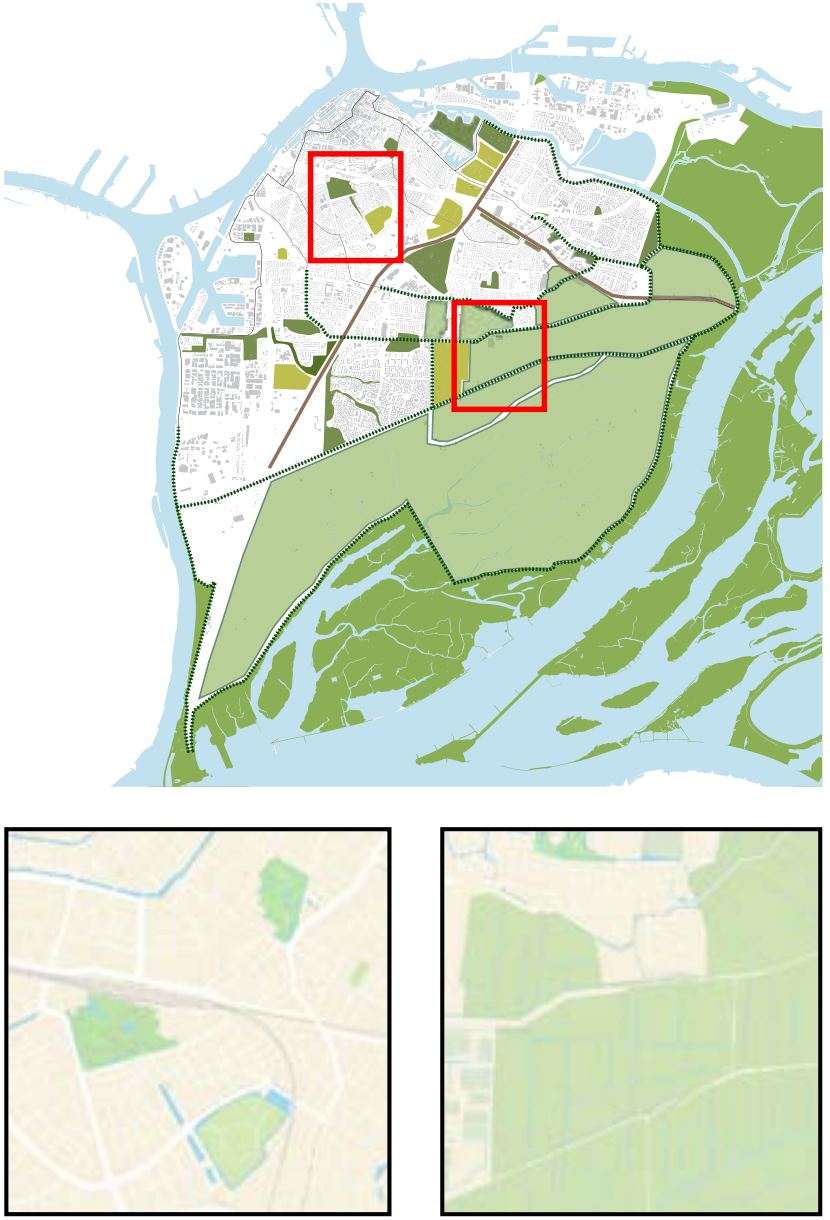


Figure 46. From the green space in the city to the city in the open green space.

Succeding dikes

The Zuidendijk along the Aloysen- of Bovenpolder is a popular dike for recreational use. It does however also have a cultural value in the sense that it is one of the readable layers of the city's history of reclaiming the land.

What makes the locationon the southeastern edge of the city more unique is the fact that is is the only location in the city where three succesive dikes can be observed without obstruction of the built environment. The landscape consists purely of agricultural polders with recreational line threading through them.

This is a quality of the location that is recommended to be preserved when assigning this area for urban expantion or intervention.

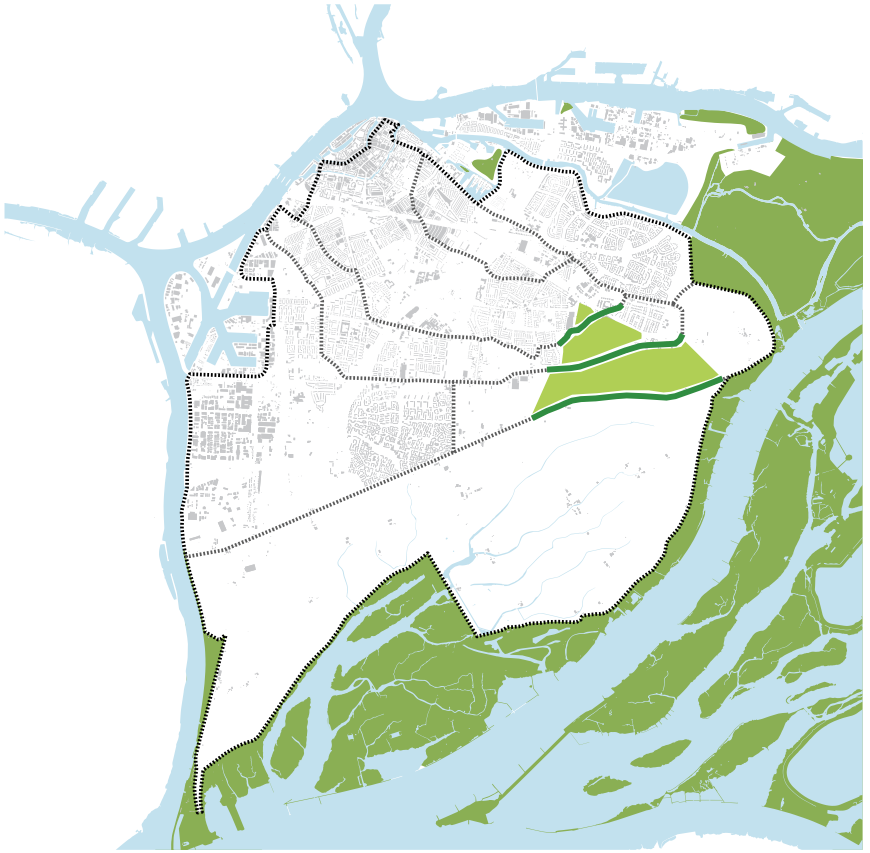


Figure 47. Unique location to experience multiple layers of dikes.

4.7 Ecological zones

Ecological zones and elements

Dordrecht is a densely built city. Within the city not much space is open for green areas. When looking at the map with the ecological zones on the island one can see that the majority of these zones can be found in the south eastern part of the city towards the city's borders.

Most of the ecological spaces in the city have the shape of a long stretched element connecting different types of green elements with eachother. The Corridor has a series of water bodies, the dike offer linear elements with trees, water and slopes and the Amstelwijckzone is shaped by an old riverbed that still is present in the landscape.

The exception to these continuous elements are the 'green oases' that can be found throught the city which is basically a collective name for the parks and open spaces that did not make it to belong to an actual ecological zone.

Within or adjacent to the project area of the Aloysen- of Bovenpolder four ecological structures can be found. The Corridor, the Aloijsenzone, the dike ribbons and the Dordwijkzone. Connecting to, extending or strengthening these ecological zones can benefit both the project location and the city as a whole.

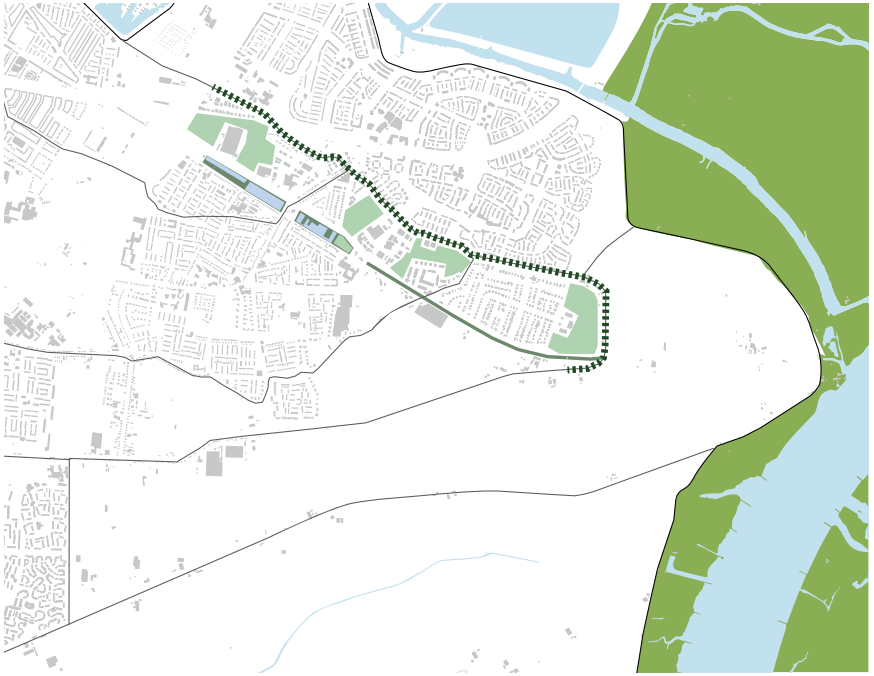
Figure 48. Ecological zones through the city.

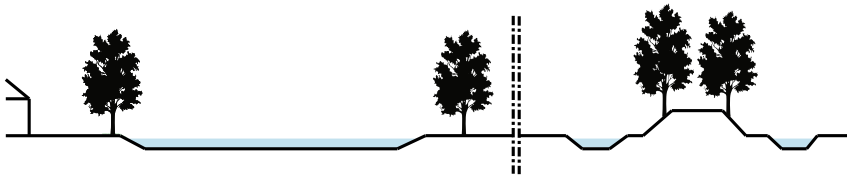
The Corridor
The corrridor as a ecological zone is carried by its edges and the alternated open spaces along the center.

The edges that form this ecological zone are the Noordendijk on the north edge and the alternating blocks of trees with water on the southern side along the Provinciale Weg. The Proviciale Weg itself can also be accounted for bringing value to the ecological unit the Corridor.

The soft ditch sides along the water bodies and the waterbodies themselves offer a suitable breeding ground for different types of birds, water plants and several insects that enjoy the humidity of the proximate water.

The blocks of tree in combination with the open scattered open fields offer an attractive home for small birds and bats that come out at night.





Aloysen zone
The Aloyzen zone is a small area that has a special value to the ecological network. It provides space for the screech owl.

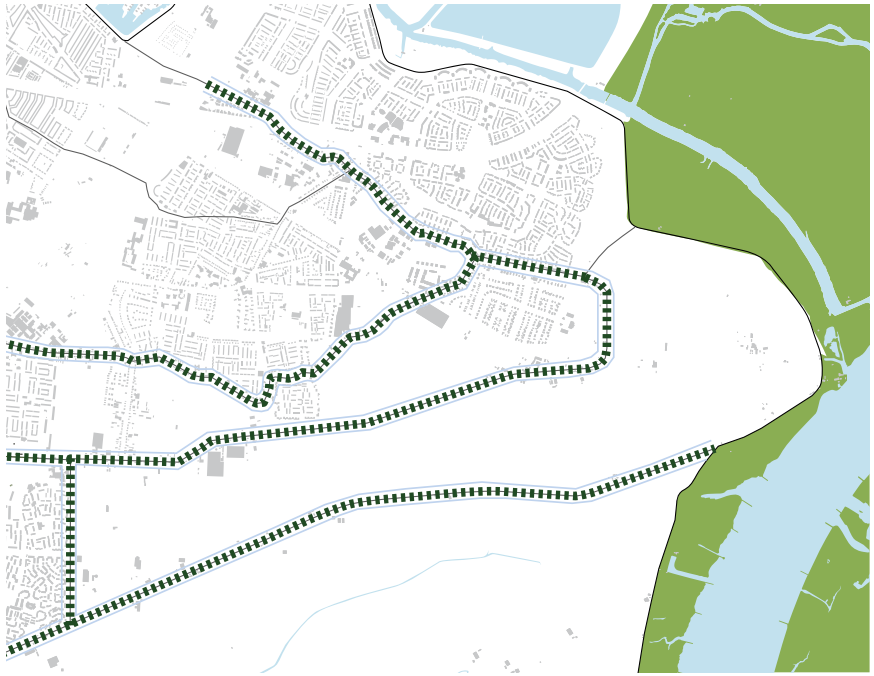
The screech owls territory is characterized by a alternation of groups of trees and larger open spaces for the owl to hunt. Combining this area with other ecological zones to promote the presence of small landbound animals would be beneficial to the habitat of the screech owl.

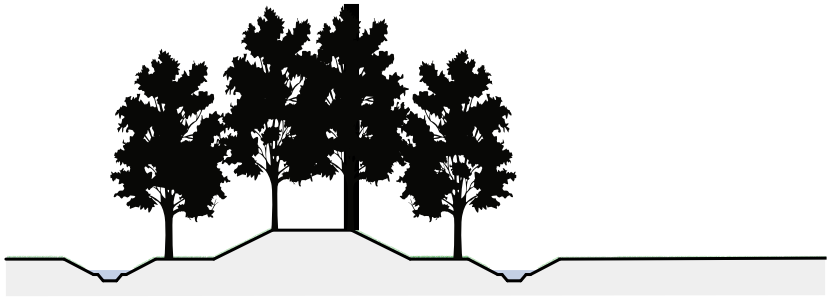
The groups of trees that the owl uses should not become too large for the animal needs to retain its possibility to freely fly around. The surface around these trees is best be well managed short cut grass.

Green ribbons

The dikes and some major roads form green ribbons that are spread through the city. The dikes are often lined with trees and have green soft slopes while the roads offer also a linear slope but do not have the continuous lines of trees as the dikes do.

The ribbons offer linear elements in the form of trees soft slopes and water trenches for different animals to use to travel. This is the case for small ground bound animals such as mice or animals that make use of the tree like small birds or bats.





The Dordwijkzone

The Dordwijkzone is the largest ecological structure in the city and offer a collection of what all other ecological zones can offer.

The area offers water bodies with soft sides, open fields in the form of parks as well as sports fields. Groups of trees and lines of trees. Green road sides as linear elements.

Due to its size and all the different typologies of green that is incorporated in this zone it is the most rich in flora and fauna diversity.

4.8 Pictoral experiences

The Aloysen-Bovenpolder is a long stretched river polder. The narrow space defined by two dikes accentuated by rows of trees with a right angled sequential polder structure can be a soothful landscape to spend time in. When moving through this landscape it can be experienced as a series of painting composition that present themselves along the routes that follow the structure of the dikes.

To map the said compostions trips were taken along the recreational network and sketches were made when a suspected qualitative composition presented itself.

The imagery that was found while strolling through the area can be divided into four different composition styles as defined by Edgar Payne (2005) in Composition of Outdoor Painting. Those four styles of compositions are the Rectuangular composition and its closely related steelyard or balanced composition, the Group Mass composition and the Tunnel composition.

To conserve the recreational quality of the area it should be attempted to preserve, strengthen or recreate the imagery that can already be found in this polder. These qualities can also prove to be a valuable asset to other functions that could be planned such as residential or outdoor recreational areas.

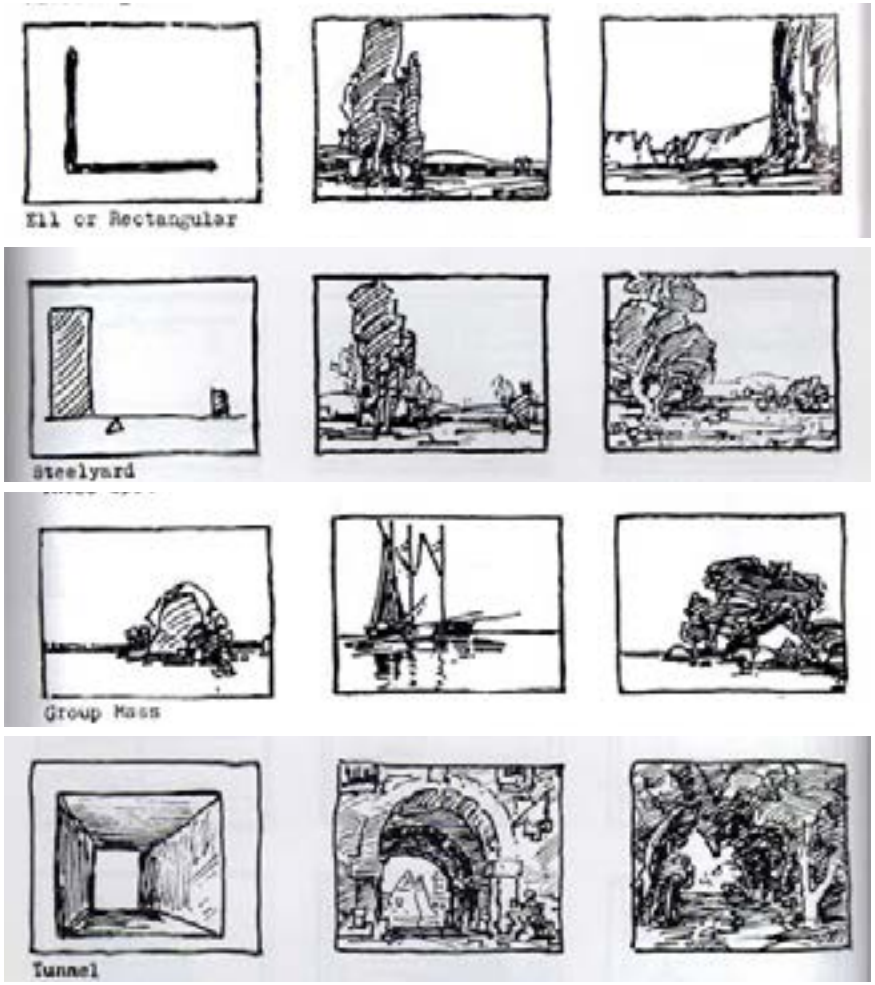


Figure 50. Ecological zones through the city. BY: Edgar Payne (2005)

Steelyards

The first distinguishable composition types are the closely related steelyard or balanced composition and the rectangular composition. This type of composition is defined by a strong high element on the foreground with a wider open view with incidentally some objects in the distance in the rest of the view.

Within the landscape the image is build up by different elements. The high element on the foreground can be the dike itself where the trees on dike form a cadre of what you see, this element can also be the farmsteads or dike houses that incidentally are located along the dikes.

The lines of trees on the parallel dike in the background and the recognizable structure of the polder form a subtle interplay of lines that connect to the high elements in the foreground. This interplay of lines create the balance or represent the base of rectangle in the steelyard and rectangular compositions respectively.

This type of composition accentuates the dynamic of the area showing the objects that can be found on and along the dike but also shows its relation to the depth and wideness of the landscape and the structure of the polder.

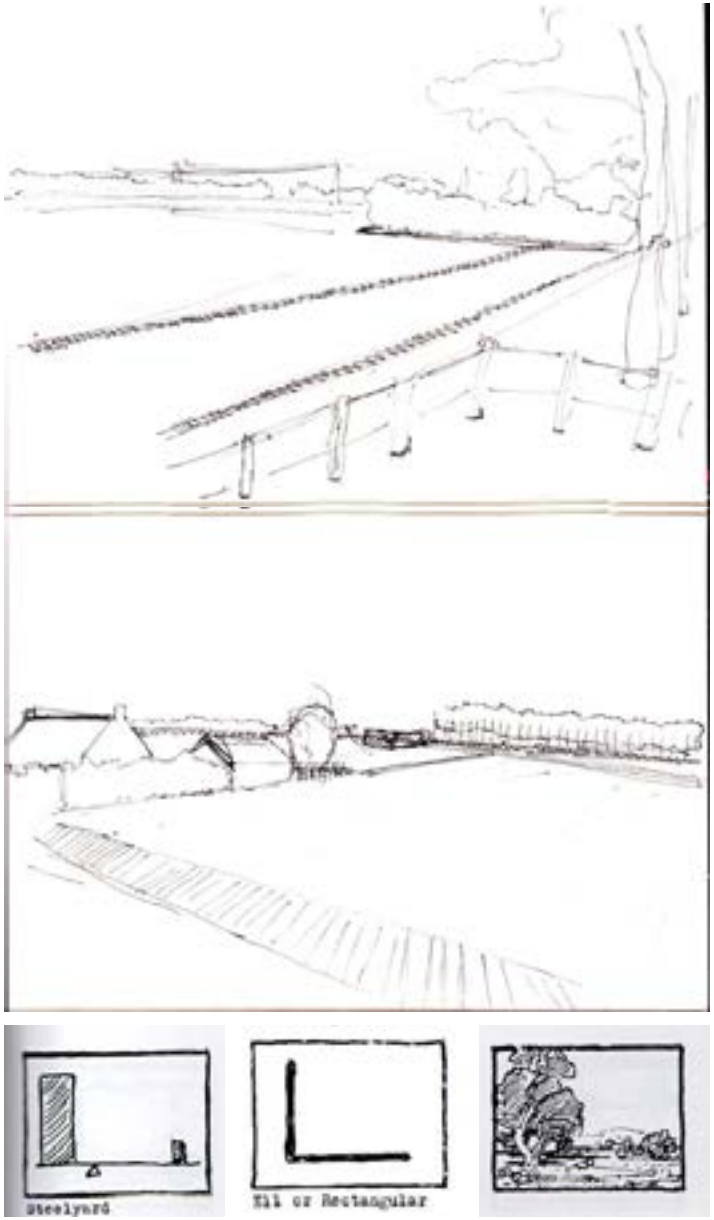


Figure 51. Ell type views in the polder.

Tunnelvision

A second type of composition that stands out is the tunnel composition. This type of compostion consists of a cadre of objects on different sides of the image while maintaining a far view through this cadre.

When moving through the area this type of composition is framed by the same type of objects that can be found in the balanced composition. However in the tunnel view these objects can be found closer together so they frame what you see on multiple sides, leaving a guide to a far view.

The frame guiding the far view guides what your gaze towards the next dike that is closeby. Guiding your view perpendicular on the dike you are standing on restricts the view of the wide landscape to the shortest line possible. This supports the experience of how narrow but long stretched the space of this polder actually is. In addition, the tunnel composition alternated with the previous composition that lets the viewer experience the depth and wideness of the polder adds to noticing the long stretchedness.

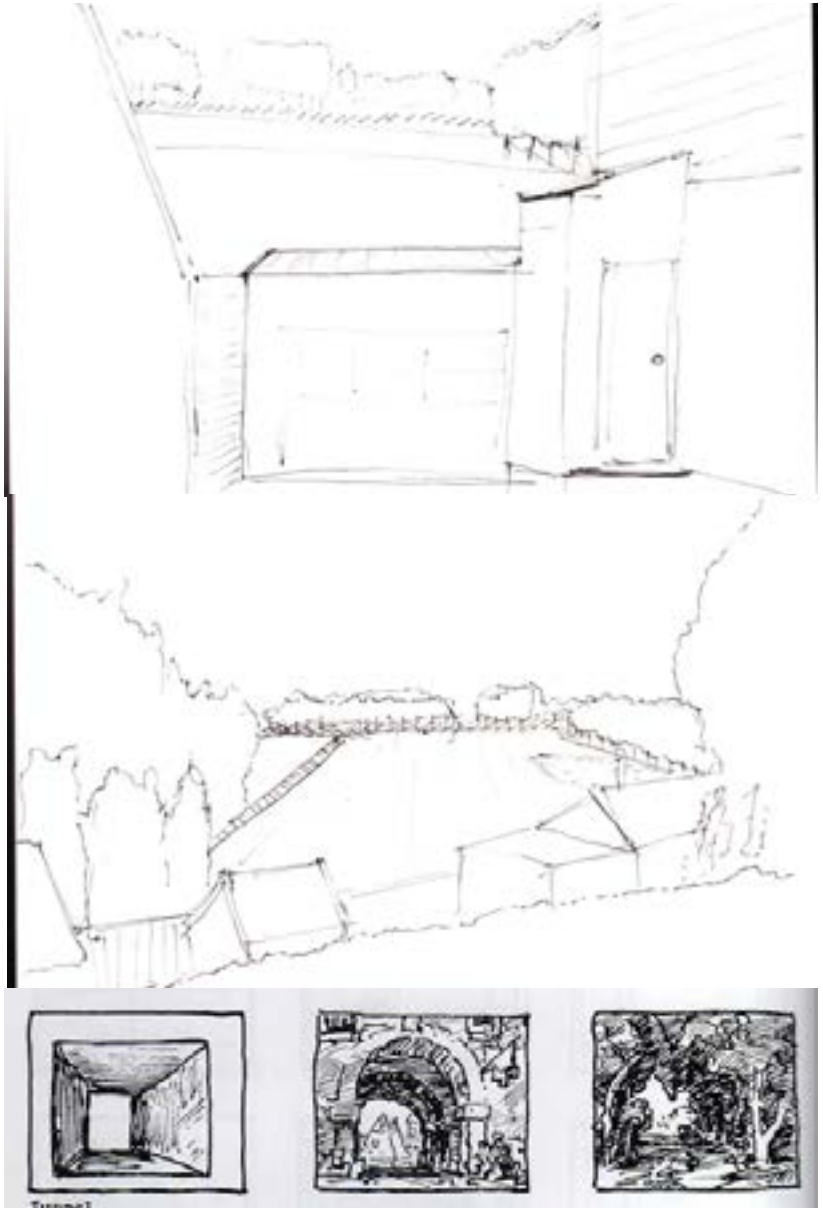


Figure 52. Tunnel type views in the polder.

The lone object

The last composition that could be distinguised from the sketches made while in the area is the group mass composition. This type of composition is based on a object or group of objects that form the center of a scene while a frame for the view is usually missing.

The polder is defined by two lines of dikes lined with trees. These dikes are continous straight parallel elements that leave a relatively narrow space in between. The objects that can be found along the dikes that form the frames of the first two mentioned compositions can be seen from the other side as well. This sometimes presents itself as a single object along a continous line that forms a central object of focus in view.

Experiencing objects from both sides, from the adjacent and from another dike, can help understand a bit of the history of the area where dikes were built in succession to win land after the Sint-Elisabethsvloed. The outer three non-primary dikes can be experienced from one another and share some similarities.

Figure 53. Group mass type views in the polder.

4.9 Spatial quality on location

Straights and angles

When moving on the Zuidendijk along the Aloysen- of Bovenpolder a duality between lines can be experienced. The difference of where the dike is straight and spots where the dike is built with an angle.

Both of these also offer two specifics on how the area can be experienced.

Straights

Firstly the straights. The largest parts of the dikes are built straight. Straight lines together with the continuous lines with trees form a tunnel that guides you along a path in this recreational network. The trees forming the tunnel provide some shelter within the wider open landscape that the dikes threads through.

When turning your head to the side the tunnels opens itself as the tree are far enough apart from eachother to experience what the area has to offer. The speed at which someone travels contributes to this system where the faster type of transport you use the more forwards your vision is drawn. While walking you will be looking more out into the open while in a car you are follwing the tunnel.

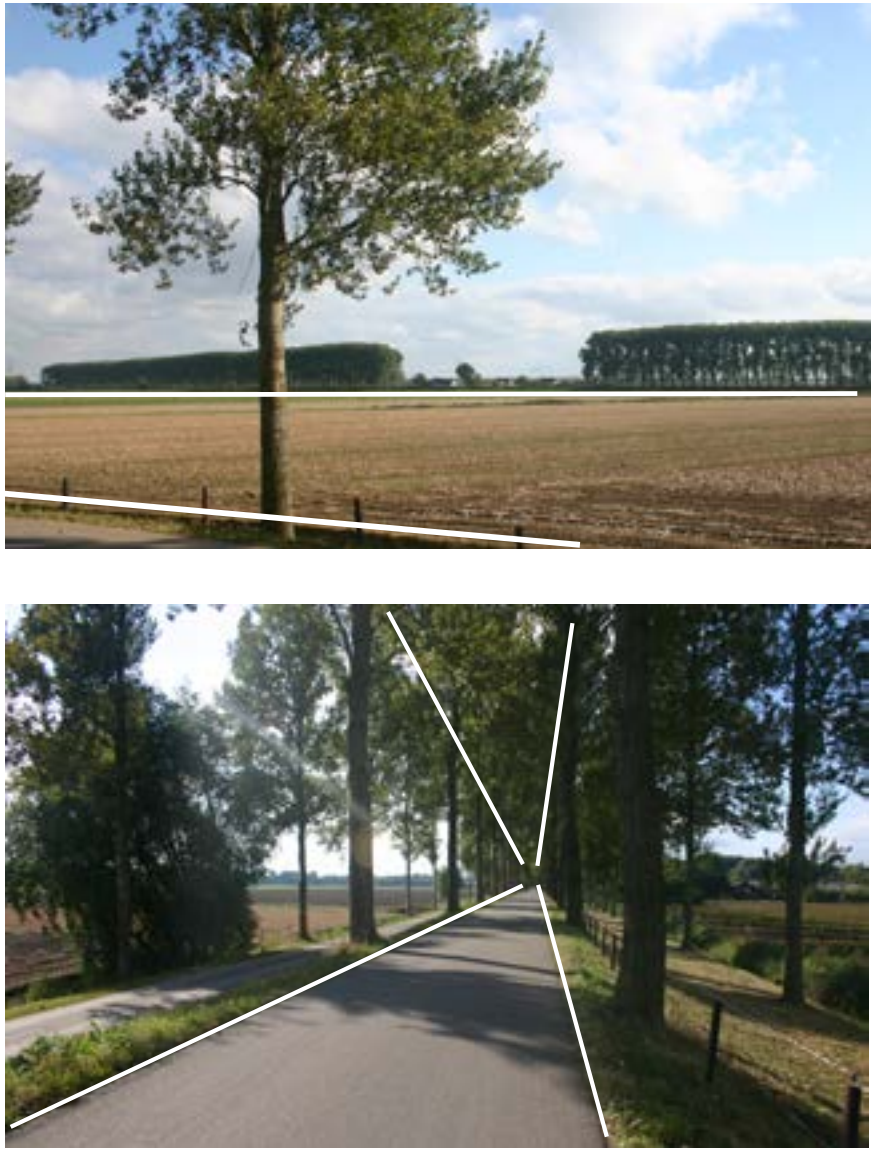


Figure 54. Straights along the dike.

Angles

In contrast to the straight lines the angles experience is of course where the dike changes direction and interupts its linearity.

The angles can be experienced in two ways depending on from what side you are coming from. Every angle consists of a pit and a vista. The pit is the inside of a corner. Thie corner will block your vision drawing attention to the location of the corner itself creating a more sheltered location.

In contrast to the inside of the corner the vista, or outside side of the corner draws your ettention to the open landscape. This is similar to turning your head on straight lines except the view is forced as landscape opens itself up while moving through the tunnel.

The duality between angles and straights make someone experience the landscape in different ways. Where the linearity offers shelter the angles provide a tools to force someone to have viewpoints by simply following the roads.

Figure 55. Angles along the dike.

Narrowness and farsights

The quick succession of the building dikes led to the strips of land in between to be narrow long spaces. In this landscape these two directions dominate the experience main sightlines.

The narrowness draws your attention towards the follow dike that is closeby. The dike that runs in parallel can clearly be distinguished in its form where the taluds start and how the trees stand on the dike in a rythmic pattern.

Along the other axix is a more impressive sightline. On can look through the entire polder. The framing dikes on each side help guide your vision twards the end of space slowly disappearing into the distance.

The dynamic that is created between the narrowness and farsights improve ones experience of the area. The alteration of things to look at closeby with your sight wandering further away makes for an engaging experience of the landscape.

Figure 55. Narrowness and farsights within the riverpolder.

Figures 56 & 57. Narrowness and farsights within the riverpolder.

Dominant polder structure

In addition the narrowness and the farsights the successive dikes also form the structure of the polder plots. The narrow spatial compostion only allows for one way the watering system of the polder could sensibly be integrated, perpendicular to the dikes.

The perpendicularity supports the feeling of the narrow space in between the dikes as the trenches in between plots of land do give a direction parallel to the narrowness of the area.

Figure 58. The polder's typical trench pattern.

Design exploration

As a starting point for the design three seperate designs based on characteristics of the river polder to serve as starting point for the end product.

The first design is based on the playful duality of angles and tunnels along the dikes. A subsystem of angles is made where focus is given to long viewpoints when traveling along the dikes as well as on the outside of the planned residential areas.

The second design is based on the space between the dike being long stretched but very narrow. The design focuses on strengthening that characteristic by narrowing the space even further. The residential reserved building sites are based on where a person can still experience the long strechedness of the polder while moving along the dike.

The third design is fully based on using the polders trench structure as leading element. Residential strips are built along the different trenches making use of the quality of water in a built environment and strengthening the linearness of the trenches with the parallel strips of housing.

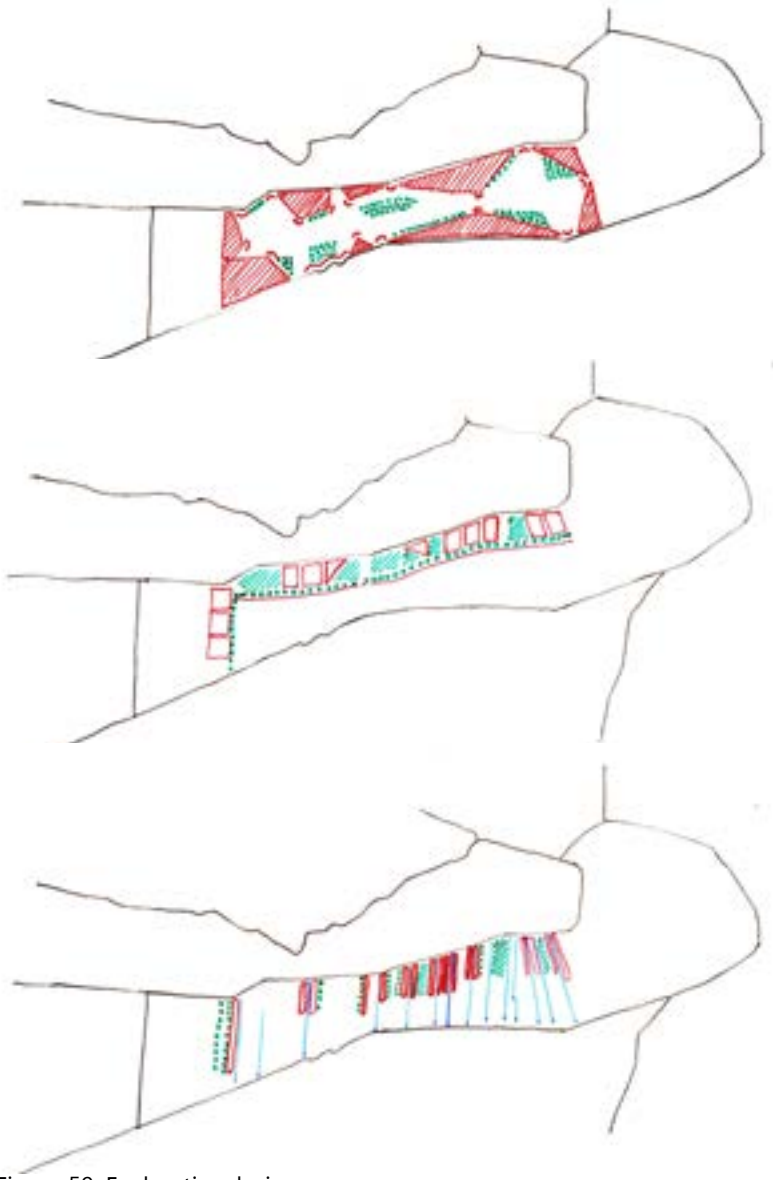


Figure 59. Explorative designs

5 Design

5.1 Framework

The design goal of the design being an adaptive plan that can incorporate different dynamics from the city as well as offer a solution towards the looming threat of water under climate change calls for a design that can progress under certain needs. When more room for housing is needed a new block for expansion can be considered and when water levels keep rising the plan can transform to its final room for the river stage.

For such a plan the basis will be a framework that can be developed until its boundaries are met. The framework of this plan consists of building locations that are determined by different factors such as sightlines, recreational experience of the area, green structuresand typologies of how the edges of the mounds can connect to the dike and the landscape.

On the other hand the framework sets the base for the water safety plan and how this will affect the dike and what this will mean for the mounds.

The design on how to develop the mound, how many houses what typology of housing, what to do with the inner courts of the mounds is partly open to the developer that chooses to build on one of these locations.

Within the set framework on a larger scale one can find the shapes of the mounds as well as the positioning of the mounds. Between these mounds open spaces are present in the form of water retention areas. These water retention ponds are located at the lower lying parts of the polder and the excess ground can be used for the construction of the adjacent mounds.

In the framework also a suggestion can be found on a potential plan for the zuidpolder. This polder is located between the project site and the city. As is wished by the municipality the green atmosphere should be kept intact. The suggestion maintains the main green open areas and uses them to extend existing ecological structures as a link towards the project location.

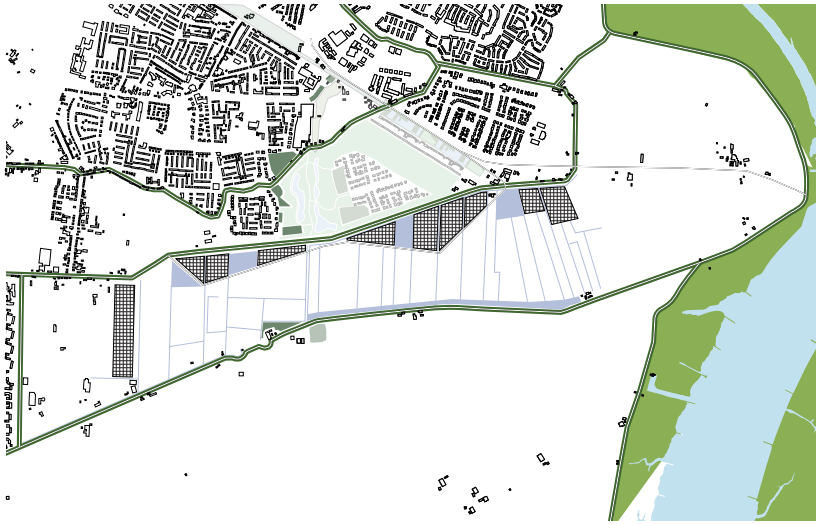


Figure 60. Framework for developments.

Dike as leading element

Considering the historical context and value of the dikes of Dordrecht as well as the recreational purposes it serves for the city, the Zuidendijk will be the leading element in the framework. Developments in the form of mounds should be attached to this dike and can later help strengthen it as well in its role as primary water defense.

The dike and its role in being able to experience the different layers of multiple dikes within the landscape is something that should be valued.

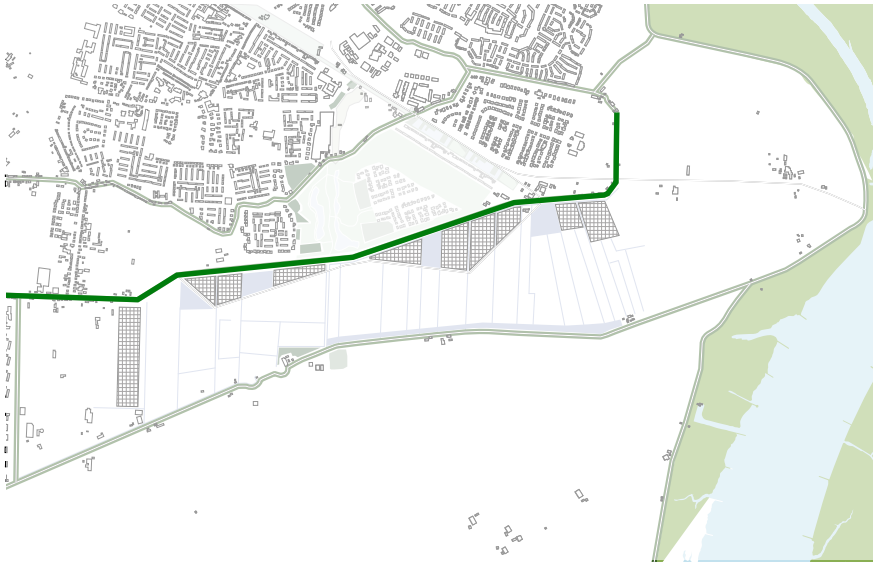


Figure 61. Dike as leading element for developments in the polder.

Faces towards the dike

The mounds that can be build along the dike should have a face towards it. Since the 60's developments in Dordrecht are bound by the different dikes on the island. These developments have little to no relation to the dike and make the dike feel like a forgotten part of the city. Having the mounds face the dike can solve such a potential future case by prescribing front doors or no backyards to be situated along the recreational route. This promotes social control and stimulates social meetings.

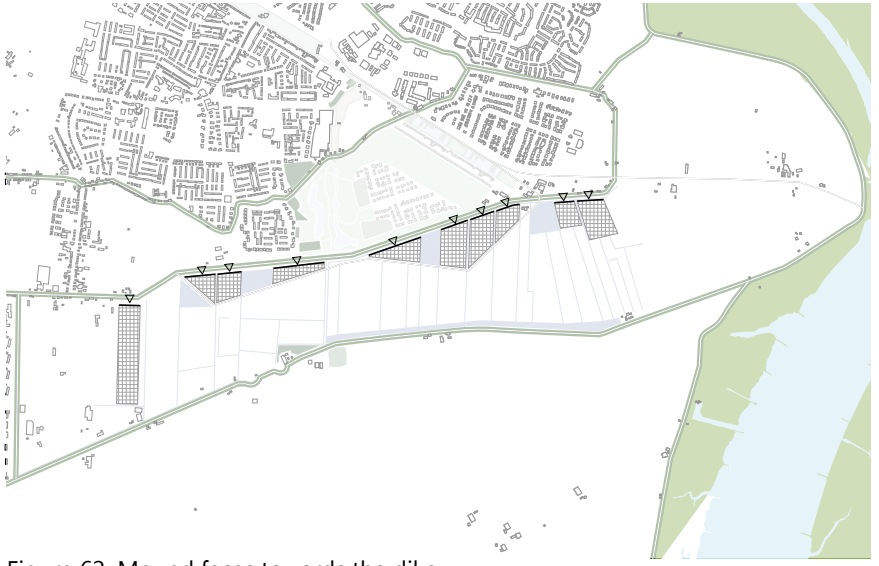


Figure 62. Mound faces towards the dike.

Shaping the mounds

The main contributer to the shape of the to fields that can be developed are the sightlines. The area is used recreationally and the dike offers the possibility to experience to open landscape and its spatial qualities. The sightlines used to shape the plots are based on the angled sightlines that follow from the Zuidendike towards the open landscape and long stretchedness of the polder or elements that can be found along the adjacent Zeedijk. These sightlines resulted in compact locations along the Zuidendijk not built too far into the polder so the long nature of the polder is still experiencable as well.

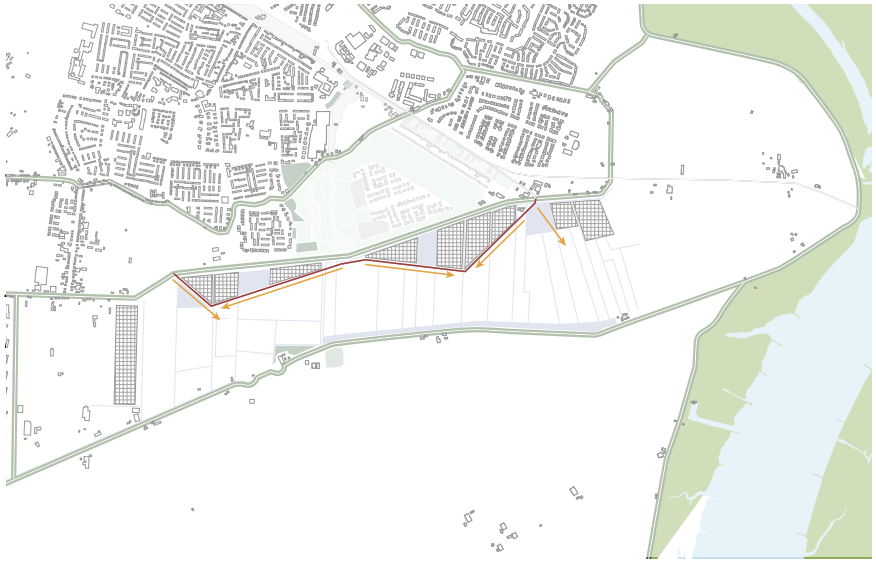


Figure 63. Sightlines determine mound boundaries.

Polder structure

The other shaping factor of the plots is the polder structure. Trenches in the polder that connect the parallel dikes offer a natural rythm that divided the land in smaller strips. This rythm also offers a basis for the size of the future mounds. Keeping these trenches intact will be a testament to the location as well as keep the sightlines perpendicular to the dikes in place that guides vision to experience to how nearby the folling dike actually is.

Figure 64. Polder structure divides the mound into smaller segments.

Ecological structures

The city is limited in its amount of open green space, this means that most of the ecological structures that can be found on the island of Dordrecht are found towards the borders of the city. The plan is connected to three ecological structures. Towards the eastern side of the plan it connects to the Corridor a green space alternated with parts open water. This is continued in the green nature of the mounds themselves with water ponds in between them. Secondly the Aloijzen zone, a ecological zone of forested areas alternated with open spaces. This will be driven to connect towards the outer Zeedijk. And lastly the dikes themselves that serve as green lints through the city scape. Leaving the dike intact as a continuous object and continuing on the other present structures serves will benefit both the city and the location itself.

Retention ponds

The area knows different water problematics. One less directly related to the river is rainfall. Extreme rainfall can cause the area to go blank while droughts can happen as well although these are less dramatic as the river can provide water if needed.

Adding retention ponds offers a solution to excess water and also provides a small buffer in can of droughts. The ground that is excavated for the ponds can be used to develop the mounds.

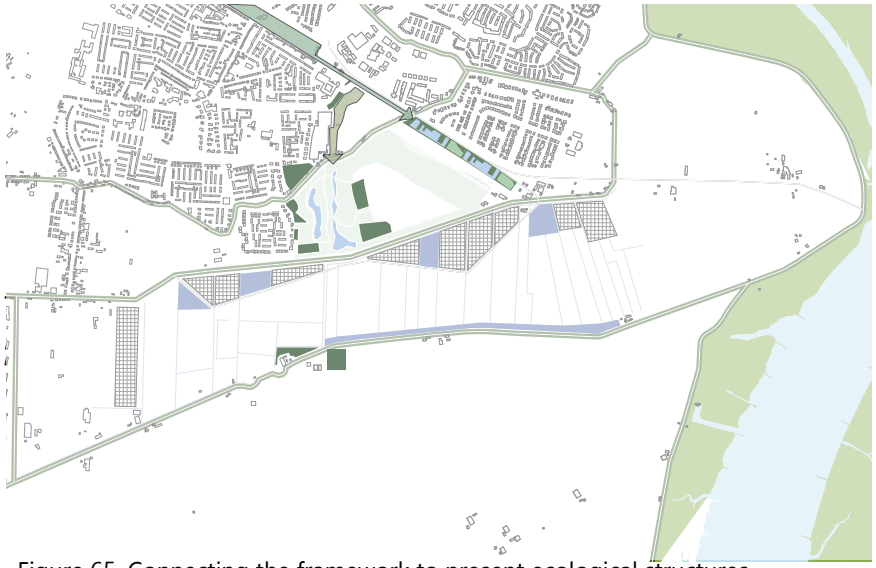


Figure 65. Connecting the framework to present ecological structures

Figure 66. Water bodies to help with rain retention.

5.2 Mound ruleset

The framework continues on a smaller scale. The first prescription on the smaller scale is that the open plots for development should all be in the shape of mounds as height is the main tools to survive in flooding areas is height. Higher ground ledges or barriers are used to keep the water away from where it is not wanted.

Within this project mounds are a fitting typology as the buildings will be situated along the Zuidendijk offering a tool to cover the difference in height of the polder and the dike. The mounds that can be built are different from conventional mounds as they are much larger in size and can serve a multitude of homes or other buildings.

The ruleset for mounds consists of the relation to the mound to its surroundings and a base for flood safety. The mound offers opportunities concerning self reliance in case of flooding and sustainability.

Self reliance and sustainability
They should be equipped with a combination of PV panels on the roofs, shallow ground warmth that can be gathered from the mound and a large septic tank for when the sewer dysfunction under a flooding, the habitants of such mounds could live up to a week without major discomforts.

These solutions would scale up to 50 houses or 200 residents per mound. If high density typologies like apartment buildings are the main type of building for a mound then other solutions mainly an alternative source for warmth should be considered. Going in the same line as the shallow ground warmth a viable option would be a Thermal Energy Storage system (WKO) so the mound can still be self serving. An option like this would be more expensive but drastically improves thermal capacities.

For a sewage tank to be large enough to serve 50 homes or 200 people for a week it should have a volume of at least:

120 liter per person per day * 200 people * 7 days = 168m^3

That could be in the form of every house their own tank of 3,5 m^3 or one central tank with dimensions of 4m*4m*10m.

Electricity during a flooding should only break down if the central is hit by the flood however technology for PV panels have come thus far it would be an unwise decision not to use them in sustainable development. To be 100% self reliant every home should have incorporated 40m^2 of solar panels. This would make roofs have a special design preferably facing towards the sun on a slanted roof.

These homes would be gas-less as enough energy and warmth can be gathered from the ground and from the sun.

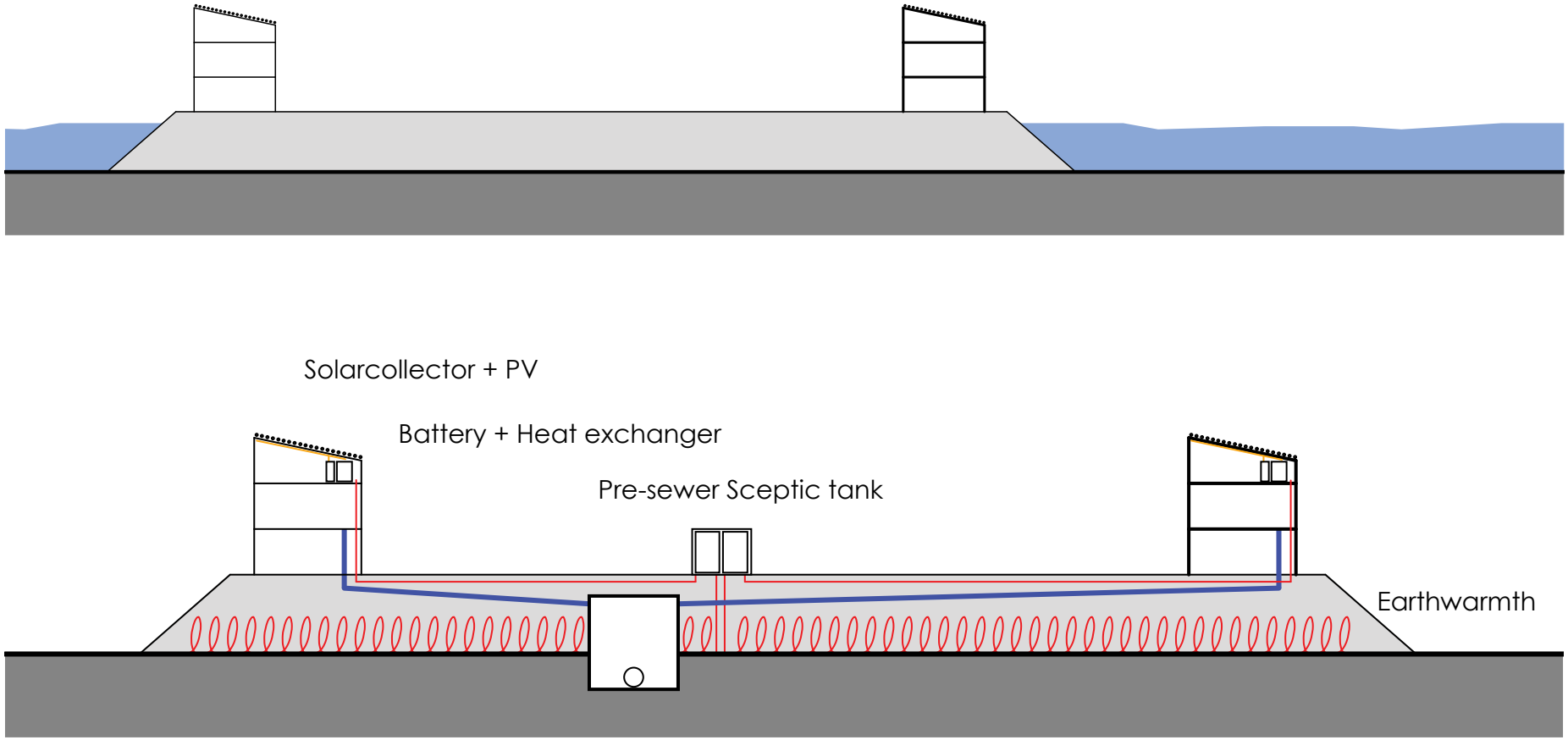


Figure 67. Self reliance and sustainable measures integrated within the mounds.

Mound configuration

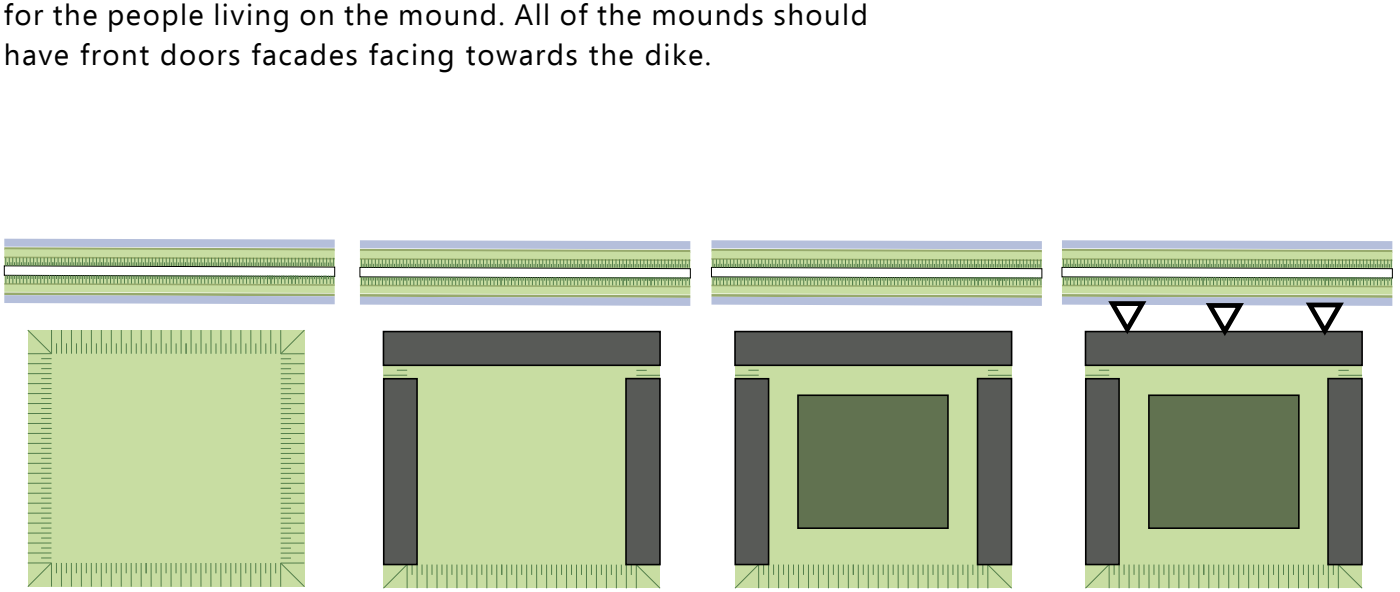
The Zuidendijk that will be built along currently has recreational, cultural, historical and ecological value. Knowing how developers have treated other dikes when developing new residential areas a ruleset has to be put in place what is allowed and what is not allowed to build along the dike.

Firstly the spatial configuration of the mound. Being a mound the first given is that an area along the dike is heightened to three meters above the ground level. followed by giving the mound solid recognizable edges towards the dike. Within the mound an open space should be available as outdoor area for the people living on the mound. All of the mounds should have front doors facades facing towards the dike.

The inner areas that are stated to be an open outdoor space can have different fill ins ranging from small apartment blocks to single houses urban farming lots or just kept as a

small private park for the surrounding residents to enjoy.

These rules mainly cater towards the dike being the spine of the expansion project. Making sure the recreational route will not be the victim of numerous backsides affecting its value towards the general public.



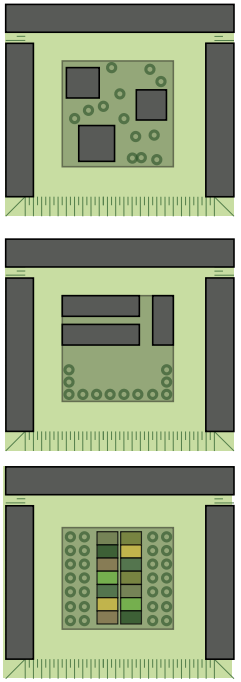
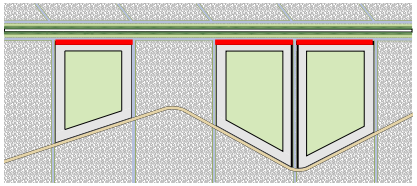
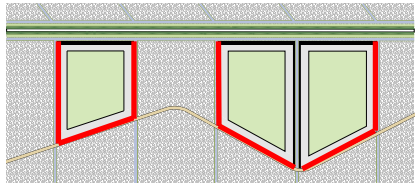


Figure 66. Spatial configuration of the mound.

Example sections of facing the dike



Example sections towards the open landscape



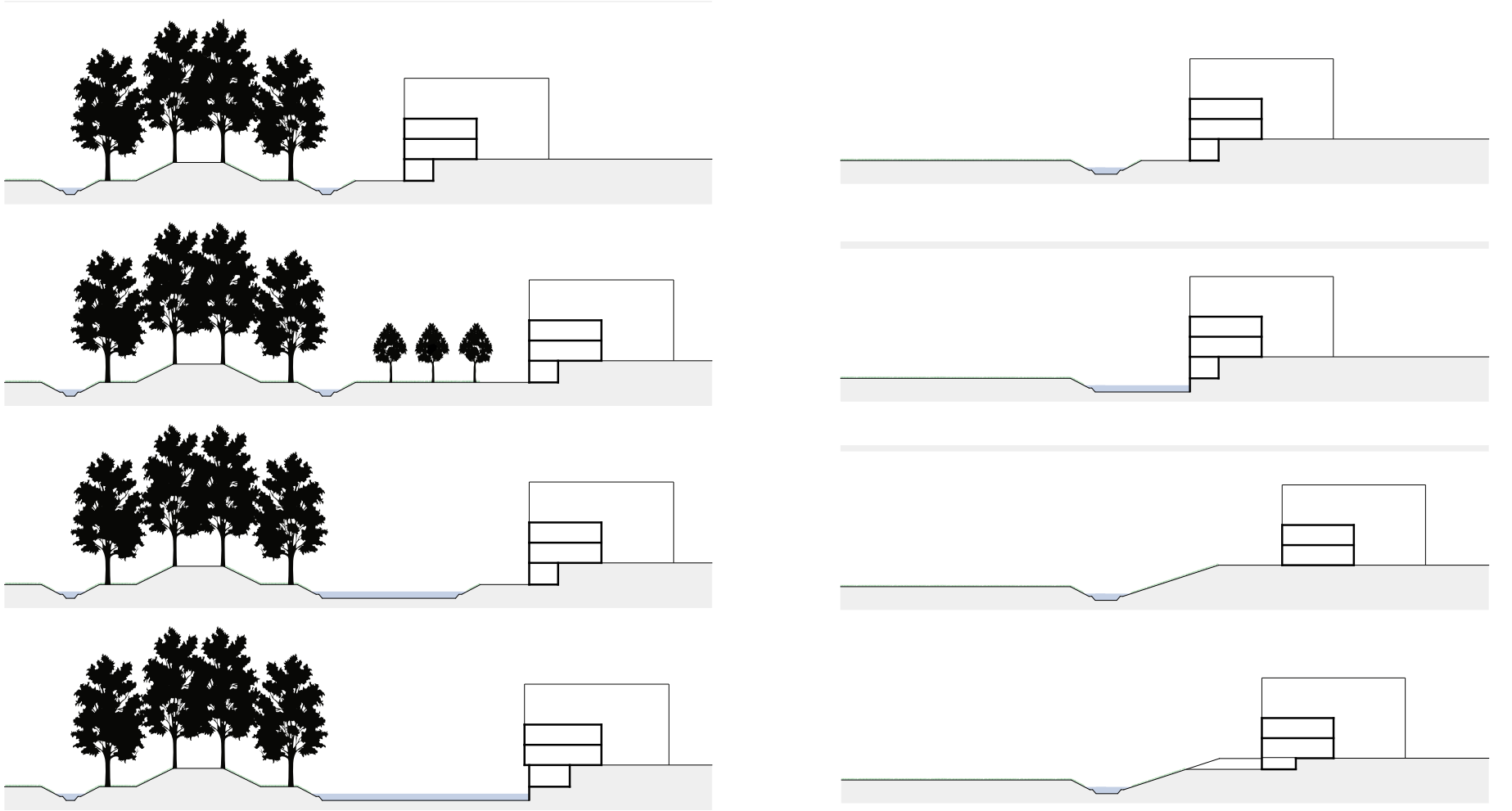
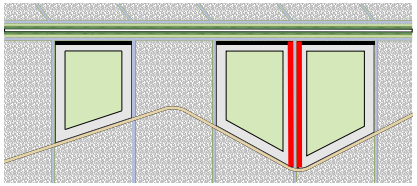
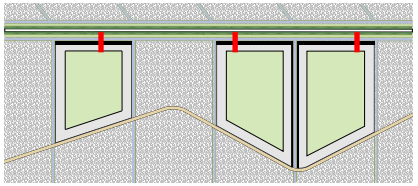


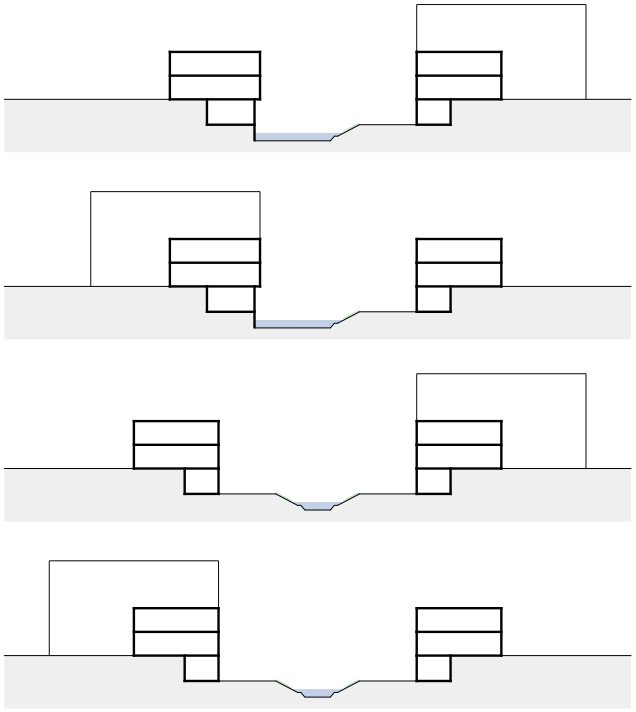
Figure 67. Possible edges of the mound connecting to the dike and polder landscape.

Example sections of mounds facing each other



Example sections of connecting to the dike





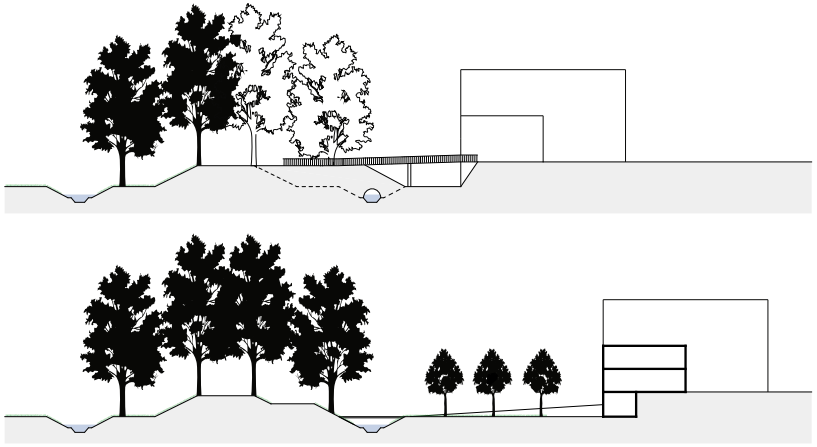


Figure 68. Possible edges of the mound connecting to other mounds and connecting infrastructure to the dike.

Dike strengthening

The water safety plan for the area within the project accounts for the possibility to transform the area into a floodable area in a room for the river concept. This means the Zuidendijk that will be built along transforms from a compartment dike to a primary dike. Extra needed height to comply to the requirement of a primary dike prescribe a reasonable amount of extra height as the Zuidendijk in its current shape will not suffice.

This expansion of the dike will incorporate the adjacent mounds as an integral part of the new water defense system. The area in between the dike and the mounds will be filled up causing the lower ground below dike and mound level to disappear. The dike will now be higher than the mound. This means the lowest floor that was a social connection to the polder level will not be needed anymore. The room there can transform into a storage room or another home function that does not need sunlight.

Two options are given to the location of the highest point of the dike. One where to current position is used as highest point. This model leaves most room along the fronts of the houses for infrastructure and the top of the dike can be used as recreational route that allows a full experience of the surrounding landscape. The second option is one where the original dike is still largely intact and can still function to help against the effects of piping. The top of the dike would then be close to the homes causing a more initmate space along the frontsides of these homes. In this case the main infrastructure would flow on the higher point of the dike while recreational slower traffic will have stay on the lower part where the old dike can be found.

Both options could be implemented if the choice to transform the area into a room for the river location is made. Because the plan is a framework time will tell which of the options offers best compatibility for the situation.

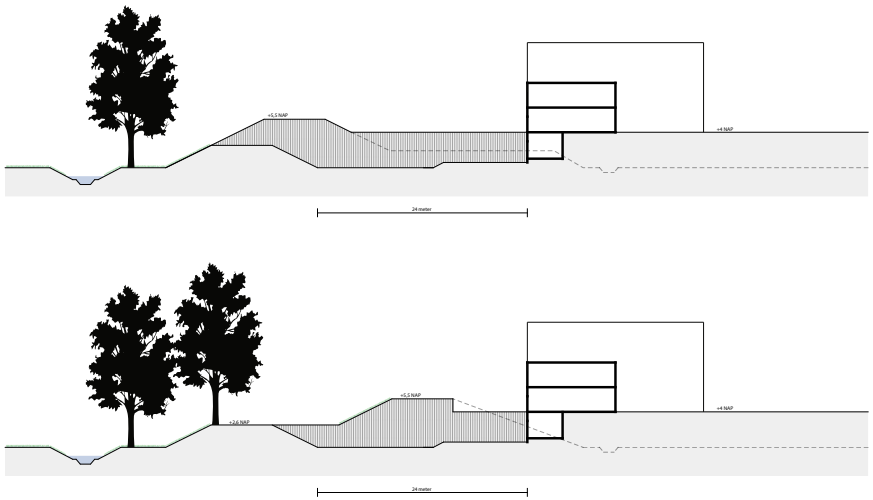
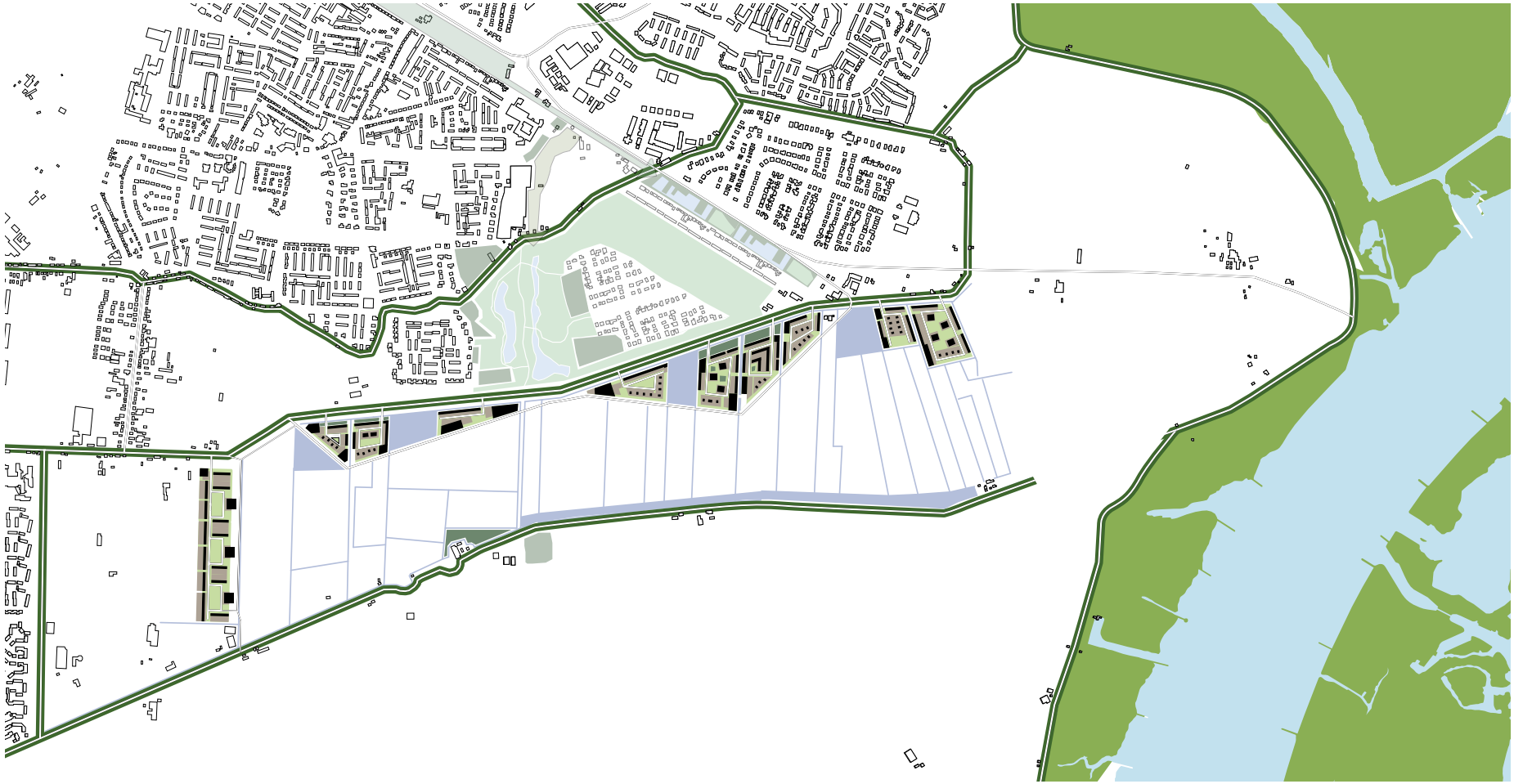
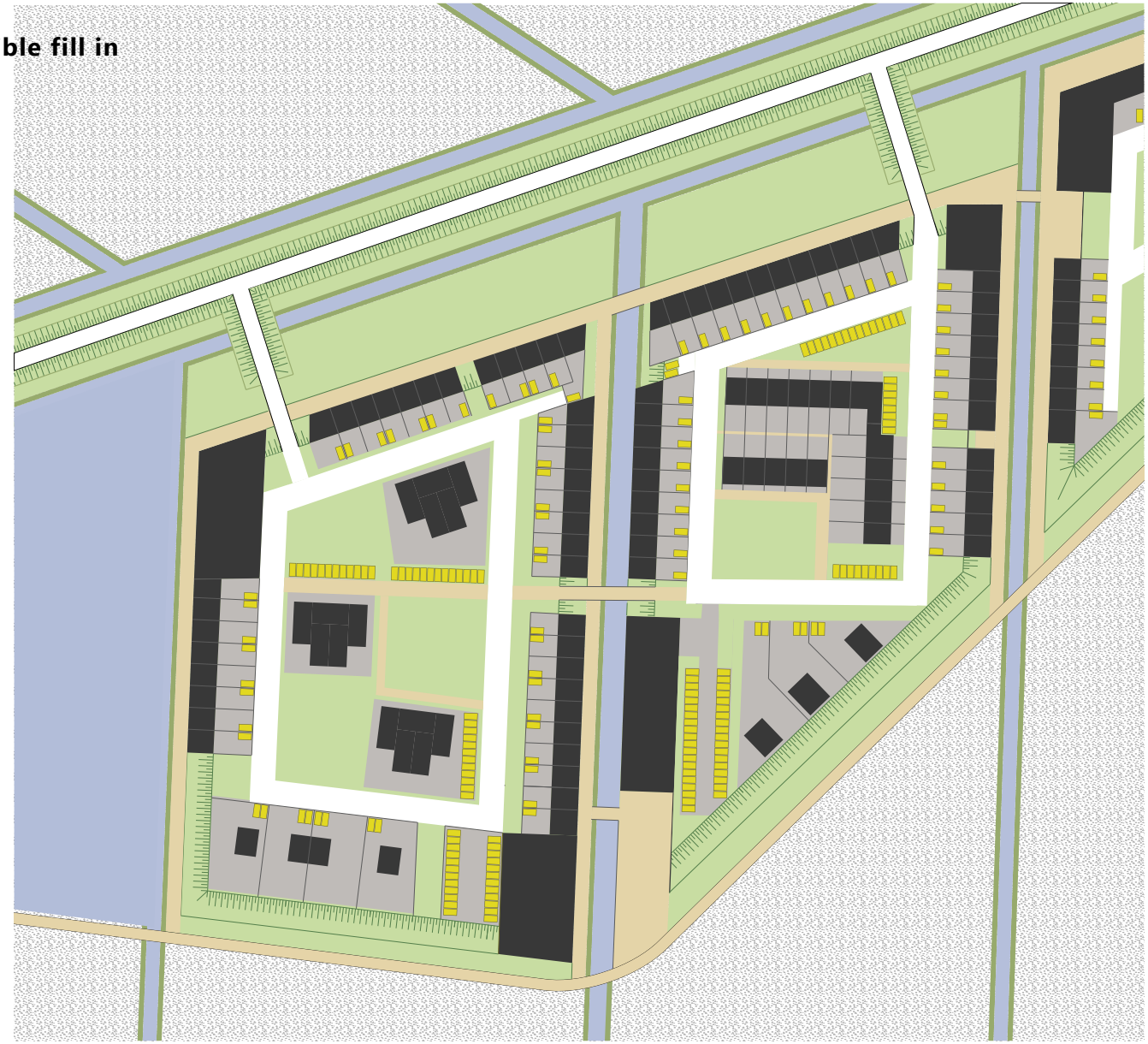


Figure 69. Future dike upgrade when Room for the River plan is realised.

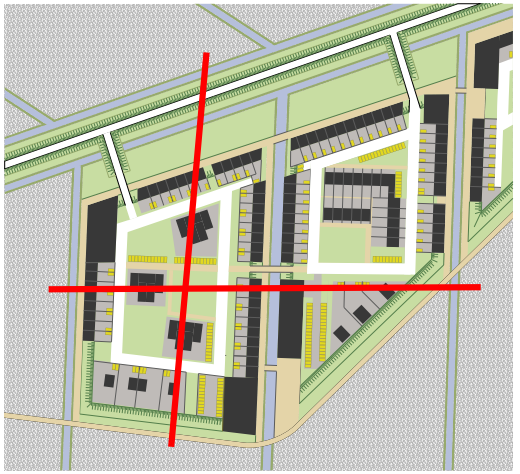
5.3 Possible plan

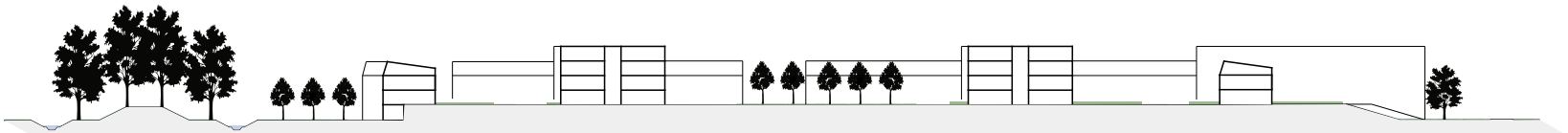


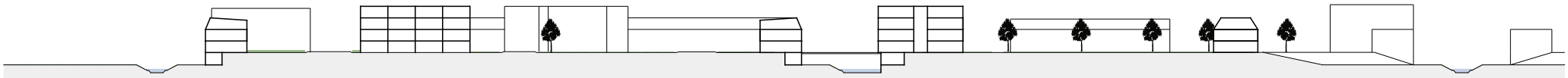
Detail of a possible fill in of ttwo mounds



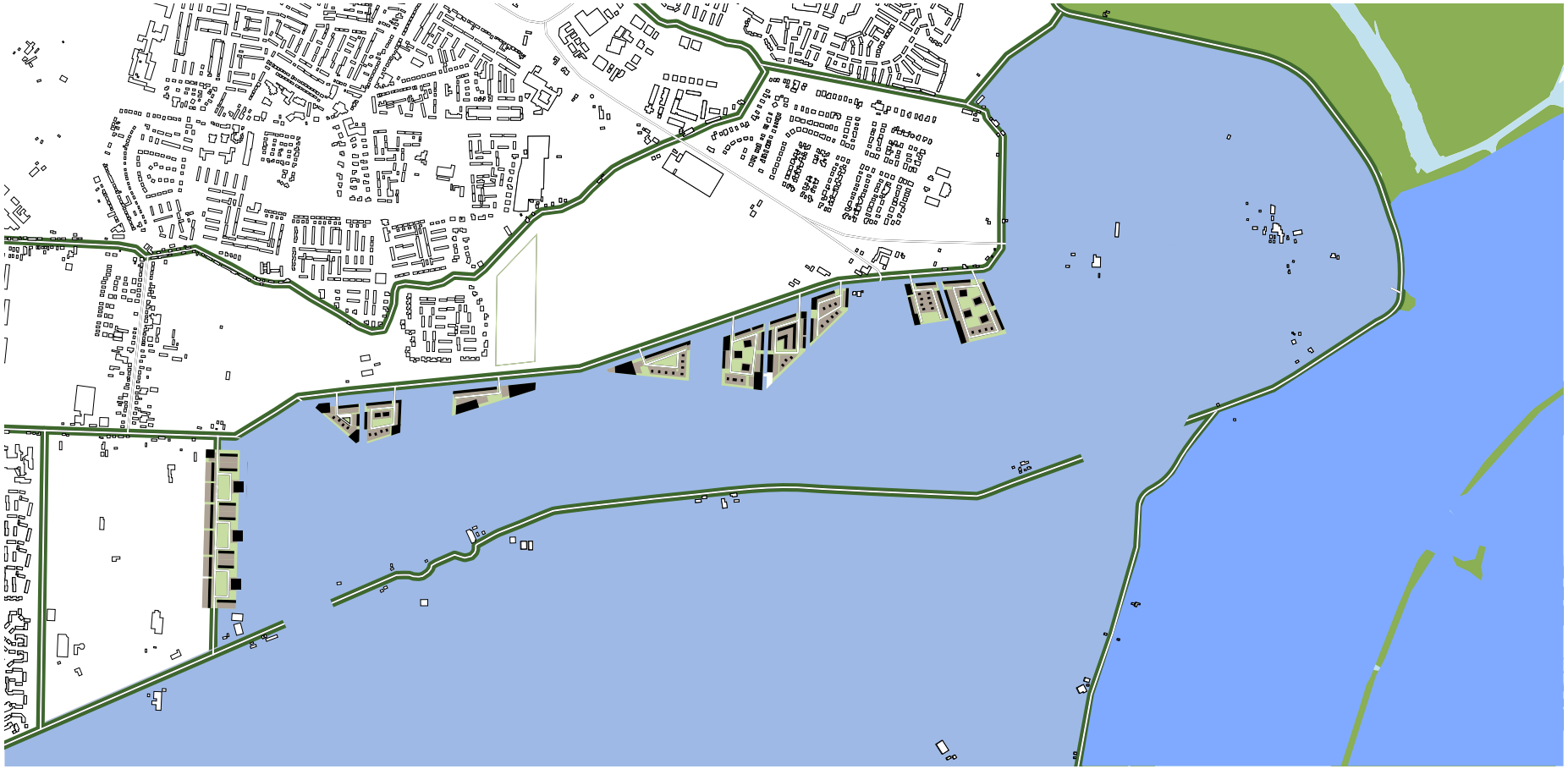
Sections of the possible fill in



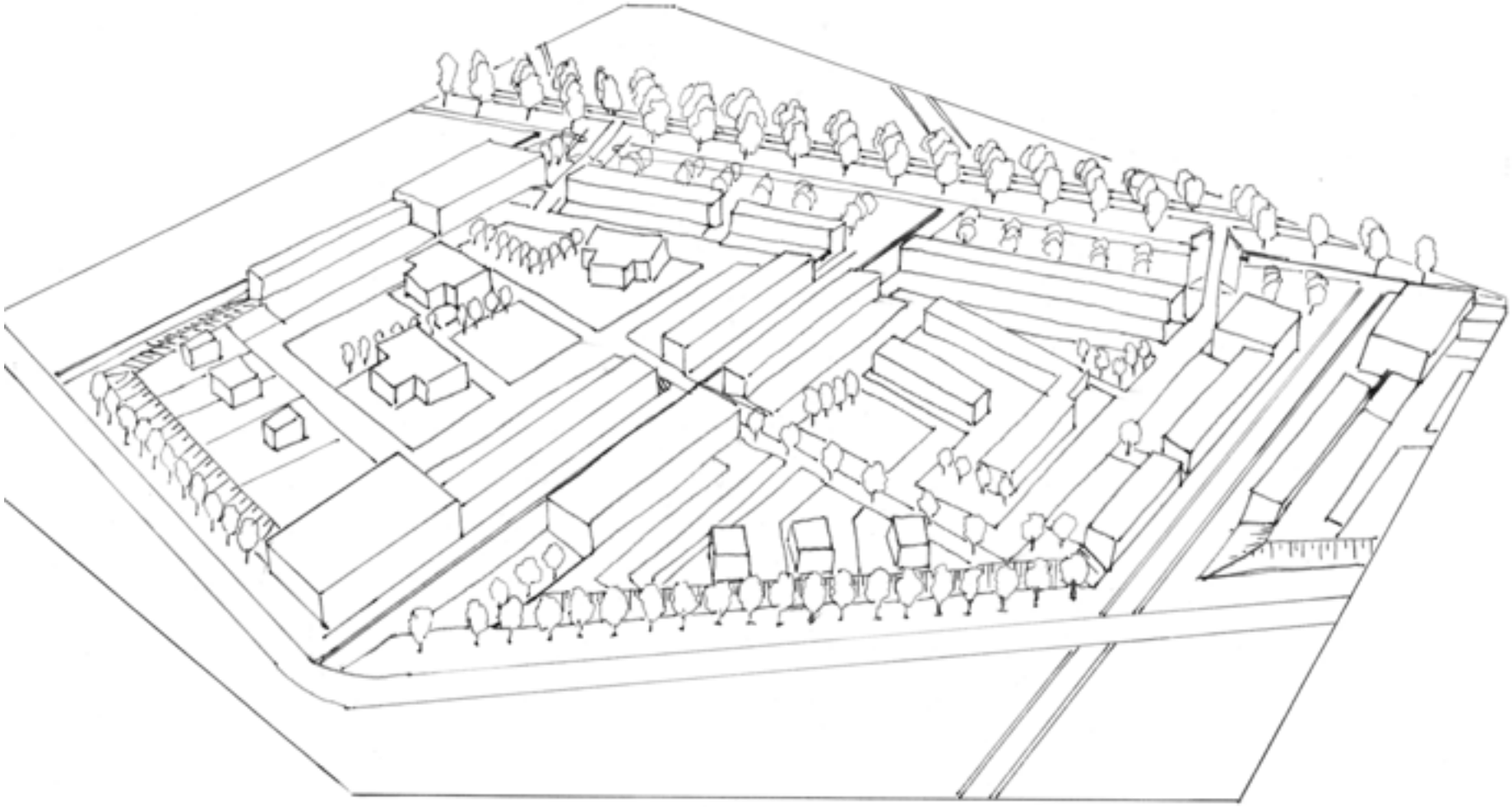


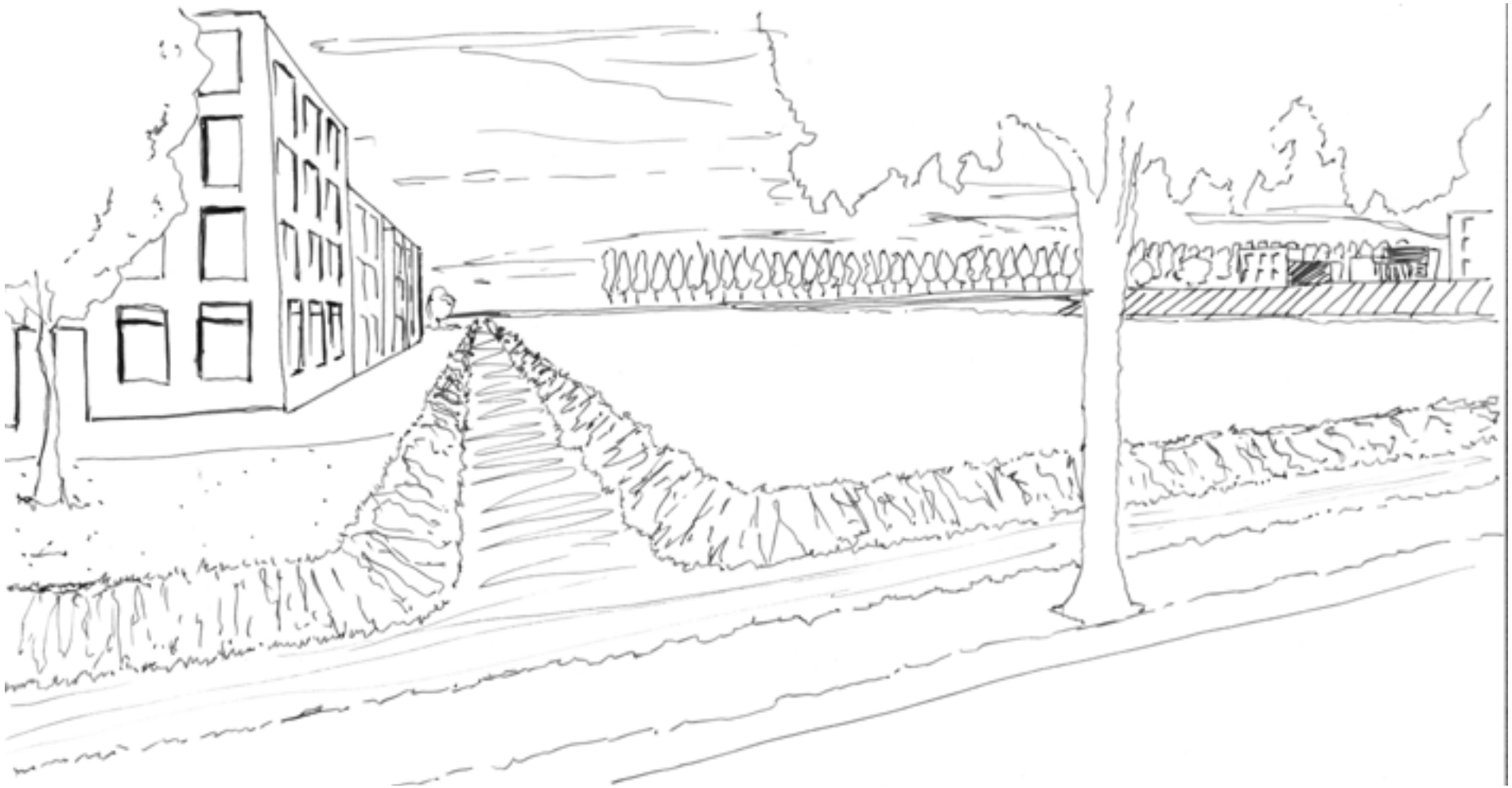


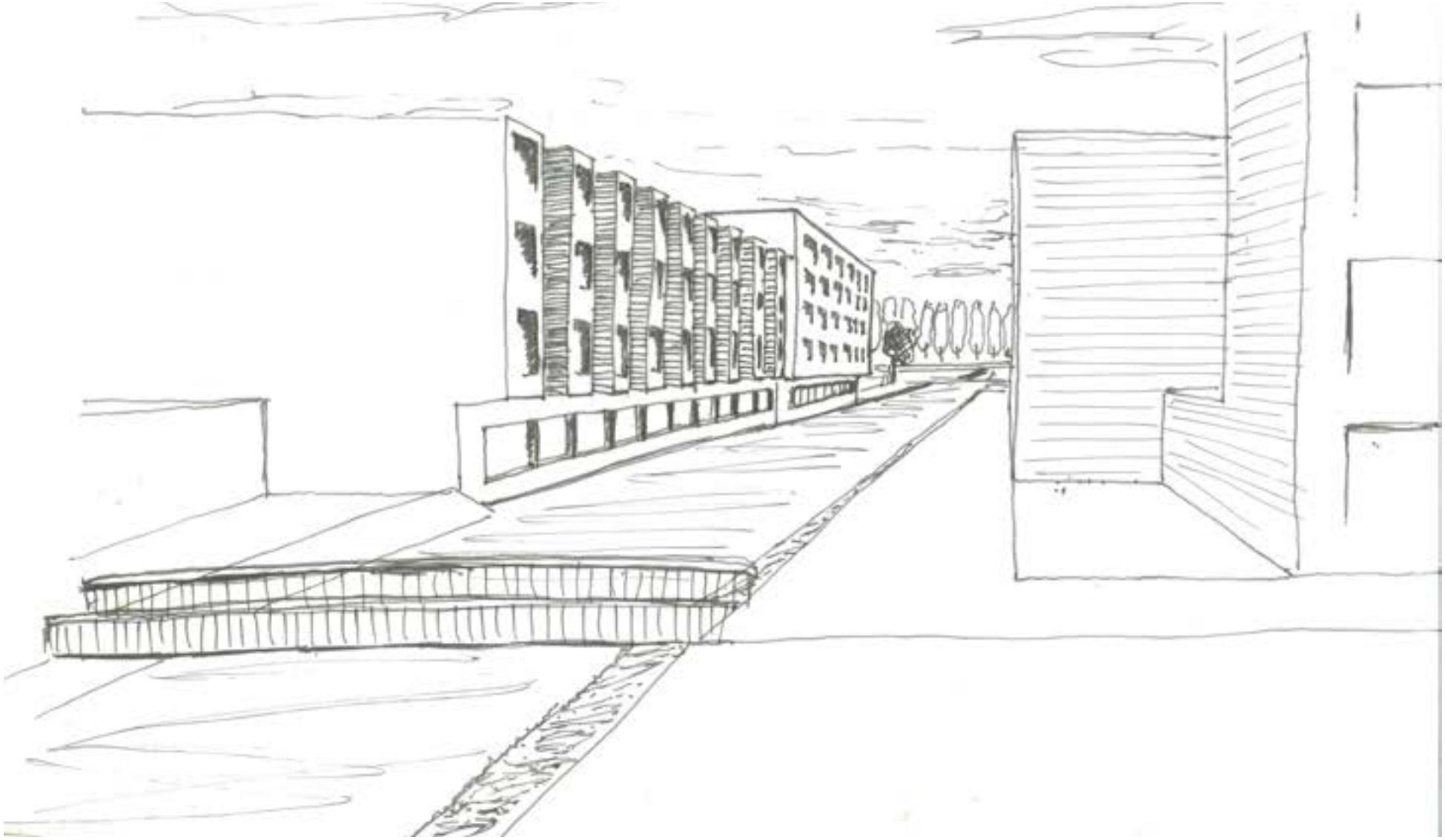
Mounds in a flooded situation

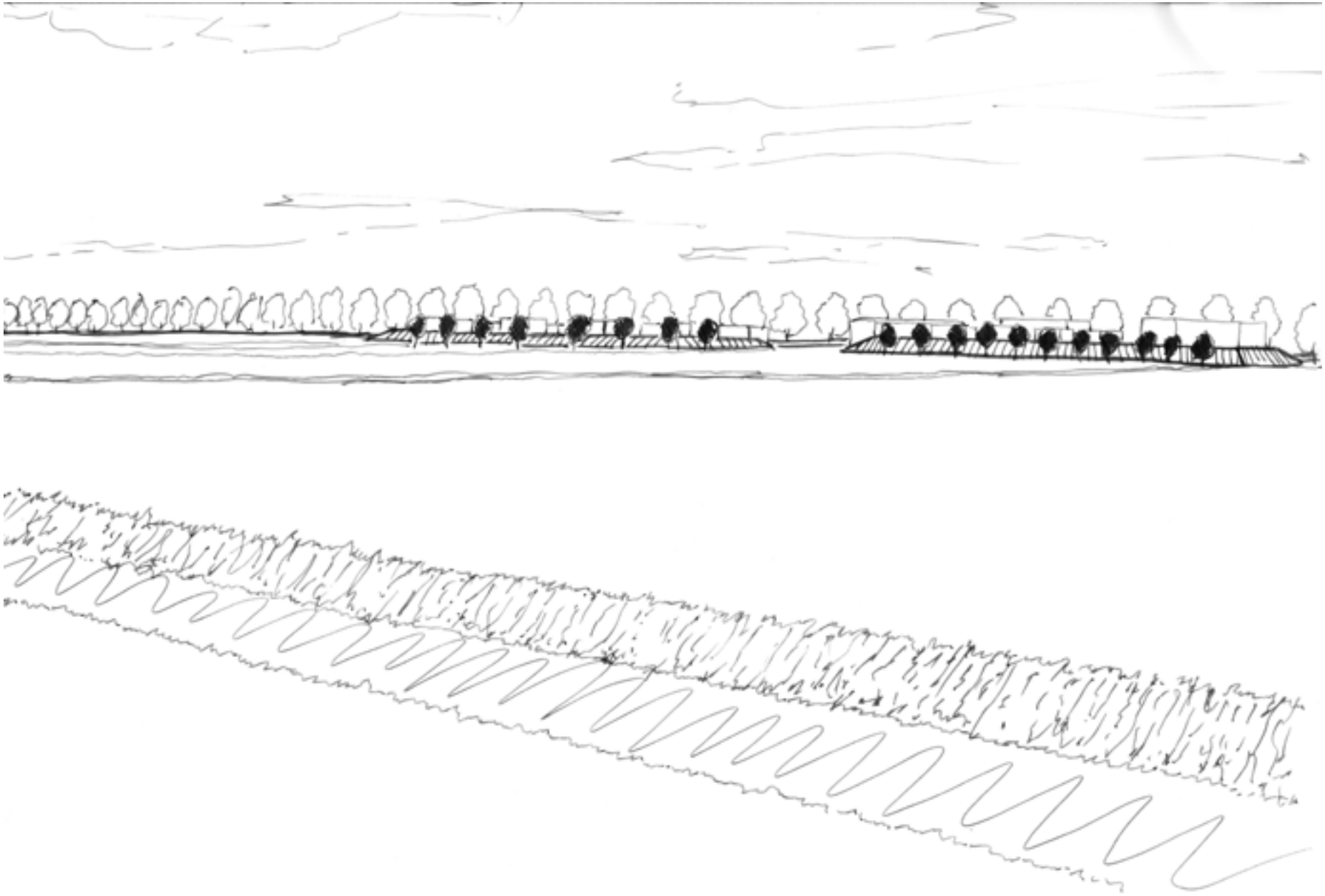


Impressions









5.4 The design in water safety

One of leading approaches towards water safety measures is the multi layer safety approach. This approach consists of as the name suggest multiple layer that should guarantee safety for people that live within a plans boundaries.

The first layer as pictured on the bottom in the image is the primary defense of an area. This is most often a strong dike that keeps the water out of the built environment. This layer is not that different from a conventional approach to water safety.

The second layer states that the spatial structure of an area that is protected by the first layer should be organized in such a way that when the dike fails damage would be mitigated as much as possible. Different options are available for this such using differences in height or compartmentation of an area.

The third layer is an emergency plan for when a flood is too much for the first two layers to handle. This emergency plan often consists of a evacuation strategy or ways to survive a couple of days on higher locations within the city.

Figure 70. Multilayer Safety Approach. FROM: www. wrij.nl

Overview
The plan will be sectioned into the different layers that can be found in the multilayer safety approach.

At the end a second variant for layer 1 will be shown with the suggestion of how the dike system can transform to function in a better way when water levels keep rising due to climate change. The changes there are aimed at increasing water safety for the region around the island of Dordrecht rather than the southern side of the city alone.

Layer 1
The first layer of safety in the plan consists of the normal outerdike that we still use today. For the coming years this dike should be sufficient to handle the water threat.

In addtion to the main dike a perforation is made in the Zeedijk that during a dike failure at the most critical point, Kop van 't Land, would allow the water to flow into the Polder de Biesbosch.

This could be argued to be a level 2 intervention but in this division it will be counted towards the main dike system.

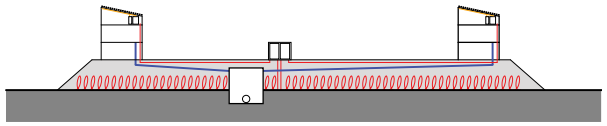
Layer 2

The second layer consists of the different mounds that are projected in the polder. When the main dike fails and the polder becomes flooded damages to the residential blocks is negated for the mounds would be too high for the water to reach.

Layer 3

The third layer in the plan is a continuance of the second layer. The mounds that residential areas are situated on offer space for self reliant systems. With solar panels on the top of the houses, an emerency sewer reservoir and a system to gather warmth from the ground people that live on the mounds can survive without too much implications in their own homes.

May a disaster take too long the dike that the mounds have access to provides a route that can be used to move further inlands.



Layer 1 future

The potential first layer for when climate change keeps pushing water levels higher and higher and forces the city to find other ways to battle against the given threats the dike configuration can be adapted.

The primary dike will serve as a buffer dike with a controlled acces point for water to flow into the area. This system would recude water levels around the island. The Zuidendijk will be upgraded to a primary dike but does not need to have the full height since it is supported by the buffer dike reducing the water pressure.

6 Afterthought

6.1 Conclusions

Summary

The initial goal of the project was to search for new input for the discussion on how to plan for uncertain futures. The idea of an adaptive plan that could work in multiple scenarios. No regrets interventions that we can already enjoy today but make us prepared for what the future might bring.

The project found a basis in the room for the river method in providing a safer environment in the wake of climate change and rising water levels. The room for the river methods is however specialized or mostly used in higly agricultural locations. For this project the room for the river method resulted in a new water front for the city of Dordrecht.

The proximity of the city added some new challenges to designing such a water safety plan. The finer structures of the city that cannot be found in agricultural areas prescribe some wishes for its borders. Main contributers are urban expansion, green structures, cultural context and spatial quality of an area.

The presented design is in basis a framework. A framework that can partly comply to urban expansion with in mind the previously mentioned wishes and incorporates a two step water safety plan for the island of Dordrecht initially and later if water levels keep rising for the region of the Drechtsteden.

The typology for development that follows from the research is a continuation of the concept of the mound. For this location as the border of the city development on mounds in for single buildings was not interesting. The mounds were upscaled which offered new possibilities.

The upscaling provided means to create small urban more dense nodes along the dike. Locations can become more socially engaging and developing these mounds will be more cost effective. The extra size also offered to possibility to integrate some self reliance and sustianable measures into the mound., typically ground warmth and a sewage tank. In addition the possible urbanization of the mound's edges offer a more flexible way of connecting the mound to a more urban or more agricultural landscape.

Figure 71. Lonely farmhouse on its own mound in the Noordwaard. FROM www.ruimtevoorderivier.nl

Findings

While the design can offer an integral solution towards Dordrechts water safety problematics and smaller city dynamics, the given interventions were very site specific in their making. This project's solutions may not be, or be less applicable to a random other location that has to deal with the threat of flooding.

The continuation on the approach on room for the river however may be interesting in the larger discussion on water safety in urban deltas. The research attempted to determine different factors that play a role in the urban landscape that would be affected in creating a new waterfront on the edge of the city. These factors such as cultural context, spatial qualities, and ecological structures will also be needed to take into account on other locations.

Building on and upscaling mounds while integrating self reliance and sustainability measures in them is something that can be repeated on other sites as well. Urbanization of the edges of the mounds offer new possiblities on using this typology in different settings in or around the city landscape. New ways of integrating the mounds in other spatial settings can be researched and the principle could be used in further elaboration of the multi layer safety approach.

As climate change will continue to increase the pressure on our water defense infrastructures, design with nature and room for the river solutions seem to prove themselves to be the way to more forward. Giving in to the natural dynamics of nature and finding ways how to manage within these circumstances offers a solid platform for sustainable solutions.

Figure 72. Possible implementation of mound on harbor redevelopment location..

6.2 Reflection

A search towards creating an adaptive landscape that could adapt to urban influences as well as the threat of rising water levels. The initial goal of the project was ambitious but the framework was still rather vague. This slowly evolved into the question on how to integrate urban dynamics with contemporarily used climate change measures as the room for the river concept. In this final summary a reflection is made on how the design relates to the research and the research studio, and how it can contribute to the wider discussion on water safety in urban deltas.

Relation between research and design

As the project progressed the goal of the project shifted as well. One could say that by attempting to create something that is adaptive the way to get there will be adaptive as well. The initial setup of the research was in basis a linear process from problem statement towards theory onto site analyses and finally the design. The project however due to its start without a well-defined scope gained excess of input towards creating a design. This input consisted of research aimed at finding aspects that should be incorporated in an adaptive landscape.

It was only until later that the research that was done in search for the design had most of the answers in relation to urban influences that could be integrated into, or have an effect on, a room for the river type intervention. It was a natural occurrence of 'research by design' where the exploration for design parameters offered insights into the problematics that followed from the research question. The research also helped to redefine the research question to a more delineated task.

Relation between the design studio and the project

I was fascinated with the idea of an adaptive landscape in relation to the water on the one hand and towards the city on the other. Both of these dynamics are complex and the future has different ways in which these dynamics may present themselves.

This fascination would fit perfectly in the studio of Delta Interventions that was presented as having to goal to explore the effects of climate change in urbanized deltas and experiment by design in search for better water safety measures. With the goal of finding new spatial patterns or qualities that could not only benefit cities but promote a sustainable water landscape as well.

In the end my project was shifted more towards finding a sustainable way to live in a floodable area that was created as a means to improve safety of the entire region. Further development and elaboration was done on existing methodologies rather than reinventing the wheel again.

Graduation lab methodology and the used methodology
The studio has a strong emphasis on research by design. Drawings are a tool to understand different processes that present themselves in delta areas and using these drawings may inspire you to new ideas or find solutions to difficult design tasks.

As stated before initially the chosen methodology for this project may have been a method aspired by the studio but in practice it turned out that the need to keep drawing and exploring options did help towards attaining the end goal. Some drawings raised more questions but some provided answers as well.

Wider social context
Water safety is an issue that is pressed due to climate change to be a rapidly evolving problem to tackle as this design task is not only applicable to Dordrecht or the Netherlands. Climate change and therefor its water problematics are proving to become more and more threatening in delta areas all around the world. One could say that in the Netherlands we have the safest delta to live in due to our technical interventions along the seaside.

However now we are finding out that technical prowess is not as sustainable as we might think. New solutions are being sought and a general trend is to make way for the force of the water that is estimated to grow for the foreseeable future. The room for the river methodology proved itself to be a fruitful approach towards alleviating water threats. This project however showed me that this methodology still had some shortcomings in its application in more urban settings. Having attempted to further progress in the room for the river methodology to battle water threats in river deltas gives new insights to how this methodology can be expanded towards more urbanized areas rather than only use the open landscape.

The found tools and exploration of the possible design options that are left in the use of mounds could serve a function not only in cases like the one presented in this project but as well as other water safety related building assignments. One could think of simply a safer and more sustainable way to build in outer dike areas or the redevelopment of harbors into residential areas.

As sea levels are rising and the discharge of rivers will come in more extreme highs and lows the search towards new ideas and solutions must continue because in the end, we are fighting to keep our cities habitable. This should not only be on a technical level but should be spatial pleasant as well.

6.3 Theory paper

Abstract – Climate change proves itself to be an increasing factor to be considered in current and future urban planning. However there is no standard methodology or approach for redeveloping urban deltas into something more sustainable, resilient and adaptive than their current status. We are still in the process of developing, researching and finding ways how to best achieve those goals. (Environment Agency, 2005) (Meyer & Nijhuis, 2016) Different approaches to find adaptive solutions are being used. Approaches that can be found are Design with nature as inspired by Ian McHarg, scenario building and the no regrets approach. In practice, methodologies that are experimented with today can partly be traced back to be a combination of different aspects of these three approaches. The subject of adaptive planning is still in rapid development through methods like discussions, workshops and experimental research projects. Main literature is on adaptive planning is not yet set. A basis of this research therefor rests on interviews with experts from and workshops organized by the TU Delft, HKV and Deltares.

The research aims to get a grasp of the basis of different methodologies used in adaptive planning and what methodologies or approaches to adaptive planning look like in contemporary projects. The findings of the paper will be used to guide setting up an approach to adaptive planning for my own graduation project.

Key words – adaptive planning, design approach, climate change, delta planning, adaptive design

1 Introduction

One of the most pressing developments in contemporary urban planning is climate change. Climate change is posing a serious threat to sustainable urban development, placing many cities at risk. (Wamsler, Brink & Rivera, 2013)

The majority of larger cities in the world reside in areas that are suspect to flooding, located along coastlines or in river deltas. Despite the danger of flooding there is still an ongoing trend of people moving towards these cities. Looking at the number of people that are taking part in this process expected is that by 2030 50% of the world's population lives within 100 kilometer of the coast. (Adger, Hughes, Folke, Carpenter & Rockström, 2005) It is understandable why people have positioned their cites in river delta areas. The river in these locations offered reliable clean water resource, the land is very fertile enabling proper agriculture, waste could be disposed of easily and it offers a means for transportation to trade. (De Graaf, 2012)

The threat of climate change calls for action to rethink how urban deltas can exist under the increasing risk of being flooded. Resilient cities and sustainable transformation of cities can only be achieved if adaptation becomes an inherent part of the urban planning practice. (Wamsler, Brink & Rivera, 2013)

There is no standard methodology or approach for redeveloping urban deltas into something more sustainable,

resilient and adaptive than their current status. We are still in the process of developing, researching and finding ways how to best achieve those goals. (Environment Agency, 2005) (Meyer & Nijhuis, 2016)

The starting point of this paper will be a hypothesis based on own findings that were acquired through interviews with experts from; and workshops organized by the TU Delft, HKV and Deltares. The hypothesis is that the basis of adaptive design in relation to climate change can be found in a combination of three approaches: design with nature, no regrets approach and scenario based planning. The goal of this paper is to delineate these approaches and compare them to methodologies used in contemporary delta planning in the Dutch south-western Rijn delta.

2 Where do adaptive measure fit in the process of the changing climate?

2.1 The process of adaptation.

Adaptation is a phenomenon that can originally be seen in nature. It is the result of living organisms changing their appearance, form or habits to survive or perform better in changing environments. This is a natural slow process. To turn this process into a model that can be steered this process can be mapped. Martín, de Lope and Maravall depict the adaptation process into three steps: Rationality and intelligence, Anticipation and Adaptation. In order to adapt to changing environments one needs to understand the environment (Rationality and intelligence), be able to make a prediction on how the environment will change (Anticipation) and find a solution to how current systems can be altered to cope with the projected change (Adaptation). (Martín, de Lope and Maravall, 2008) This model is originally aimed at computer science but the theory can be projected to other professional fields as well. For urban design the backwards engineering of the adaptation process can partly be seen in conventional design processes where analyses and understanding of a location or environment is often the first step.

2.2 How can planning cope with climate change: Slow vs fast processes

The urban delta is a complex system that houses different processes. Both natural processes and human activities. The landscape can be seen as a slow changing environment where human interaction delivers a fast changing dynamic. (Meyer & Nijhuis, 2016) The speed at which natural processes and human activities occur can be divided into three levels. The slowest level is the natural environment. Change is the result of gradual processes as sediment flow of rivers or erosion. The second level consists of the long-term, social, ecomomic and cultural history. And in the third level people and politics

can be found. (Braudel, 1966) McHarg's approach in 'Design with Nature' (1969) depicts this further into the layer types of the substratum, the layer of infrastructural networks and the layer of urban and agricultural land use patterns. (Meyer & Nijhuis, 2016)

Effects of climate change fall under the lowest dynamic layer. As people this layer can't be built directly but can be influenced by people. For example in the Netherlands the land in the province of Zeeland was protected from flooding with dikes. Due to these built dikes sediment flow from rivers accumulated in front of these dikes creating new land. This new land was very fertile and was protected with dikes again. (Meyer & Nijhuis, 2016) The landscape was in a way altered (islands grew) by creating infrastructure for flood protection. Understanding how the different dynamics relate to each other is the first step for a design to be resilient and adaptive. (Roös, 2014)

3 Methodologies in adaptive planning

These are the methodologies from the hypothesis that I assumed to be the basis of adaptive design approaches used in contemporary adaptive planning projects. These methodologies would be the Design with Nature approach by Mc Harg, scenario planning and the No Regrets approach.

3.1 Design with nature

In origin McHarg's approach, to include several structural layers of the landscape in the design process, was aimed at taking advantage of ecosystem services and promote environmental and public health. The ecological science that is used to dissect different layers into comprehendible data functions as base input for a design and can play a leading role in the decision making process of a project. (Yang, Li & Li, 2013) In the approach it is concluded that people are holistically connected to the environment. To attain a resilient and adaptive society it is needed to benefit from the protection and enhancement of the environment. Accepting and strengthening the environment integrated into an urban plan would benefit both. (Roös, 2014)

To continue on this idea Roös suggests that combining the theory of McHarg with the methodology of pattern language by Alexander offers a basis for adaptive design. The layered approach of McHarg where different dynamics are visualized can be further specified into design principles formulated through patterns that can be found within those layers. In the goal to create an adaptive design it is key to grasp an understanding of the natural dynamics and what they may be in the future. And find solutions to how patterns in infrastructural and cultural layers can be integrated in those natural dynamics. (Roös, 2014) The difficulty lies in combining the dynamics of these different layers and find appropriate solutions. Short term solutions might not be beneficial to

long term safety. Local short term measures often reside to 'hold the line' measures that focus on strengthening current solutions or creating new dikes to keep the water out. In the long term the effort and resources spent on these solutions are gone to waste and may be contra productive towards the initial goal of keeping people safe. (IPCC, 2012)

The approach is adaptive in identifying the leading dynamics that are least flexible and using these dynamics to be a guide for the design of an area. This should lead to sustainable or durable solutions in relation to the changing environment while integrating cultural components. (Roös, 2014)

3.2 Scenario based research

"Scenario planning techniques are increasingly gaining attention in the process of spatial and urban planning because of their usefulness in times of uncertainty and complexity. Scenario planning encourages strategic thinking and helps to overcome thinking limitations by creating multiple futures. In this way, it can help to shape the future according to the values and desires of society." (Stojanović, Mitković & Mitković, 2014)

Ducot & Lubben (1980) propose a model differentiating four kinds of scenarios divided in two categories of two types. The first distinction made is between descriptive and normative scenarios where descriptive scenarios are an objective depiction of events where normative scenarios are set up to incorporate preferred variables. The second distinction is between explorative and anticipative scenarios. Explorative scenarios use the current situation as a starting point and aim to see how to continue from there where anticipative scenarios set an end result and question how to get to that result.

Scenario	Explorative	Anticipative
Descriptive	For the given causes – What can be the next results (effects)?	For the given results (effects) – what could be their causes?
Normative	For the given measures – What can be the goals achieved?	To achieve given goals – what measures could be taken?

Table 1. Scenario types (Ducot & Lubben, 1980)

When looking at planning for future uncertainties normative anticipative scenarios are most interesting to work with. While explorative descriptive scenarios are more suited for exploring a given short term design task or researching options.

Scenarios can be used for different purposes and work on a multitude of scales from local neighborhoods to mondial settings. The thematic and scale of the scenario is based on the research goal or what subject is being explored. It is of importance that the delineation of a scenario based research is done extensively to ensure relevance of the outcome of

the research. (PBL, 2013) The better we can map what the future might bring the better we can prepare for one of its pathways. The most resilient designs or developments are the ones that would serve a goal in multiple scenario's.

3.3 No regrets approach

Urban planning that has to deal with climate change is about taking future uncertainties into account. The effects of climate change are still predictions and come in the form of a range of possible change in water levels, whether it be rainfall, river flow or sea levels.

"Unforeseen events, natural and human-induced, will occur. For these reasons, the best insurance policy is one that improves society's generalized ability to cope with disasters, environmental and otherwise, not simply to mitigate one potential disaster scenario that may or may not occur" (Adler et al., 2000) The no regrets approach, in relation to climate change, is based on combining urban development with the uncertainties of climate change. No regrets policies and actions are those that are beneficial to implement whether or not the consequences of climate change or a disaster turn out as expected. (UNISDR & UNDP, 2012)

The UK Environment Agency (2015) lists the following key characteristics for decision making to comply with a no regret vision:

" - No-regret actions are cost-effective under current climate conditions and beneficial whatever the out come in terms of climate or sea level.

- Low-regret actions are relatively low cost and are likely to be beneficial under predicted future climate or sea level scenarios.

- Win-win actions contribute to adaptation and provide other social, economic and environmental policy benefits.

- Major policy changes or investment decisions have significant, long-term consequences and costs associated with them, and require considerable analysis and public debate before a decision is made "

The no regrets approach is not only applicable to urban planning but as well for the integration of communitiy to be an integral part of making cities more resilient at different scales. (Siegel, n.d.) This could help strengthen communities and local ownership. (Siegel & Jorgensen, 2011). However it is essential that the given communities and local residents are engaged in the process and planning of creating said adaptive plans to help them understand the context and local policies. (UNISDR, UNDP, 2012)

Mapping the uncertainties of climate change and developing a long term plan to cope with the given problematics may set boundaries on the possibilities within a project plan. However it can also be used to inform short term planning and create better integral solutions. (UNISDR & UNDP, 2012)

4 Methodologies compared

When looking at these approaches, and their ability to tackling uncertainties of climate change, some differences, similarities and compatibilities can be seen.

The three approaches are different in the in their main characteristics. They all use different starting points from where the design originates. Design with nature is using slow natural dynamics as a basis for a design to create a resilient plan. The no regrets approach attempts to increase the value of a plan with short term benefits integrated in long term measures. And scenario based design uses a wide range of predictions to grasp an understanding of an area and form the puzzle of how to prepare for its future.

While being different from each other the approaches consensus can be seen when looking at the basis of different dynamics as described by McHarg. When the goal is to be adaptive determined should be what to be adaptive for. The three approaches all base their findings on a problem statement in the slow changing natural layer and what its effect could be in the future. The design with nature approach uses it as a guide to base a resilient design on. The scenarios approach uses a scope of predictions of changes in the natural layer to attain an understanding of the possibilities what could be considered in a design. And the no regrets approach uses the measures needed to cope with climate change as inspiration for integration of short term plans to create more value.

The different methods do not exclude one another to be used within a design process. They each have their own qualities. The scenario approach adepts more at being a tool for analysis of the problematic and attain a wide comprehensive view on design goals and possibilities. The design with nature is an approach that excels at long term resilience and sustainability of a plan. And the no regrets approach is most useful as a tool to integrate long term plans to integrate with short term projects or benefits. Combined together this could lead to a resilient adaptive design.

5 Methodologies in current practice

As stated earlier there is no standard methodology or approach for redeveloping urban deltas into something more sustainable, resilient and adaptive than their current status. Three of the more fruitful recent approaches to research and design adaptive solutions in the Netherlands are the Room for the River approach, scenario based research as seen in the Delta Programma 2050 and 2100 and a more recent approach, the Robust Adaptive Framework.

4.1 Room for the River

A more recent iteration of McHargs Design with Nature theory can be found in the 'Room for the River approach'. This approach is developed in the search for a solution to the water problematics that can be found in the Dutch river delta. Past canalization projects of the Dutch rivers have decreased their capacity to mitigate extreme river fluxes, increasing flood probabilities in populated areas. (Meyer & Nijhuis, 2016)

The introduction of the Room for the River idea was a turning point in the idea that nature in relation to water safety could be fully controlled. The room for the river approach aims to rediscover the natural flowing dynamics of the rivers by providing more space to the river where is needed to reduce the pressure of floods on the dikes that keep the hinterlands safe. The extra space that is made available for the river to use as a flood plane is then used as means to strengthen environmental or ecological systems. The approach introduced a new framework between manmade infrastructures and natural elements with space for local needs for urban or agricultural land use. (Meyer & Nijhuis, 2016)

4.2 Delta Programma 2050 and 2100

One of the largest contemporary examples of scenario based planning in the Netherlands are the 'Deltascenario's for 2050 and 2100'. Their methodology is based around setting up a scope around four extremes in predictions in two moments in time. These four extremes consist of a matrix with on one axis socioeconomic growth or shrinkage and on the other axis rapid climate change versus moderate climate change, resulting in four different scenarios. This methodology does not aim to paint an accurate prediction of the future but rather to set up a wide scope to grasp some understanding of the range of possibilities of what might happen in the coming 50 and 100 years with a focus on water problematic and how this effects the built environment. They emphasize the growth in range of possible future outcomes between the 2050 and 2100 predictions. The further you try to forecast the more variance will be introduced. (PBL, 2013)

The research offers insight into design tasks and serves as tool to get inspiration from in a design process but it does not contribute a concrete design itself. The goal of using these scenarios is to map a range of possibilities that might present itself in the future and the problematics that come along with them. This way scenarios can produce qualitative (a storyline for a setting) and quantitative (eg. Change in water levels) information. (PBL, 2013) The characteristics of the scenarios can be reproduced on a smaller scale to help explore the problematics but also opportunities a location has to offer. This would then help to work to a design that can function within these different scenarios.

4.3 Robust Adaptive Framework

The most recent of the three approaches is an approach suggested by IPDD (Integrated Planning and Design in the Delta) developed by members of TU-Delft, Erasmus University, Wageningen University, PBL, Deltares, RoyalHaskoningDHV, H+N+S Landscape architects, MUST Urbanists, HKV and GeoNovum. Their work resulted in a plan called the Robust Adaptive Framework. This approach can be seen as a continuation of the Room for the River concept. The former approach was found to be not flexible enough to be applicable in more urban settings due to the hydraulic engineering, landscape and environmental solution it uses. It could not offer solutions for the complex dynamics that can be found in more urban settings. Thus the approach should be more flexible or adaptive itself. (Meyer & Nijhuis, 2016)

As the name suggests a plan should be robust as well as adaptive. Robust in the sense that it should be able to withhold climate change threats for a longer period of time and adaptive in the its ability to incorporate different functionality. (Meyer et al., 2014) The robust plan developed in this project is aimed at the Maas and Rijn delta in the Netherlands and focuses on creating a framework for the land between the primary and secondary dikes along the rivers and waterways.

Adaptive planning in the robust framework has to offer opportunities for synchronization of all relevant processes of subsystems in a delta. This does not mean that the goal is total integration of these systems. Synchronization means that space should be available for different dynamics that can be found among the subsystems in a delta. These dynamics should not be forced to be an integral part of each other but should be able to coexist along each other. (Meyer et al., 2014)

To achieve the design of a robust framework a Delta Envisioning Support System (DENVIS) is developed. This System is a platform that promotes communication between designers, geo-information specialists and stakeholders from the government, companies and community organizations. (Meyer et al., 2014) The emphasis on information, design and insight sharing lead to more mutually accepted and executable designs for delta areas.

4.4 Current practices compared

Comparing the three recent methodologies to tackle designing with uncertain future conditions it can be seen that for the Room for the River approach and the related Robust Adaptive Framework have a basis in design with nature. Where the natural dynamics, in these approaches mainly river flow dynamics, determine the outlines of a design. In the Room for the River approach solutions to strengthen ecological structures are often used while the Robust Framework creates opportunities for a more diverse set of processes to be developed. When a basis is found to mitigate the possible future's water threat the design task within the approaches is

to find a way to increase an area's spatial quality integrated with the water safety intervention. Short term benefits tagged along with long term safety precautions. This can be seen as an attempt for creating no regret decisions.

The Delta Scenarios 2050 and 2100 research is a bit different from the other two. This research is primarily aimed at information and insights generation and the sharing of said information to promote adaptive research and design. While cities and deltas are complex structures on its own (Meyer et al., 2014), attempting to scope the future for these structures can even be more complex. Aquiring information and insights from different experts to set up relevant scenarios is key to its effectiveness (Stojanović, Mitković & Mitković, 2014)

The focus on information sharing from scenario based approaches can also be seen in the Robust Adaptive Frameworks approach where the DENVIS tool is used for discussion and knowledge distribution. The increased focus on information sharing can be linked to attempting to create an adaptive design. While the suggested tools are means to tackle the problematic of uncertain futures they are mainly a guide to help users in processing acquired or available knowledge into spatial characteristics for a given site. This would mean central within creating adaptive designs is gathering and producing knowledge and insights of the different subsystems that can be found within the delta. (Meyer et al., 2014)

6 Conclusions

Climate change emerges more and more in the forefront of urban delta design problematics. Despite not having a generally accepted methodology experimental approaches play a key role in developing or redeveloping urban areas and the water infrastructures along the rivers. The reviewed recent approaches find their basis in the theories of McHarg and Braudel that different systems of the landscape work in different dynamics. To create adaptive resilient designs these dynamics should be able to coexist in harmony. Information gathering and attempting to set a scope of what the future might bring in an area scenario building is a common used method in the approaches. Also more focus is being given to the integration of long term safety measure and the short term planning possibilities. Aiming for no regrets decisions in water safety interventions a project can already bring value due to new opportunities in land use and attractive locations before a planned water safety measure in a project is actually needed.

The hypothesis of current approaches to be a continuation of design by nature, scenario building and the no regrets approach is partly true. These elements are part of current approaches but new aspects and tools in these approaches also appear. Recent approaches show that the development of methodologies to tackle adaptive design are already much more well-rounded despite being still in full development. An important role in the design process is information

sharing and debate between different experts, stakeholders and designers. (Meyer et al., 2014) Every piece of insight and knowledge can help to a more conclusive plan for the uncertain future.

7 Discussion

The quest to finding methodology to tackle the problematics of adaptive design is still in progress. Methodologies chosen to review in this paper are a snapshot of current developments used in practice. Due to this subject still being relatively young and knowledge on the matter is still in development through workshops, discussion and design research there is no established base theory yet. This paper was an attempt to find out if my own theory on adaptive design methodology could stand while reviewing methodologies used in practice. While it may seem my own hypothesis was partly right it is also true that my theory would not give credit to current approaches having much more to offer than the three approaches that I claimed to be the basis of adaptive design. In 'Nieuwe perspectieven voor een verstedelijkte delta' Meyer et al. even suggests that the methodology used for adaptive design should be adaptive in itself because different design tasks in deltas vary vastly from each other. This would suggest there is no one size fits all methodology and every project should have a tailor made approach.
Climate change will stay on the agenda of urban delta planning for the foreseeable future and the need for adaptive solutions will be present as long as people will keep living in flood prone areas. As much as the subject is complex it is interesting. More research is always welcome as research on this subject will never be finished until the threats of climate change have disappeared.

Words of thanks

I would ike to thank my mentors Han Meyer and René van der Velde for their patience and help in guiding me through this graduation project. My fellow students from the Delta Interventions studio who at the start of the project provided good discussion and shared insights. Thank to my family and Sandra Suylen and her family for their continued support throughout the entire process.

7 References

7.1 References

Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R., & Rockström, J. (2005). Social-Ecological Resilience to Coastal Disasters. Science, 309(5737), 1036–1039. http://doi.org/10.1126/science.1112122

Adler, J. et al. (2000). "Greenhouse Policy Without Regrets: A Free Market Approach to the Uncertain Risks of Climate Change". Competitive Enterprise Institute: Washington, D.C.

AHN. (1996). Actueel Hoogtebestand Nederland. 2015, from http://www.ahn.nl/pagina/viewer.html

Braudel, F. (1966). La Mediterranee: La part du milieu, Paris: Laibrairie Armand Colin

Dammers E., Van 't Klooster S., de Wit B., Hilderink H., Petersen A. & Tuinstra, W. (2013).

Scenario's maken voor milieu, natuur en ruimte: een handreiking. Den Haag: PBL

Ducot, G., & Lubben, G. J. (1980). A typology of scenarios. Futures, 12, 51–57.

Environment Agency. (2015). No Regrets Planning for Sea Level Rise and Climate Change and Investing in Adaptation: A Good Practice Guide. United Kingdom

IPCC. (2012). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.

Martin H., J. A., Lope, J., & Maravall, D. (2009). Adaptation, Anticipation and Rationality in Natural and Artificial Systems: Computational Paradigms Mimicking Nature, 8(4), 757–775. http://doi.org/10.1007/s11047-008-9096-6

McHarg, I. (1969). Design with Nature, New York: Natural History Press

Meyer, H., Bregt, A., Dammers, E. & Edelenbos, J. (2014). Nieuwe perspectieven voor een verstedelijkte delta: naar een aanpak van planvorming en ontwerp. Amersfoort, Must Publishers ISBN: 978-90-814455-0-4

Meyer, H., Nijhuis S. (2016). Designing for Different Dynamics: The Search for a New Practice of Planning and Design in the Dutch Delta. In: Portugali J., Stolk E. (eds) Complexity, Cognition, Urban Planning and Design. Springer Proceedings in Complexity. Springer, Cham

Payne, E. (2005). Composition of Outdoor Painting

Planbureau voor de Leefomgeving. (2013). Deltascenario's

voor 2050 en 2100: Nadere uitwerking 2012-2013

Roös, P. (2014). Design with Nature: A proposed model for coastal settlements in Australia adapting to climate change and extreme weather events.

Siegel, P.B. & Jorgensen, S. (2011). "No-Regrets Approach to Increased Resilience and Climate Change Justice: Toward a Risk-Adjusted Social Protection Floor"

Siegel, P.B. (n.d.). "No Regrets" Approach to Decision-Making in a Changing Climate: Toward Adaptive Social Protection and Spatially Enabled Governance Retrieved from http://www.wri.org/our-work/project/world-resources-report/no-regrets-approach-decision-making-changing-climate-toward

Stojanovic, M., Mitkovic, P., & Mitkovic, M. (2014). The scenario method in urban planning. Facta Universitatis - Series: Architecture and Civil Engineering, 12, 81–95.

UNISDR & UNDP, (2012). Disaster Risk Reduction and Climate Change Adaptation in the Pacific: An Institutional and Policy Analysis. Suva, Fiji: UNISDR, UNDP, 76pp.

Wamsler, C., Brink, E., & Rivera, C. (2013). Planning for climate change in urban areas : from theory to practice. Journal of Cleaner Production, 50, 68-81. DOI: 10.1016/j.jclepro.2012.12.008

Yang, B., Li, M.-H., & Li, S. (2013). Design-with-Nature for Multifunctional Landscapes: Environmental Benefits and Social Barriers in Community Development. International Journal of Environmental Research and Public Health, 10(11), 5433–5458. http://doi.org/10.3390/ijerph10115433

END