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URBANISM

FLOODPROOF ALMERE 2.0

An integral approach to the balance between measures on different layers of multi-layer safety.

MSc THESIS

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Colophon

Almere 2.0 Floodproof

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Keywords
flood control policies, multi-layer safety, flood risk, urbanized delta, climate proof, Southern Flevopolder, Almere 2.0

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Delft, July 2013

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Preface

This P5 report or master thesis is the result of my master graduation research and design, with the title: "Almere 2.0 floodproof". The graduation project marks the end of my master studies Urbanism, at Delft University of Technology, faculty of Architecture, Urbanism and Building Sciences. The majority of the research is executed at PBL Netherlands Environmental Assessment Agency (PBL) in Bilthoven, at the departments of Water, Agriculture and Food, and the department of Spatial Planning and Quality of the Local Environment.

Hereby I want to thank everyone who contributed to the execution of this study. The elaboration of the results would certainly not succeed without the help of many actors (appendix 8.1) who were willing to provide the required information and to think about the subject. My special thanks go out to Peter Otten from the Municipality of Almere, Joost Knoop and Leo Pols, my internship supervisors from PBL, Evelien Brandes and Fransje Hooimeijer, my mentors at TU Delft, and Frank Koopman, my external examiner at TU Delft, for their willingness to act as a mentor.

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Contents

1. Introduction

In the Randstad and the major cities in the Netherlands still remains a task of densification, mostly in areas with a high flood risk (PBL, 2011: 16; Van Drimmelen & Oosterberg, 2005). Typical example of this are the plans for Almere 2.0: 60,000 new dwellings for a growth from 190,000 to 350,000 residents and business areas for 100,000 new employees planned for 2030 in a deep polder. This means more dwellings on the same surface, more construction in the subsoil and increased use of the outdoor space. Question is how planners and urban designers can spatially anticipate on flood risk in new developments and re-development areas. Nowadays, it is either fighting against water, or working with it. The dominant approach towards water management in the Netherlands is a technical one aimed at ensuring safety and protecting land by blocking out water (Voogd & Woltjer, 2009: 189). This however illustrates the lack of integration between water management and spatial planning: water boards construct and maintain dikes, and behind the dikes planners and urban designers develop land use plans, without worrying about flood risk.

Raising dikes may be a cost-effective and administratively simple solution, but not always contributes to spatial quality of an area. Furthermore, implementation of climate proofing measures in urban development today may considerably reduce costs for tomorrow (PBL, 2011: 44). Spatial measures can be taken not only to prevent floods, but also to lower the impact. This approach, the so-called multi-layer safety approach (MLS), has been introduced in the National Water Plan (NWP) (VenW et al., 2009). Somehow a balance must be found between measures on these different layers.

Besides these safety assignments, there are a lot of spatial planning assignments which are typical for every urban area in the Netherlands, e.g. realising desired program, spatial quality, water nuisance, drought and water shortages, as well as heat stress in extremely hot summers. Furthermore, the current economic climate calls for a new, more flexible spatial planning form and a different role of the urban planner in area development in the Netherlands. Almost all planned developments in cities are put on hold, and the large amount of program planned for Almere does not form an exception. Introducing possibilities to make an urban plan flexible, for instance by making a plan phaseable, can be the answer. Large infrastructural interventions such as dikes however have a limited flexibility. How to deal with this in a smart way, integrating water safety and other assignments of spatial planning?

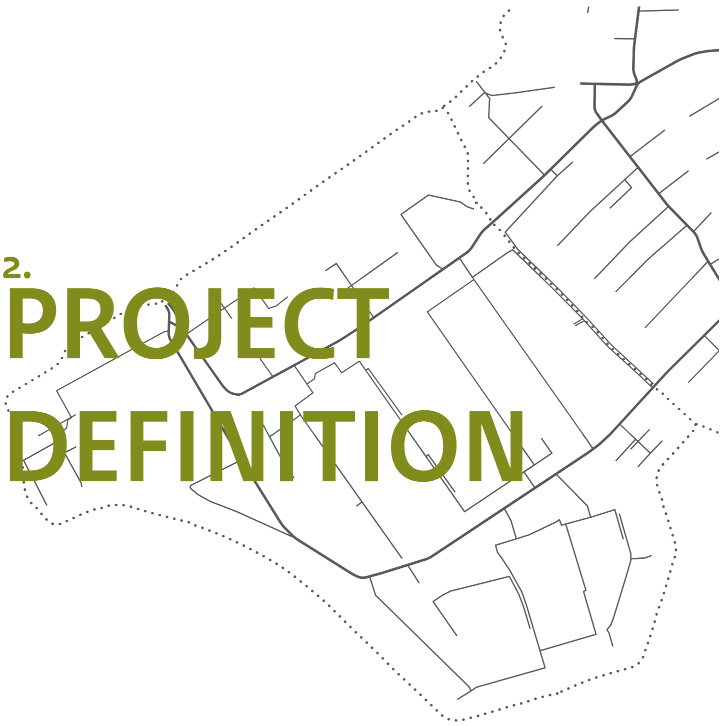
This project tries to provide handles for integral assessment of flood risk management measures in different domains and policy levels, based on the case of Almere.

Reading guide

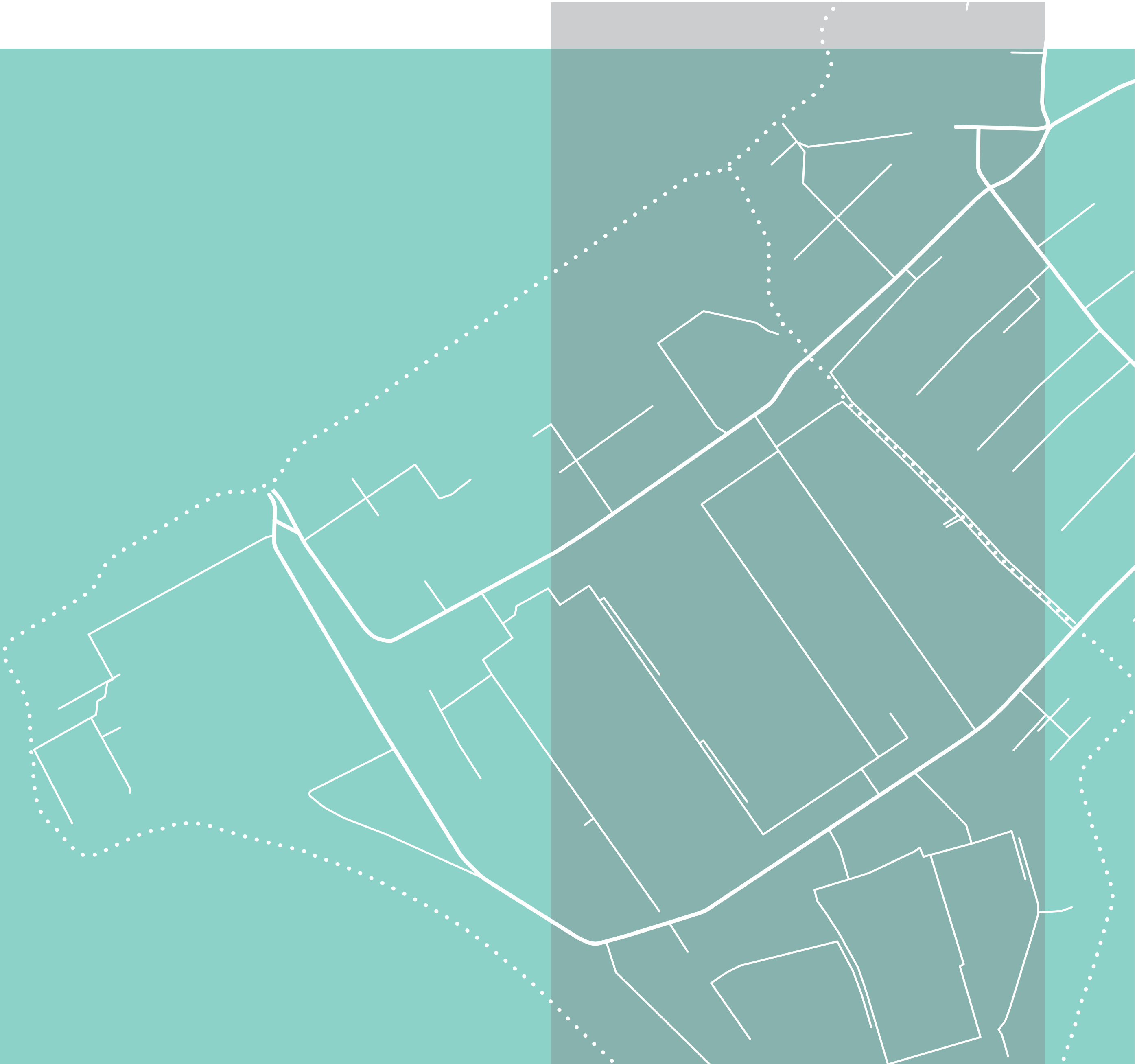
In this report the problem for the location and intended research approach will be discussed. The report roughly deals with three questions. First, a theoretical framework discussing different types of interventions in the three layers of MLS that increase physical water safety deals with “what is *imaginable*”. Second, an analysis is made of the project location, resulting in different alternatives for the Southern Flevopolder and designs of key interventions which point out “what is *possible*”. Third, the framework for balancing the flood risk management measures based on multiple criteria such as cost-effectiveness, spatial quality, flexibility, governmental complexity and possibilities to link to other climate related issues will be introduced. This framework applied to the three alternatives provides an answer to “what is *desirable*” in the Southern Flevopolder. In the final chapter, conclusions and recommendations are presented.


Pumping station “De Blocq van Kuffeler”

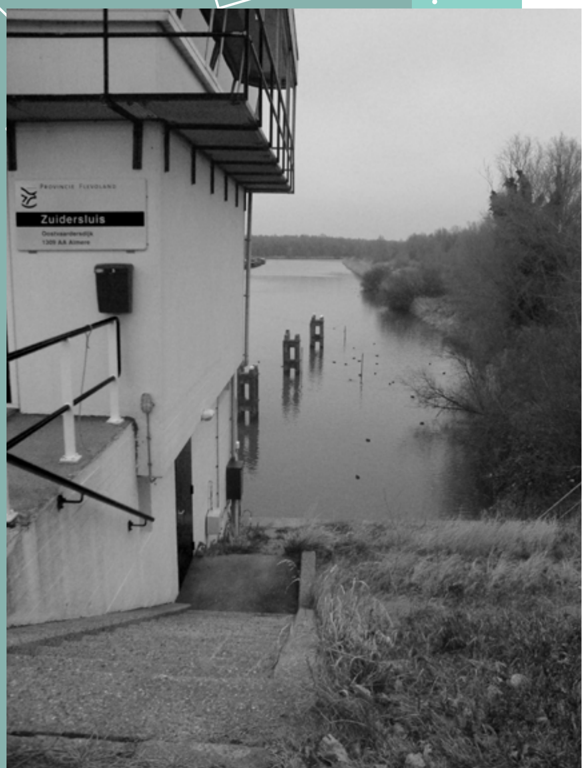
2. PROJECT DEFINITION




Sluice “Zuidersluis”,



at the end of the Hoge Vaart near the Markermeer



View to Hoge Vaart from Oostvaardersdijk

Project definition

2.1 Problem statements

Worldwide climate change

Although there still are doubts about the extent to which global warming takes place, it is established that this phenomenon occurs with climate change as a result (IPCC, 2012). On the one hand, climate change means more water: the sea level rises and the peak discharges of rivers increase. Moreover, intensive precipitation occurs more frequently. These are hard to absorb locally and can lead to water nuisance and damage.

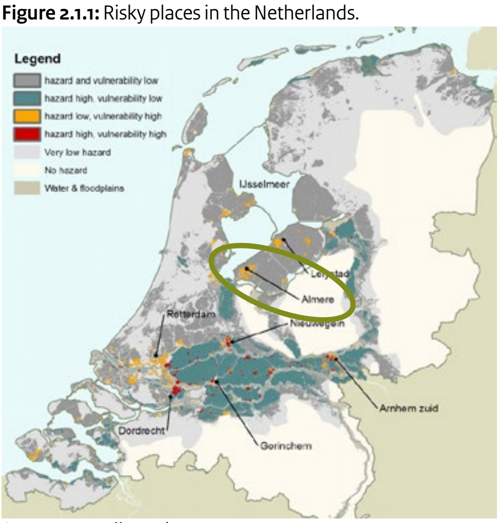
On the other hand, climate change also means less water: prolonged periods of drought and heat can create unpleasant urban living conditions and result in lowering of the groundwater. This leads to dehydration of the soil, so that oxidation occurs, and thus subsidence of the land (Goudie, 2006; Kundzewicz et al., 2007; Parry et al., 2007).

Red deltas: pressure of urbanization and flood risks

Almost 60 percent of the Netherlands is sensitive to flooding (PBL, 2013: 38). A big part of the country lies below sea level, and large rivers like the Rhine, Meuse, Scheldt and Ems flow into the sea through the Netherlands. The regions where the risk of flooding is the greatest, are the most densely populated and intensively used. In the Randstad and the major cities in the Netherlands still remains a task of densification, mostly in areas with a high flood risk (PBL, 2011: 16). Typical example of this are the plans for Almere 2.0: 60,000 new dwellings for a growth from 190,000 to 350,000 residents and business areas for 100,000 new employees planned for 2030 in a deep polder. This means more dwellings on the same surface, more construction in the subsoil and increased use of the outdoor space. This makes the potential impact of floods increase, because more lives and property are at stake (see figure 2.1.1 and 2.1.2). The Netherlands is therefore a so called 'red delta'. For these regions there is a special planning task (Van Drimmelen & Oosterberg, 2005; Hidding & Van der Vlist, 2003).

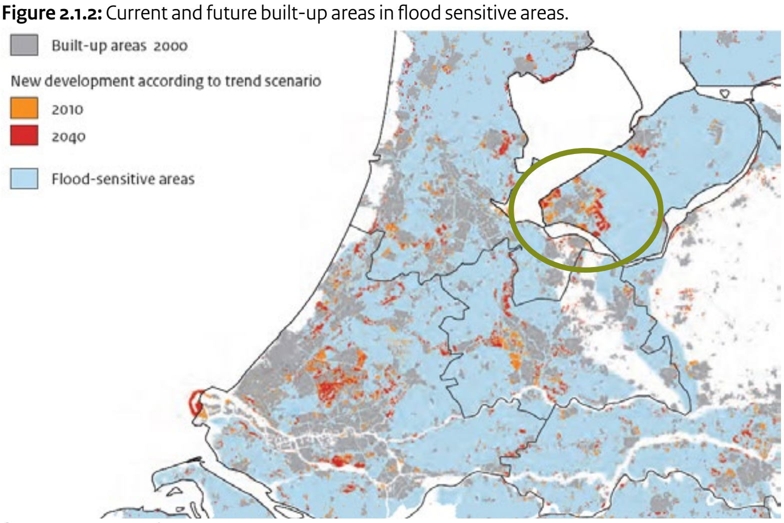
Furthermore, these areas contain more paved surface, accelerating the urban runoff of water, causing compaction of the soil. This way, the land keeps getting lower relative to the water level, causing mainly the impact component of flood risk to increase. Risk is generally referred to as the product of *probability × impact* (VenW, 2007: 51). Regarding flood risk this means "the chance of negative consequences

Figure 2.1.1: Risky places in the Netherlands.



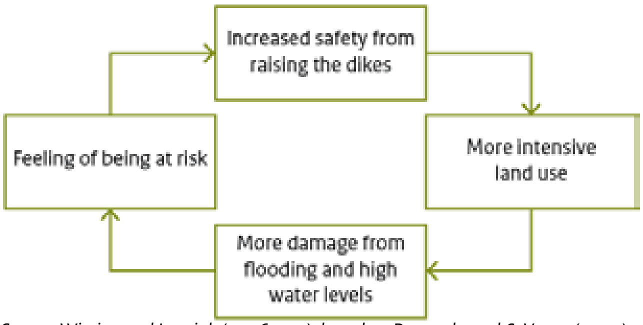
Source: De Bruijn et al. (2009: 17)

Figure 2.1.2: Current and future built-up areas in flood sensitive areas.



Source: PBL (2011: 16)

Figure 2.1.3: The control paradox.



Source: Wiering and Immink (2006: 430), based on Remmelzwaal & Vroon (2000)

of floods" (Klijn et al., 2007). These consequences consist of four types of damage: damage to human health, economic damage, social disruption and political damage (Pols et al., 2007: 48). See also section 2.5 'Operationalization of terms'.

Traditional and alternative flood policies

A shift in discourse

For centuries the Dutch have reclaimed land and protected themselves against water (coming from rivers and seas) traditionally by the construction of higher and stronger levees (Brouwer & Van Ek, 2004). This illustrates the dominant approach towards water management, a technical one aimed at ensuring safety and protecting land by blocking out water (Voogd & Woltjer, 2009: 189). It also illustrates the lack of integration between water management and spatial planning: water boards construct and maintain dikes, and behind the dikes planners and urban designers develop land use plans, without worrying about flood risk. In planning there are however more ways to deal with flood risk. Over the past few years there has been a call for alternative flood control policies, with more integration of water safety and spatial planning, e.g. Brouwer and Van EK (2004), Tromp and Van de Ven (2011), Reinhard and Folmer (2009) and Wiering and Immink (2006). Wiering and Immink (2006: 429) speak in this context of the safety discourse[1] of the 'battle against water', the existing Dutch planning doctrine of separating water and land use while relying on dikes. This may be a cost-effective approach, but perhaps not so sustainable[2] towards the future. When we look at the ecological and socio-economic advantages on the long term, there is a strong case for alternative flood control policies.

1 Discourses are images and concepts that are connected to each other and together give meaning to social and spatial phenomena (Hajer, 2006).

2 Sustainability means that "current and future generations must strive to achieve a decent standard of living for all people and live within the limits of natural systems" (Berke et al., 2006: 11).

First, implementation of climate proofing measures in urban development today may considerably reduce costs for tomorrow (PBL, 2011: 44). Furthermore, by artificially controlling water levels and systems, ecosystems get more vulnerable. Moreover, due to future climate change and further densification, social and economic consequences of floods increase. Nowadays, we can hardly afford floods, because every risky place is built-up. We are, as it were, caught in what is often referred to by professionals as the *control paradox* (fig. 2.1.3) (Remmelzwaal & Vroon, 2000; Wiering & Immink, 2006). Over the years, a feeling of insecurity led to heightening dikes, which led to a greater sense of safety. Because of this, the land will be more intensively used, which will again lead to more flood risk, and so back to heightening dikes, and so on. The result is that disasters such as floods occur less often, but when they occur, the impact and damage increase. To shift from traditional to alternative flood control policies, a change of discourse is needed. This way, 'fighting water' changes into 'embracing water'.

Water safety in the Netherlands: the introduction of MLS

On national level the climate challenges are now acknowledged and treated in the National Water Plan 2009-2015 (NWP), and the latest Delta Programme (DP2013) (VenW et al., 2009b; IenM & EL&I, 2012). With the NWP becoming active, and the introduction of the DP2013, there has been given response to the call for an alternative policy, by making a political choice for the multi-layer safety approach (MLS; fig. 2.1.4). MLS addresses, in addition to prevention, limiting the consequences of flooding by a more effective spatial organization and effective disaster management. This could be done at high risk locations to limit the *residual risk* (IenM & EL&I, 2012: 11).

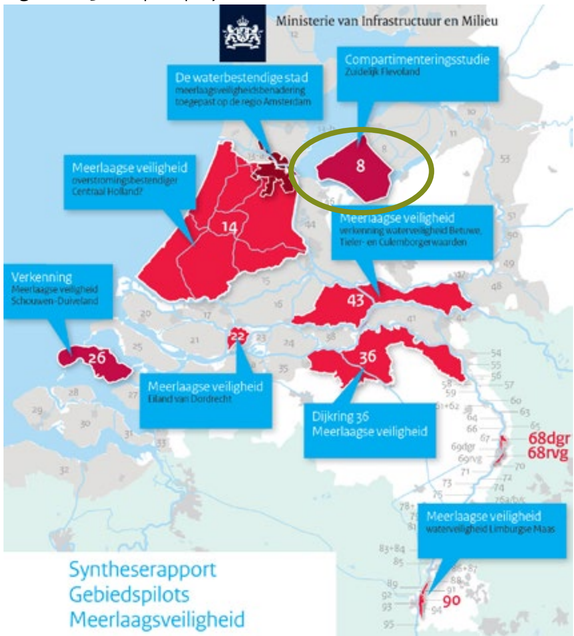
Following the NWP, a number of pilot projects were launched, including Randstad dike ring 14, Amsterdam waterproof city, Island of Dordrecht dike ring 22, South side Meuse dike ring 36, Betuwe dike ring 43 and Meuse in Limburg dike rings 68 and 90. A compartmentalization study for southern Flevoland is added to this (see figure 2.1.5). In DP2013 the area around the major rivers, parts of the

Rhine Estuary-Drechtsteden region and the area around Almere are designated as areas of attention. Here, measures in the second and third layers, combined with preventive measures, may suffice to achieve the required level of protection (IenM & EL&I, 2012: 43-44).

Figure 2.1.4: Multi-layer safety (MLS) in picture.

Source: VenW et al. (2009a: 15)

Figure 2.1.5: The pilot projects, southern Flevoland outlined.



Source: Oranjewoud & HKV Lijn in water (2011: 1)

The first layer, '*Prevention as the policy cornerstone*', responds to the probability-component, whereas the second layer – '*impact reduction by sustainable spatial planning*' – addresses the other component of flood risk. The third layer is that of '*Systematising and sustaining disaster mitigation*': measures aimed at minimization of victims, damage and social disruption. The distinction between the three layers is not absolute. Reasons for interventions in layer 2, such as adjusting evacuation routes, can come from the third layer, while strengthening a dike to prevent floods – layer 1 – needs space. Reserving this space then again belongs to layer 2.

Different terminology

The terminology of the EU Floods Directive differs from the usual jargon in Dutch water management. Especially regarding 'prevention' and 'protection'. See also fig. 2.1.6. In this thesis, the **terminology of the NWP** will be maintained. However, since the European policy is directional for the long haul, it is recommended that the European terminology eventually will be copied to the Dutch water policy.

Towards an integral approach

The linkage of climate adaptation to the spatial development requires by definition an integral approach (Pols et al., 2012: 11). It is not just about water management measures, but also about changes in land use. Actually about sustainable development. Smart links to other functions may contribute to a more efficient use of resources and technological innovation. However, integrated solutions are often difficult to achieve because our spatial planning is still organized in a very sectorial way. Primary responsibility for prevention rests with the Dutch ministry of Infrastructure and the Environment (IenM) and water boards. Provinces, municipalities and IenM[3] are responsible for safe and sustainable spatial planning. The safety regions and the ministry of the Interior and Kingdom Relations (BZK) coordinate disaster management (VenW et al., 2009a: 16,19,28). This illustrates the lack of integration between water management and spatial planning: water boards construct and maintain dikes, and behind the dikes planners and urban designers develop land use plans, without worrying about flood risk.

Heightening dikes may also be an administratively simple solution, but with a strictly preventive strategy a lot of opportunities may be missed for an integral approach that adds to other values, such as adding to spatial quality and other spatial planning assignments which are typical for every urban area in the Netherlands, e.g. realising desired program, water nuisance, as well as water shortages and heat stress. The combination and interplay between the layers is the most interesting. It is not necessary to divide the attention between the three layers, but the point is that we focus on a conscious use of the resources. In which layer that resources are used is a consideration of area-specific factors, according to Gustin (2012). Somehow a balance must be found

3 The merger of former Dutch ministries V&W (used to be responsible for prevention) and VROM (used to be responsible for spatial planning) into the Ministry of IenM, responsible for both prevention and spatial planning, thus provides opportunities for a more integrated approach.

Figure 2.1.6: Different terminology in different policies.

EU Floods Directive *EU Richtlijn overstromingsrisico's (ROR)*	**Flood risk management plans** *Overstromingsrisicobeheerplannen (ORBP-en)*	**National Water Plan** *Nationaal Waterplan (NWP)*
Protection *Bescherming*	Protection (against flooding) *Bescherming (tegen hoogwater)*	Prevention (layer 1) *Preventie (laag 1)*
Prevention *Preventie*	Prevention (of damage) *Preventie (van schade)*	Protection (layer 2) *Bescherming (laag 2)*
Preparedness/ *Paraatheid*	Crisis management *Crisisbeheersing*	Disaster management (layer 3) *Rampenbeheersing (laag 3)*
Emergency operations/ *Calamiteitenplanning*		
Restoration or recovery measures/ *Herstelmaatregelen*		

Source: IenM (2010)

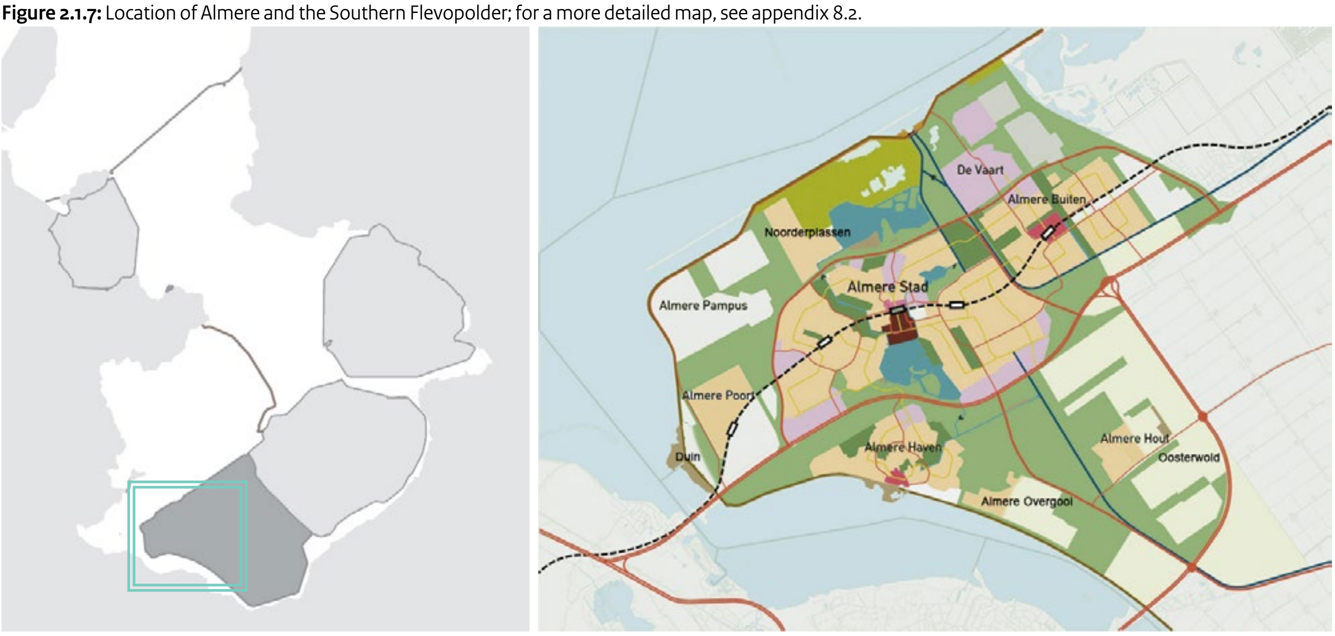
between measures on these different layers, taking these criteria into account. A more detailed research is needed on what is possible, and desirable.

Changing role of the urban planner

Large urban developments or urban renewal projects usually have a very long time span between initial design and final completions. The large amount of programme planned for Almere 2.0 is no exception to this. During this time it is possible that there will be changes in the economic structure, in the labour and housing markets, in availability of technology and in lifestyle (Stouten, 2010: 224). This uncertainty of the future is even further enhanced by the current economic climate. Even though for coming decades still a growth is expected for Almere (De Jong & Van Duin, 2011), these uncertainties ask for a different role of the urban designer. An urban design can no longer just be a rigid blueprint with some fancy impressions and sections, an urban plan has to take into account the changing context and be able to anticipate on it. This means that an urban plan somehow has to be flexible, which in the case of urban design means being able to adapt to changes like the ones mentioned above. New development will occur more in a kind of spontaneous urban planning or 'organic growth': incrementally driven, varying and growing with time.

This project tries to provide handles for integral assessment of flood risk management measures in different domains and policy levels, based on the case of Almere.

Figure 2.1.7: Location of Almere and the Southern Flevopolder; for a more detailed map, see appendix 8.2.



2.2 Location

Characteristics of Almere and the Southern Flevopolder

Below the characteristics of Almere and the Southern Flevopolder are described, according to layer of MLS, and other (climate change related) problems. A more elaborate analysis of the location is shown in appendices 8.4 and 8.5.

Layer 1: prevention

Southern Flevoland is a low lying polder, with an average surface level of 4 meter below NAP (AHN, 2012). It is part of dike enclosure 8 with a relatively high safety standard and surrounded by firm, twentieth century levees (see figure 8.5.5 in appendix). Current safety level of dike ring 8 is 1:4,000. The economically optimal safety level however is, according to Kind (2011: 56), 1:10,000 (fig. 2.2.3). A safety level of 1:4,000 means that the probability that the normative high water level is exceeded is once in 4,000 years. According to De Graaf (2009: 27) however, the actual annual probability of a flood is higher than the probabilities of exceedance, because the failure of a dike often is the result of other mechanisms than overtopping caused by high water levels, such as piping. This is confirmed by the recent VNK (Dutch: *Veiligheid Nederland in Kaart*) study for dike enclosure 8, which shows that in practice the probability of flooding is 1:550, and that there are a few weak spots in the dike susceptible to piping, overflowing, overtopping and an unstable foreshore (see fig. 8.5.6 in appendix) (Bossenbroek, 2012: 12, 52). Thus, even though the safety level against floods is high, the event of a dike breach cannot be ruled out.

The whole Flevopolder has been reclaimed in different stages. First the Eastern Flevopolder fell dry in 1957. The Knardijk, that now separates Eastern and Southern Flevoland, fulfilled the function of water defence. When the Southern Flevopolder fell dry in 1968, this function matured. Nowadays, the Knardijk is a regional water defence, with a compartmenting function between the two. The dike can protect one compartment when in the other compartment a breach of the primary barrier occurs (figure 2.2.1) (Van Duin, 1984; Delta Programme IJsselmeergebied, 2010).

Asselman and Alberts (2008: 10-14) describe several scenarios for Southern Flevoland. The breach with the greatest implications for Almere occurs when the Oostvaardersdijk at Almere succumbs and the passages in the Knardijk are closed. Therefore, this worst-case scenario will be taken as a basis for my study (see figure 2.2.2 and 2.2.7). Flevoland as a reclaimed lake is special, because it is a low lying area, which after a flood does not drain by itself. Even with maximum use of pumping stations and pumps the polder remains under water for more than one year – this is the longest flood duration in the Netherlands (fig. 2.2.4). A long recovery period is the result (Provincie Flevoland, 2012).

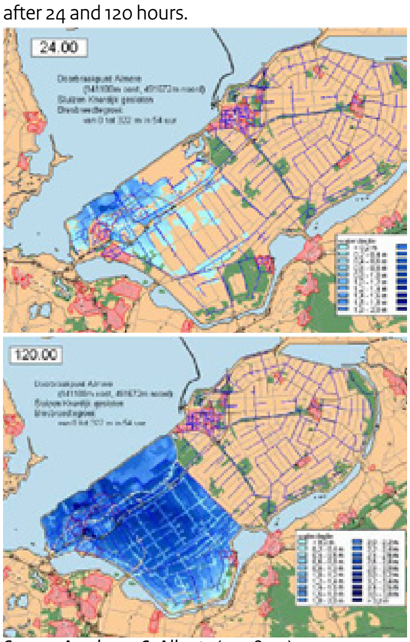
Layer 2: impact reduction by sustainable spatial planning

The Southern Flevopolder is an area that is – as urbanized, deep polder – intrinsically vulnerable. The dike ring strongly expands in terms of population concentration and economic value, which will increase this vulnerability even further. Even in these current

Figure 2.2.1: Compartmenting function of the Knardijk.

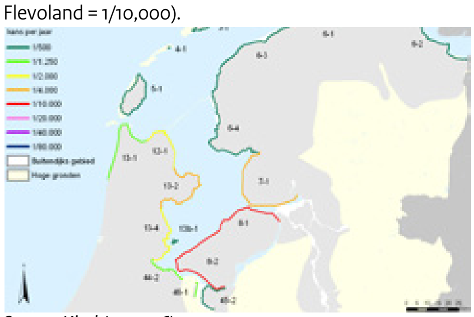
Source: Bossenbroek (2012: 94)

Figure 2.2.2: Flooded area in case of dike breach after 24 and 120 hours.



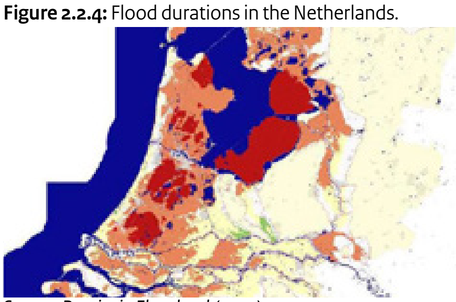
Source: Asselman & Alberts (2008: 12)

Figure 2.2.3: Economically optimal safety levels (red = Flevoland = 1/10,000).



Source: Kind (2011: 56)

Figure 2.2.4: Flood durations in the Netherlands.



Source: Provincie Flevoland (2012)

times, when the economy is stagnating and there are a lot of uncertainties about shrinkage or growth in the future, Almere is still expected to grow (fig. 2.2.5) (De Jong & Van Duin, 2011). The Schaalsprong Almere 2.0, part of the major project Rijk-Regioprogramma Almere-Amsterdam-Markermeer (RRAAM), with 60,000 new dwellings for a growth from 190,000 to 350,000 residents and business areas for 100,000 new employees planned in 2030, contributes the most to this growth (figure 2.2.9) (Gemeente Almere, 2012a). Moreover, with the expected growth for the coming years, flood risk will increase a lot due to an increase of the impact. According to Klijn et al. (2007), current costs in case of a breach will be 7 billion euro for the whole dike ring 8. In 2040 this amount can rise up to 18 billion euro. Of course these figures apply to the whole dike ring, but the majority of the increase is accounted for southern Flevoland, mainly due to the strong growth of Almere.

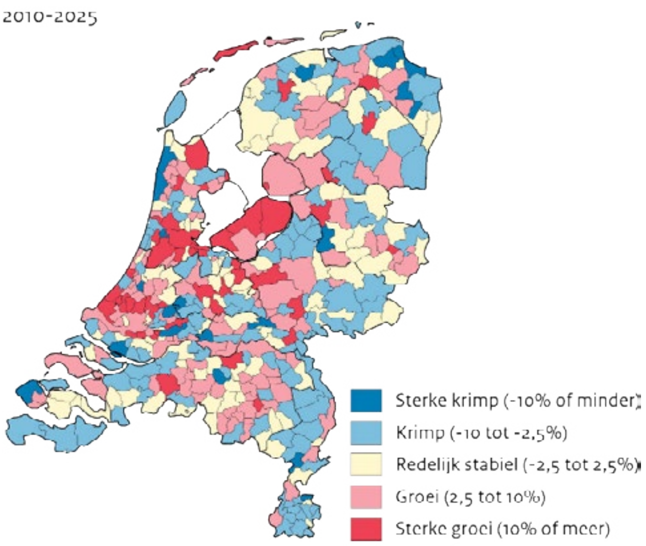
Besides this enormous pressure of urbanization, the polder is intersected by major infrastructure lines like state highway A6, the train track from Weesp to Lelystad, and several main roads, which partly are situated on dikes that serve as compartmenting elements (figure 2.2.6). Furthermore, several vital and vulnerable functions like a dependance of internet hub SARA (former Stichting Academisch Rekencentrum Amsterdam) (SARA, s.d.) and the hospital Flevoziekenhuis are situated in the polder (see also appendix 8.5.5).

Layer 3: disaster mitigation

Surrounded by big waters like the IJsselmeer, Markermeer, IJmeer, Gooimeer, Eemmeer, Nijkerkernauw, Nuldernauw and Wolderwijd, the Flevopolder is an island with limited ways of large scale evacuation and with a threat of water from all sides. Especially the possibilities for residents and other people present to get themselves into safety outside or inside the polder seem eventually inadequate. Therefore, given the short warning period and the rapid influx of water, a relatively short period and a limited number of evacuation routes is available.

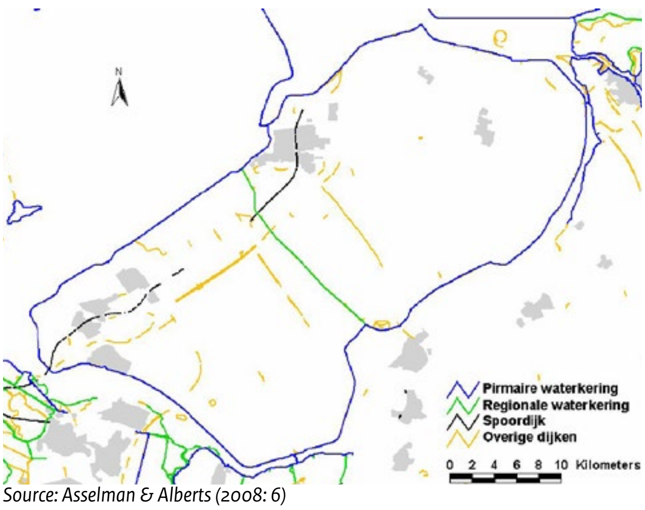
Furthermore, plans to lower the A6 to increase the connection between Almere-Stad en Almere-Haven will have negative consequences for evacuation in times of flooding, because this main evacuation route will also flood. The predicted evacuation fraction of Flevoland is 0.55, which means that according to the average outcome of different scenarios, 55 percent of the inhabitants will be evacuated preventively (fig. 2.2.8; (Beckers & De Bruijn, 2011). Because of the complex cauliflower structure in some areas such as Almere-Haven, and access to neighbourhoods by roundabouts, the evacuation of the neighbourhoods in Almere takes 24 hours (figure 2.2.12). In other words, if you are the last to get in your car, and join at the end of the line, you have to wait 24 hours to get on the highway. From there, it will take another 6 to 9 hours to get out of the polder. The flood calculations shown in appendix 8.7.1 show that the actual arrival time of water in the city after a dike breach is almost in every scenario less than 24 hours, sometimes even less than 6 or 3 hours. Evacuating the whole Southern Flevopolder takes at least 60 – 150 hours (6 days), while the warning time and time for preparation is two hours at most. Also emergency relief and rescue operations are hereby made more difficult

Figure 2.2.5: Population change per municipality, 2011-2025.



Source: De Jong & Van Duin (2011: 7)

Figure 2.2.6: Compartmenting elements in the area.



Source: Asselman & Alberts (2008: 6)

Figure 2.2.7: The story of a flood scenario.

This scenario starts from a heavy storm, caused by a depression that is heading towards North-Germany from the north of Scotland. Because of north-western wind the water levels in the southern part of the IJsselmeer have raised, so that flushing water from the Markermeer to the IJsselmeer is no longer possible. This causes the water level in the Markermeer to rise as well. The wind has the force of a hurricane. There is no more time to evacuate. Moreover, the conditions are too bad to take the streets. Many trees have been blown down, train traffic has stopped, and the Stichtse Bridge has been closed due to a tilted truck. The Oostvaardersdijk collapses under the force of meter high waves and the pushed up water. Within hours, the water reaches Almere. In the lowest parts of Southern Flevoland even the attics are not a safe place anymore. Emergency relief has a slow start, due to flooded access roads.

Source: Asselman & Alberts (2008: 3, 12)

(Veiligheidsregio Flevoland, 2008).

Water nuisance, soil subsidence and other climate change related issues

Other factors that contribute to the increasing flood risk are the soil subsidence, and the expected water level rise of the IJsselmeer and Markermeer due to adaptation to climate change (Asselman & Alberts, 2008: 15). Besides these safety assignments, there are also climate related assignments such as water nuisance, drought and water shortages, as well as heat stress in extremely hot summers. The maps in appendix 8.5.1 of the current ground level and that in 2040 show a very deep polder, which will become only deeper due to soil subsidence (figure 2.2.10). The deepest part is that of the area in Almere Oost, where also a large part of the expansion is planned. This area, and the area in Almere-Pampus in the west, will have to deal with water nuisance in 2040, which will only be increased by the added amount of paved surface in the new urban areas (figure 2.2.11; Waterschap Zuiderzeeland, 2010).

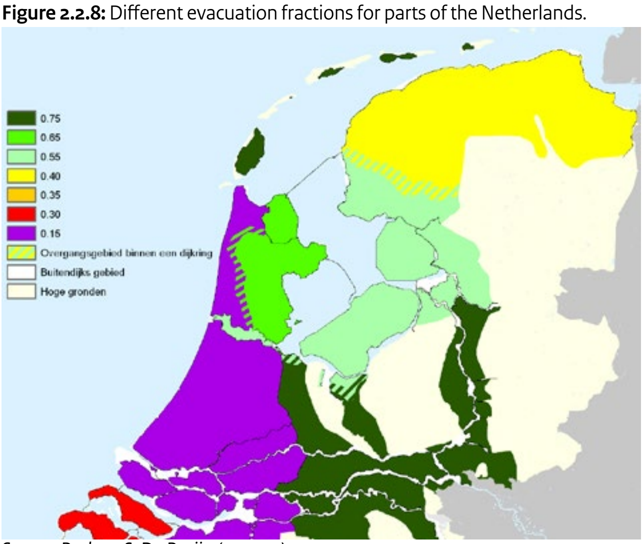
The problems of a young city

Almere faces the problems of a young city. The city is often perceived as monotonous or ugly, without a real identity (Heijmans, 2008). This is probably because it was built in such a short time span, with cheap resources and a lot of town houses that look all the same. Almere is a split city; the neighbourhoods stand on their own, as was the idea of the structure vision by Teun Koolhaas according to which Almere was built (Van der Most, 2011). In addition, Almere is characterized by functional separation. This means that functions are spatially separated, which has a large influence on the time and space. The inhabitants of Almere have a strong urge to move to use several functions, leading to an increased mobility. The green buffers between the red cores also function as a barrier, making Almere not one real interconnected city, but a city consisting of a lot of small, individual parts (De Bois, 2012).

This is also reflected in the characteristics of the facilities. In Almere much space is created for an individual way of leisure activities. Regarding the Schaalsprong, compared with other regions with around 350,000 inhabitants such as the Leiden region, Almere has to grow a lot in terms of facilities. Research by INTO (2007: 44) shows that the current facilities of Almere, particularly regarding hotels/restaurants/cafes, culture and tourist attractions, and in lesser extent in terms of shops, is regarded below standard. The amount of facilities, measured by the number of jobs in those sectors compared to the population size, is insufficient (see also appendix 8.5.6). Therefore, the planned extra programme for sports, cultural activities and certainly also for education, is essential to make the Schaalsprong work.

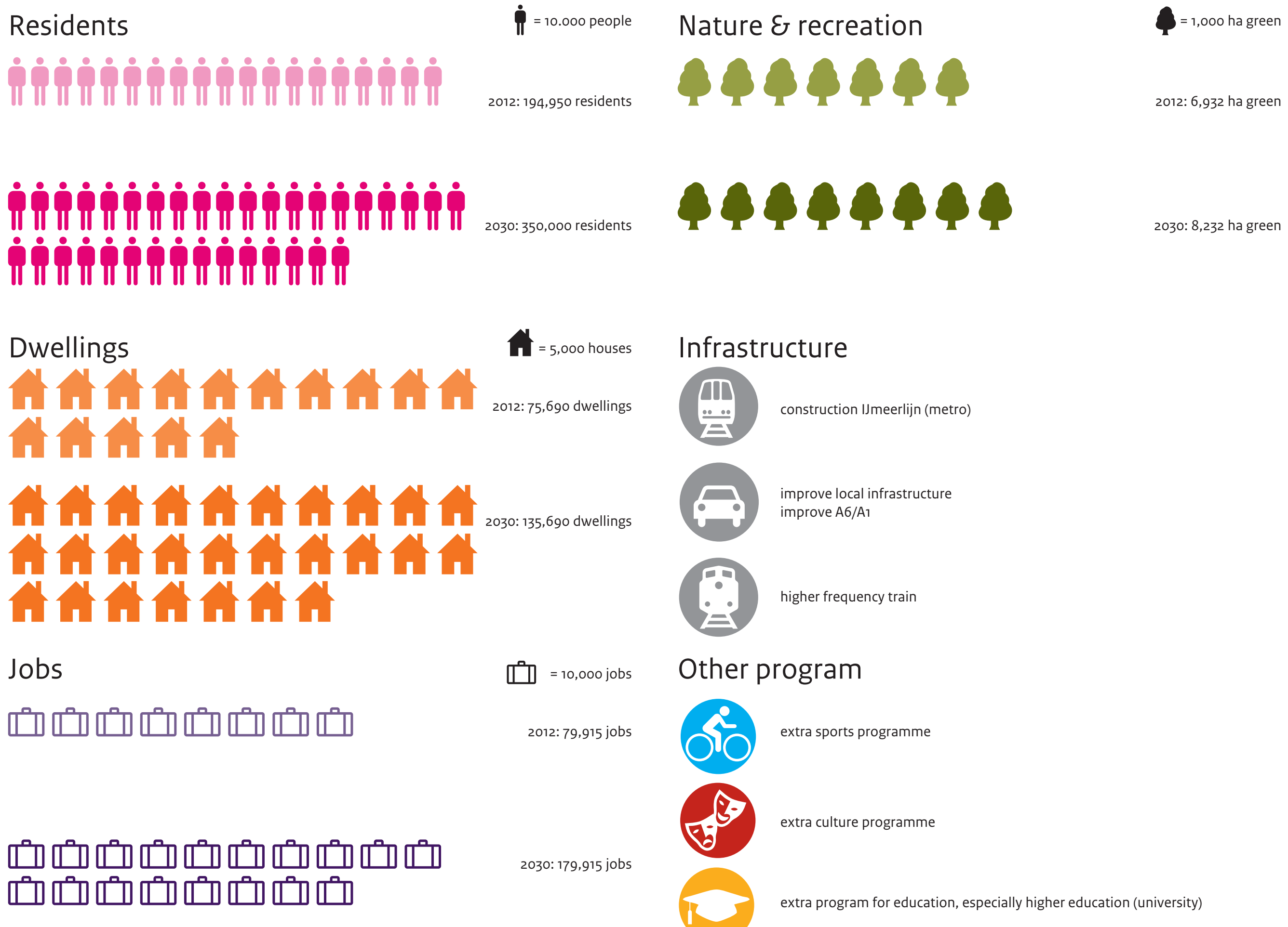
All these assignments together require a comprehensive approach varying from interventions in buildings and public spaces to structural measures on the scale of the polder itself.

Figure 2.2.8: Different evacuation fractions for parts of the Netherlands.



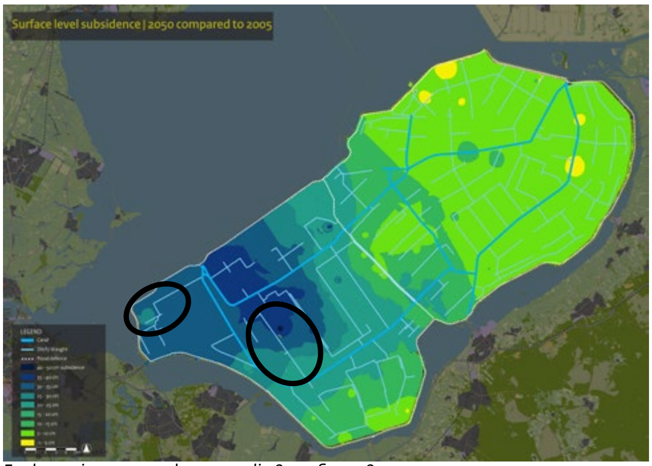
Source: Beckers & De Bruijn (2011: 13)

Figure 2.2.9: Urban assignment for Almere 2.0.



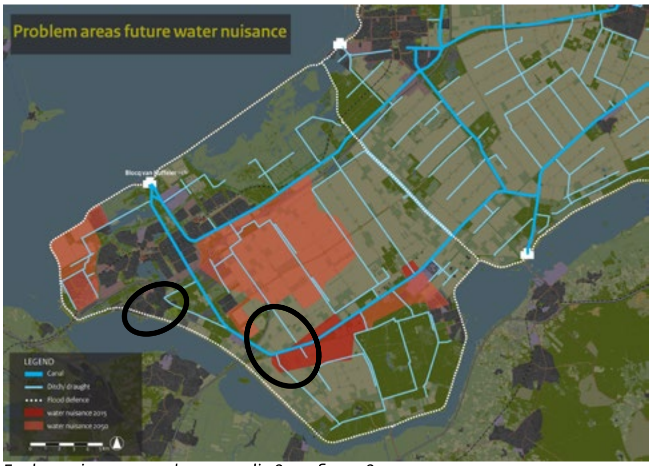
Source: adapted from Gemeente Almere (2011) and Gemeente Almere (2012a)

Figure 2.2.10: surface level subsidence, 2050 compared to 2005; the Almere 2.0 expansion areas Pampus and Oosterwold marked.



For larger image, see also appendix 8.5.1, figure 8.5.3.

Figure 2.2.11: Problem areas future water nuisance; the Almere 2.0 expansion areas Pampus and Oosterwold marked.



For larger image, see also appendix 8.5.1, figure 8.5.7.

Figure 2.2.12: Evacuation times from neighbourhoods and on main roads.

Cores to evacuate	Evacuation route	Exit point	Total amount of evacuation time needed (in hours)	
			On main roads	From neighbourhood
Almere	A6 south	Hollandse Brug	9.4	24
Almere	A27	Stichtse Brug	9.4	
Zeewolde, Almere	N705 and N305 via N301	Nijkerk	5.4	11

Source: adapted from Veiligheidsregio Flevoland (2008)

2.3 Aim of the project

Goal of this graduation project is to apply multi-layer safety, with the focus on spatial interventions, in areas with a major development task.

Ultimately the research part of the project resulted in a report on the different spatial interventions that reduce flood risk in the three layers of MLS, and an investigation on different criteria that should be taken into account when making a comparative assessment between alternative design solutions of interventions on different layers of MLS. This has resulted in a practical framework for comparative assessment, which can serve as a tool for integral spatial planning, communication between planners and designers, to help develop certain strategies for development and flood proofing.

The design part is meant to test the framework for comparative assessment and as a showcase of the spatial implications of all the possible and desirable spatial interventions that reduce flood risk in the three layers of MLS. A number of alternatives for the planned expansion of Almere 2.0 in (or outside) the southern Flevopolder are proposed that make the link from theory to practice. What these interventions would really look like, when applied to this specific location, is illustrated by two urban designs for key interventions in the existing city and the open polder.

2.4 Research questions

The research and design of the graduation project has been executed partly at Delft University of Technology (TU Delft), and partly at PBL Netherlands Environmental Assessment Agency (PBL), at the departments of Water, Agriculture and Food, and the department of Spatial Planning and Quality of the Local Environment.

One of the conclusions of the PBL is that there is still a missing link between climate adaptation and climate mitigation. Common tendency in the Dutch policies and way of thinking about water safety is that it is either prevention, or accommodation. The PBL advises that mitigation and adaptations should go together. My task at the PBL has been to develop a framework for trade-off/balance between measures on the different layers of multi-layer safety, to seek for smart combinations of different interventions. This balance can be evaluated based on relevant criteria like spatial quality, flexibility of implementation and cost-effectiveness in terms of economic costs. A secondary evaluation, not leading for the decision making, but still relevant, is whether these interventions also anticipate on other design tasks, like water nuisance, fresh water supply and heat-related risks.

Sometimes there is more to say for a measure on the first level of prevention, and other times measures on the second and third level will be more suitable, depending on previously mentioned criteria. Leading question of the research and design therefore will be:

> MRQ:
> *What is the best **balance** between the **three layers of multi-layer safety** that enhance the quality of the **built environment** and **physical water safety?***

The master thesis treats the potential improvement of the physical water safety, tested on the case of the Southern Flevopolder and the plans for Almere 2.0. Research issues are which urban and spatial factors influence the physical water safety, which types of interventions in these factors can reduce flood risk, how these interventions can be translated into different alternatives for the Southern Flevopolder, and eventually how these alternatives can be balanced taking criteria such as spatial quality, flexibility and cost-effectiveness into account.

This main research question has been answered according to the following sub research questions:

SRQ1: *What is imaginable in terms of interventions?*

- Which **urban and spatial factors** influence physical water safety?
- Which interventions in these factors can reduce **flood risk**?
- To what extend can different **types of interventions** be distinguished?

SRQ2: *What is possible at this test location?*

- What is the **specific context** of the proposed measures, and how can they be translated to several alternatives for the **context of the southern Flevopolder**?

SRQ3: *What is desirable? How can you make a proper comparative assessment?*

- What criteria and indicators can be used to **balance** the different measures? How to operationalize these criteria? (for instance spatial quality, flexibility of implementation, cost-effectiveness)
- How do the different proposed alternatives in the southern Flevopolder score on the (social/ spatial) cost-benefit analysis/ multi-criteria analysis, taking **spatial quality**, **flexibility of implementation** and **cost-effectiveness** into account?

2.5 Methodology

This chapter addresses the methodology of the research and design part of the graduation project. The following section will discuss how the research questions have been answered. Described and reasoned is which methods are used for research and design, after an operationalization of the bold terms from the problem statement mentioned above.

Operationalization of terms

(Types of) interventions

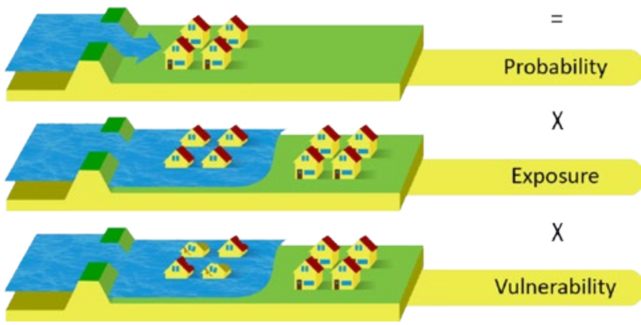
An intervention is often defined as "taking action or the process of taking part in something" (The Oxford English Dictionary, s.d.). This means that an attempt is made to prevent or alter a result or course of events. These alterations can take place on various fronts. In the context of physical water safety different types of interventions can be distinguished. This research and design will mainly focus on the three layers of multi-layer safety. This regards three layers of safety against floods: [1] prevention; [2] impact reduction; [3] disaster mitigation. Within these safety layers, different angles of approach can be found (see also chapter 4.2).

Built environment / urban and spatial factors

Urban(istic) (Dutch: *stedenbouwkundig*) means 'according to the principles of *urbanism (Dutch: stedenbouw;* the planned construction and expansion of cities)'. Because the eventual goal of the graduation project is to receive the MSc Urbanism diploma, and the graduation research and urban design have to concern urban design, the research and design will focus on urban and spatial factors, in other words the built environment, which can affect the physical water safety (further elaborated in chapter 4.1). This may include physically visible elements of the urban environment, such as building heights, functions, densities and physical characteristics of the three layers of the city plan – natural landscape, networks and occupation (Heeling et al., 2006: 19; Heeling et al., 2008).

Another factor, although not strictly physical, is the governmental aspect of the measures. The complexness of governmental structures that accompany the proposed measures, have a huge influence on whether an intervention will take place or not. This is one of the reasons that the current policy is mainly focused on prevention, because the construction and maintenance of levees comes under the responsibility of one actor, and spatial planning behind the dikes is the responsibility of another. When these responsibilities become mixed, the story becomes very complex and also the timeframe changes.

Figure 2.5.1: Definition of flood risk



Source: adapted from RLI (2011: 40)

Other factors that may influence water safety, such as climate change and awareness, will not be taken into account in the analysis, because these factors cannot be translated into an urban design. However, recommendations may be given.

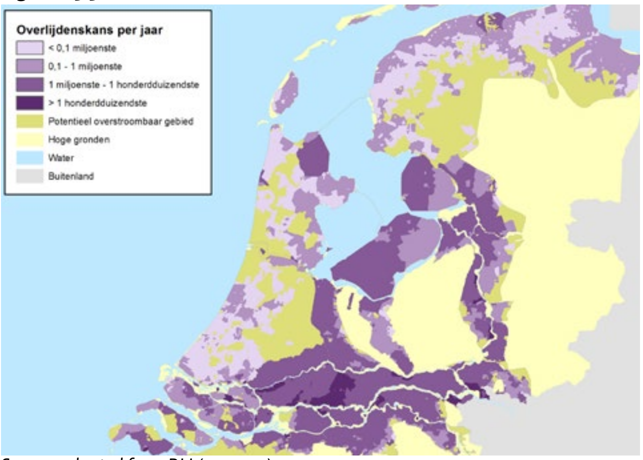
Physical water safety

Safety against water and floods is approached differently in the Netherlands and all over the world. With the National Water Plan becoming active, and the introduction of the latest Dutch Delta Programme (DP2013), there is a focus on the concept of multi-layer safety, consisting of three layers. "As such, it will address, in addition to *prevention*, *limiting the consequences* of flooding by a more effective *spatial organization* and effective *disaster management*" (Delta Programme Commissioner, 2012: 11). In my design, I take into account only those aspects of water safety that affect the physique. Prevention and sustainable spatial planning clearly include physical aspects: prevention of risky situations by (physically) staying away from the water, 'building with water', and dike reinforcements or elevations. Other aspects fall into a grey area: disaster management includes "flood alerts, evacuation, response and recovery (civil protection issues)" (Slomp, 2012: 21). Most of these issues are organizational. For an urban design, this is not relevant, and therefore not included. However, some issues like identifying, repairing/restoring and signalling evacuation routes, or building elevated shelters, are physical measures (RLI, 2011: 59; VenW et al., 2009: 71-76).

Flood risk

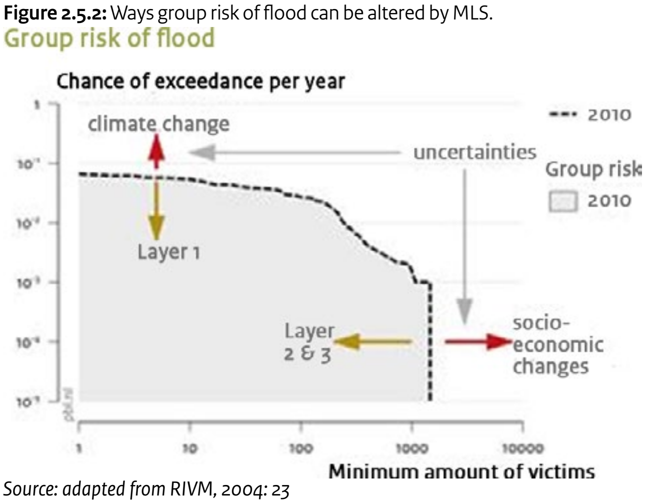
Flood risk is the risk that a flood occurs when an uncontrolled amount of water flows into the land. This can be either from a river, lake or sea (Van de Ven et al., 2009: 137). Risk is generally referred to as the product of *probability* × *impact* (VenW, 2007: 51). Regarding flood

Figure 2.5.3: Local individual risk, second reference situation.



Source: adapted from RLI (2011: 40)

Figure 2.5.2: Ways group risk of flood can be altered by MLS.



Source: adapted from RIVM, 2004: 23

risk this means "the chance of negative consequences of floods" (Klijn et al., 2007). The consequences can be further divided into two components: exposure and vulnerability. Hence, risk is also defined as *probability* x *exposure* x *vulnerability*, as is shown in figure 2.5.1 (RLI, 2011: 39-41). The probability-component of flood risk is the chance of occurrence of a flood. In the Netherlands the primary water defences together form so-called dike enclosures – 53 in total, excluding those along the Meuse. Each of these enclosures has a different safety level, that has legal status established in the Dutch Water Act, and is expressed in a maximum acceptable flood return period. The norms range from once every 1,250 years to once every 10,000 years (Brouwer & Van Ek, 2004: 1).

The consequences consist of damage to people and their property, i.e. the risk of victims, and damage risk (Dutch: *slachtofferrisico* and *schaderisico*). In the case of damage to people one should think of psychological damage and physical damage. With regard to physical damage, in the Netherlands, damage to people is mostly limited to the chance of mortalities. A distinction is made between *individual risk* of death and *group risk* or *societal risk*[1] (Dutch: *groepsrisico*). Individual risk is expressed in the Local Individual Risk (LIR). The LIR is defined as the probability per year for a fictional person present at a particular location to die as a result of flooding, taking into account the possibility of preventive evacuation. The LIR is thus not dependent on the population density (fig. 2.5.2; (Beckers & De Bruijn, 2011: 16).

For the different authorities societal risk is a more relevant measure, because "it is mainly the large number of victims per event that make the impact of floods so radical and for which government intervention is needed" (Klijn, 2008: 45). Societal risk is therefore also the most important risk that will be taken into account in this study. The probability of a given flood scenario and the relating number of people affected is expressed as the average number of victims by means of Potential Loss of Life (PLL) or a FN curve. The value of the PLL for the whole country comes down to the average number of victims per year, which is calculated by multiplying the chance of all possible events and the corresponding consequences. The FN curve sets the chance of a flood out against the number of victims, so the likelihood of the exceeding of a given number of victims is shown (Jonkman & Cappendijk, 2006: 41). Figure 2.5.3 shows the ways that interventions in the different layers of MLS can reduce either the chance of exceedance, or the number of victims. If flood defences are not adjusted, the probability of flooding due to climate change will increase. Due to population growth in embanked areas the maximum number of victims can increase. In current policy the group risk is primarily reduced by lowering the probability of flooding. However, due to climate change the maximum number of victims may even increase, for example by higher sea levels and more intense storms. Interventions in layer 2 and 3 thus can be more effective from a group risk perspective.

Damage to property is expressed as the average annual *damage in euros*. This measure is important for this study, in order to establish the cost-effectiveness. This may include direct physical damage to objects, capital and movable property, and direct damage due to business interruption, but also indirect damage, such as damage to supplying and consuming businesses outside the flooded area and time loss due to failure of roads and railways in the flooded area (Pols et al., 2007: 48).

1 Societal risk treats the probability of victims in a group. Individual risk covers the individual probability of death (Klijn et al., 2007: 117).

Pols et al. (2007: 48) argue that damage shall not only be expressed in monetary units. Fatal victims bring along, besides ethical objections to the expression of a human life in monetary units, great political damage and social disruption. Governments can also receive a serious blow as a result of flooding, causing them to not be re-elected. Social disruption can occur when different settling behaviour occurs due to sense of insecurity. This can affect the reconstruction of society.

Specific context of proposed interventions
In order to compare the different cases with the southern Flevopolder, the (spatial) characteristics of the specific context of the proposed interventions have to be determined. Is it an inner or outer dike area? In what type of landscape is the area situated? Is the intervention in a (re-construction) existing area, or in a new development area? What is the specific threat of water (sea, rivers or precipitation)? What is the important and vulnerable infrastructure in the area, where are the people and buildings that are at risk? The latter can be seen in terms of population and building density, and flood scenarios. The scale of the interventions is also very important.

(Context of the) southern Flevopolder
The southern Flevopolder is part of the Zuiderzeeproject, and is a polder that was reclaimed between 1955 and 1968. The area is demarcated by the Markermeer and Oostvaardersdijk in the northwest, the Gooimeer, Gooimeerdijk, Eemmeer and Eemmeerdijk in the southwest, the Nijkerkernauw, Nijkerkerdijk, Nuldernauw and Nulderdijk in the southeast, and the Knardijk in the northeast (see appendix 7.2). See for a further elaboration of the context of the southern Flevopolder a description of the location in chapter 2.2 and an elaborated analysis in appendices 8.4 and 8.5.

Cost-effectiveness
Economic attractiveness is measured by the ratio between costs and benefits, expressed in euros. The costs consist of investment and maintenance costs. For this, several general indicators can be used (already collected in e.g. Baan et al. (2008) and VenW (2006); see also chapter 3). Because of cost considerations the possibilities to pair with certain functions should be examined (Asselman & Alberts, 2008: 17,21).

The benefits of the proposed measures consist of risk reduction, or the decrease of the damage multiplied by the chance of a dike breach. These benefits can be determined through flood simulations, after which the resulting damage is determined. Other benefits, not expressed in euros, cover the threat of victims and the number of people affected: the number of people experiencing water nuisance because their homes are situated in the flooded area (Asselman & Alberts, 2008: 20).

Spatial quality
The different alternatives generated may affect the spatial quality of an area, especially when the relation between water, buildings, infrastructure such as dikes, and public space changes. This effect and relation is different in every local situation, created by completely different elements. There is no general definition of the term spatial quality, the term is not easy to grasp, but in general it is about a good spatial and functional relation between water safety structures, the water itself, landscape and the built environment. The exact criteria for the contribution to spatial quality of the alternatives will be established further in chapter 4.

Flexibility
The different interventions and alternatives may vary in flexibility in terms of spatial and functional use over time. For example, measures taken in the infrastructure are less flexible than local measures in buildings. And this may be a factor that influences the choice for different interventions and the balance between the different alternatives.

Uncertainties about the current economic times and climate change scenarios also call for flexible plans. For example, between 2050 and 2100 the level of the Markermeer can rise with one meter. The intervention has to be effective also towards these changing contexts in the future. Furthermore, an intervention has to be without too many complex structures, e.g. measures during a calamity that require human intervention such as closing up crossings of main roads and waterways in a compartmentalization dike (Asselman & Alberts, 2008: 21).

Research methods

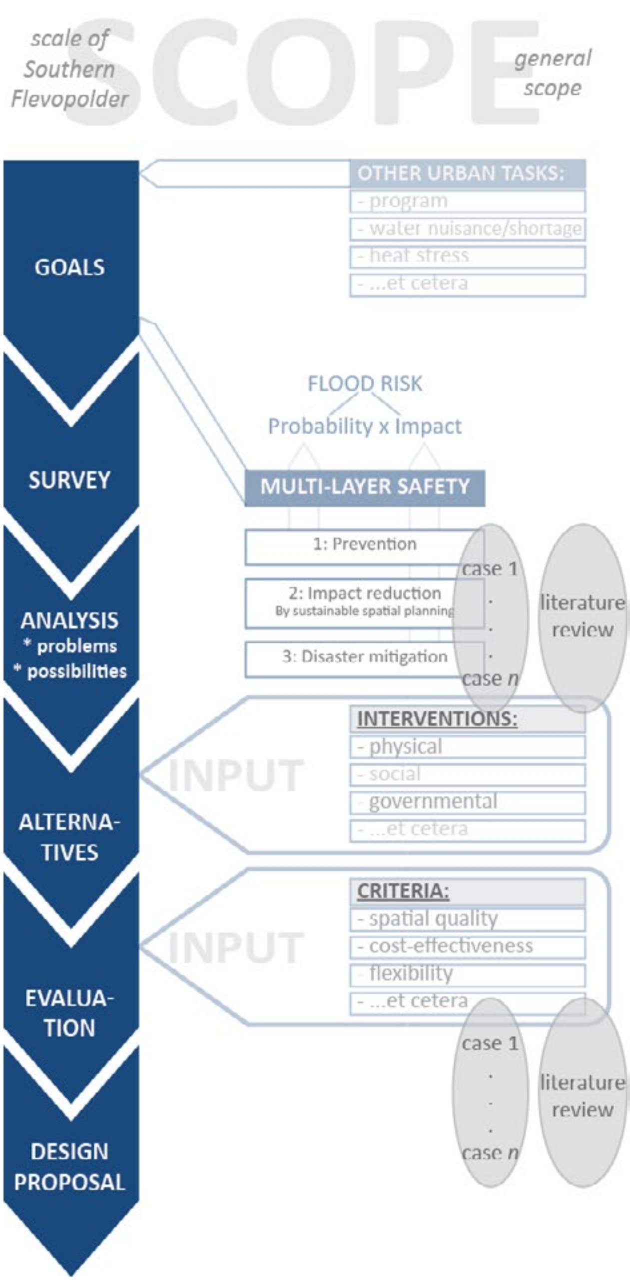
A research needs to include among other things aspects of reliability, transperency, validity and repeatability, to give it any scientific value. To meet these criteria, every step needs to be accounted for. Bryman (2008: 35) distinguishes five types of research designs: "quasi-experiments, cross-sectional or survey design, longitudinal design, case study design, and comparative design".

To gather deep, context specific information about a certain case, one can perform a **case study**. This is the study of a certain phenomenon, defined in place and time. Over time, many case studies have been done and a lot has written about executing a case study in the right way (Bryman, 2008; Flyvbjerg, 2006; Yin, 2003). In this study, a case study design is chosen to derive interventions to improve spatial quality, and criteria to test the different alternatives (see also fig. 2.5.4). For this situation this is the most suitable research design, because the research question aims at a fictive situation; the physical water safety in the Southern Flevopolder has not yet been improved, and the program for Schaalsprong 2030 has not yet been realized. For this reason, other cases than the Southern Flevopolder are studied, in which interventions are used to improve the physical water safety, and for which criteria have been made to assess them by.

Ideally, the cases should resemble the Southern Flevopolder as much as possible in terms of location/ position, height, population density, building density, threat of water etc., to be able to make the translation to the context of the Southern Flevopolder. This then results in an ex-ante evaluation of possible measures.

Two types of cases have been selected: an outer dike area in the IJmeer/Markermeer, and an inner dike area of new development in a deep polder (the executed case studies can be found in appendix 8.3). In the first category, the project of IJburg in Amsterdam has been selected, to gather more knowledge about what is means to build in the IJmeer/Markermeer, of which plans already exist for Almere-Pampus. In the second category, two projects in the Zuidplaspolder – the deepest polder of the Netherlands – have been chosen, namely the pilot projects near Moordrecht and Westergouwe near Gouda. These are two projects of new development in an 'empty' polder, whereas parts of the Southern Flevopolder have already been built. However, in a new neighbourhood in a deep polder after all the same water related problems exist, and furthermore the latest interventions are applied. This creates a broad picture of old and new interventions. In addition, transformation takes place within the existing structures. Residential buildings last an

Figure 2.5.4: Intended research and design process.



average of about 50 to 100 years, and commercial buildings have a lifespan of 20 to 55 years, so these need replacement at some point (Verbiest, 1997: 17). Especially if the design concerns a vision for the next two or three decades, within the existing structures a significant part will be newly built. Preconditions can then be given to the replacement of existing buildings.

Research

Methods for data collection that are used consist firstly of **literature review.** This way work already done will not be repeated, and there can be learned from similar experiences. Types of literature to be reviewed are relevant memoranda and reports on different scales, relevant actors and their articles, relevant folders, websites, et cetera. Following questions can be tackled by this method:

- Which *urban and spatial factors* influence physical

water safety?
- Which interventions in these factors can reduce *flood risk*?
- To what extend can different *types of interventions* be distinguished?
- What criteria and indicators can be used to *balance* the different measures? (for instance spatial quality, flexibility of implementation, cost-effectiveness; how to operationalize these criteria?)

Secondly, to get a grip on cost-effectiveness, spatial quality and governmental aspects, many **professionals have been interviewed,** such as planners, designers, engineers and policy makers (see appendix 8.1 for a list of people consulted). Professionals that are involved with the Southern Flevopolder, and have a lot of knowledge about the subject, are amongst others actors from the Water board Zuiderzeeland, Security region Flevoland, the province of Flevoland, the municipality of Almere and Deltares.

To identify spatial factors that have not come up through literature study, other **digital sources** have been consulted: Google Maps, Google Earth, and Bing Maps, et cetera. For the specific context of the southern Flevopolder, **field work** through **site visits,** and **mapping** has been done.

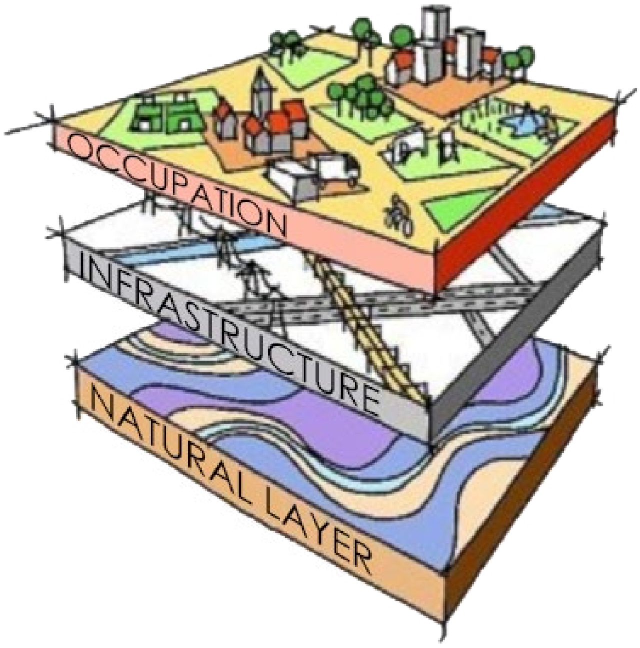
Design

Central to the design phase are the last two sub research questions:

- What is the *specific context* of the proposed measures, and how can they be translated to several alternatives for the *context of the southern Flevopolder?*
- How do the different proposed alternatives in the southern Flevopolder score on the (social/spatial) cost-benefit analysis/ multi-criteria analysis, taking *spatial quality, flexibility of implementation* and *cost-effectiveness* into account?

The specific context of the spatial interventions, and the specific context and problematics for the southern Flevopolder have been established through studying different sources such as reports, digitally by for example Google Maps, through site visits and by interviewing professionals. An important method for analysing these areas is the "layer method", figure 2.5.5, which includes an analysis of characteristics of the three layers of the city plan – natural landscape, networks and occupation (Heeling et al., 2006: 19; Heeling et al., 2008). The properties of the urban and spatial factors that influence physical water

Figure 2.5.5: The layer approach as introduced in the National Spatial Strategy (Dutch: *Nota Ruimte*).



Source: NIROV & VROM (2010)

safety are identified. Scale is very important, and also the authorities or institutions responsible for implementation. A comparison has been made between the specific context of the intervention proposed in a certain case study and the specific context of the Southern Flevopolder, to see whether this intervention is also applicable there.

Generating the alternatives is done through **research by design.** All these alternatives have been evaluated based on the criteria that together form the framework for comparative assessment. This is done through a so called **multi-criteria analysis,** with both qualitative and quantitative parameters. To evaluate the different alternatives, also a **panel of experts** helped judging them. For this, a spatial elaboration of some key interventions has been made, so that the effect on spatial quality could be tested.

Inset 2.1: Discussion amongst professionals about need for and role of multi-layer safety in Dutch spatial planning practice: critics of multi-layer safety (WaterForum Online).

"Political choice for multi-layer safety bizarre" *(Keuze politiek voor meerlaagsveiligheid bizar)*

Source: Vrijling, Professor in Probalistic Design and Hydraulic Structures TU Delft, in: Lammers (2012) on WaterForum, 27 April 2012.

"TU Delft-researcher Rijcken questions multi-layer" *(TU Delft-onderzoeker Rijcken plaatst vraagtekens bij meerlaagsveiligheid)*

Source: WaterForum Online (2012b) on WaterForum, 27 June 2012.

Inset 2.2: Discussion amongst professionals about need for and role of multi-layer safety in Dutch spatial planning practice: proponents of multi-layer safety (WaterForum Online).

"Constructing dikes only is not sufficient" *(Alleen dijken bouwen is niet voldoende)*

Source: Jonkhoff, economist TNO, and Van Ginneken, Project manager at Royal HaskoningDHV (2012) on WaterForum, 4 July 2012.

"Use all opportunities for integral safety" *(Alle kansen op integrale veiligheid benutten)*

Source: Gustin, Advisor and Project manager water for APPM Management Consultants (2012) on WaterForum, 9 July 2012.

"Multi-layer safety victim of battle of faith" *(Meerlaagsveiligheid ten prooi aan geloofsstrijd)*

Source: Van Huut, Deputy Director of the Delta Programme Rijnmond-Drechtsteden (2012) on WaterForum, 16 July 2012

2.6 Scientific and societal relevance

Scientific relevance

In the Netherlands, flood risk and the roles of spatial planning and water management are subjects that to a large extend have been mentioned in scientific and professional literature.

Over the past few years there has been a call for alternative flood control policies, with more integration of water safety and spatial planning, e.g. Brouwer and Van EK (2004), Tromp and Van de Ven (2011), Reinhard and Folmer (2009) and Wiering and Immink (2006). With the National Water Plan becoming active, and the introduction of the latest Dutch Delta Programme (DP2013), there has been given response to this. However, amongst professionals there is still a discussion about the real need for multi-layer safety (see quotes from WaterForum in inset 2.1 and 2.2). Van Huut (2012) sees two movements as a result of a battle of faith: believers and non-believers of multi-layer safety. Proponents of pure preventive measures accuse 'enthusiasts' of trying to apply multi-layer safety in areas where this is not useful or efficient, and 'inner dike spatial planning busybodies' (Dutch: *binnendijkse ruimtelijke ordenings regelneven*) of not dividing their attention efficiently between the 'niggling' benefits of flood resilient building in Almere and other greater threats (Lammers, 2012; WaterForum Online, 2012a; WaterForum Online, 2012b).

According to Nijwening (2012), newly graduated (civil) engineers such as those of TU Delft usually come up with very technical, rational and cost-effective proposals. Nijwening (2012) states that there is still a bit wrong with the realization by those newly graduated (civil) engineers that providing technical measures really and always is part of a broader social process, in which the technical-rational perspective is only one of many.

Integral approach again is the keyword. Fact is that already many studies have been done on possible interventions, e.g. Pols et al. (2007), Provincie Utrecht (2010), Pieterse et al. (2009), RLI (2011: 59), Van de Ven et al. (2009) and Xplorelab (2008c). However, no unambiguity is created, no links are established, and no hierarchy ascribed to various interventions that reduce flood risk. Moreover, multi-layer safety is still too much considered as layer 1 versus layer 2. However, the combination and interplay between the layers is the most interesting. It is not necessary to divide the attention between the three layers, but the point is that we focus on a conscious use of the resources. In which layer that resources are used is a consideration of area-specific factors, according to Gustin (2012). A precise research is needed on what is possible, for example, the costs and the effectiveness of reducing risks.

The tendency of this discussion amongst professionals points out the need for an applied method or tool for an integral approach, exactly the added value of this project. This project tries to provide handles for integral assessment in different domains and policy levels.

This framework for comparative assessment will not only be applicable for the context of Almere and the Southern Flevopolder, but it will be transferrable to other locations of new development or redevelopment in deep polders with a high flood risk.

Involved disciplines

This project mainly takes place in the field of urbanism, but also touches upon civil engineering, urban and regional planning, and all the domains that are involved, such as social and behavioural sciences, demography, economics, landscape design, water- and nature management, sustainability or traffic engineering.

Societal relevance

In the speech by the new Dutch king, His Majesty King Willem-Alexander, on the occasion of his investiture, the importance of responsible water management for Holland was stressed once again (inset 2.3)

The fact that also in society there is a need for other measures than purely prevention, also because of the visual pollution and the possibly negative effect on the spatial quality that dike reinforcements and raised dikes entail, is illustrated by Markus (2012), see inset 2.4. In this case, the residents of Uitdam, a village in Noord-Holland where the dike of the IJsselmeer has to be raised and expanded towards the lake, take action against the dike reinforcement. This levee no longer meets the requirements of the Waterboard. Plans are to construct an outward dike reinforcement, with the new top of the levee twenty meters outward. Inhabitants of Uitdam fear for a loss of the unique town character, and a loss of visual relation with the water, which can have a negative effect on the market value of their houses. This is one of the reasons why in this graduation project the contribution to spatial quality is one of the criteria used in the framework for comparative assessment of the alternatives.

In a broad sense, the societal relevance of this study lies in the fact that in the Netherlands there are many social activities and planned development that take place in areas with a high flood risk. This study provides tools to deal with this and still expand and redevelop in these areas, and thus will have a wide support base.

In a narrow sense, this study is relevant for the new residents, businesses, employees and visitors of Almere that will be attracted to the city through the Schaalsprong 2030.

Inset 2.3: Speech by His Majesty King Willem-Alexander on the occasion of his investiture, stressing the importance of water(management).

Source: RIVD, 2013a.

"It has also allowed me to gain a deep insight into issues, such as responsible water management, which are fundamental to our country" (RVD, 2013b).

Inset 2.4: Newspaper headings: Developments of preventive measures are being reflected in newspapers and related to the affected inhabitants (Trouw).

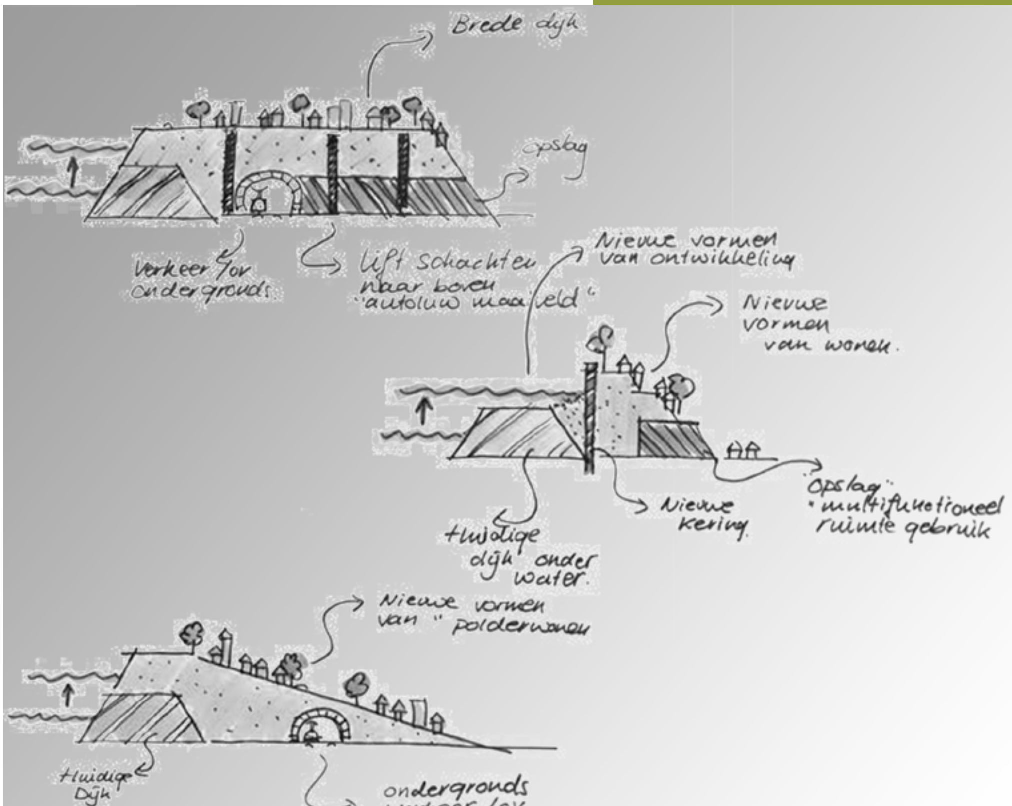
deVerdieping
Trouw

"Inhabitants of Uitdam are not afraid of the water"

"Residents of village in Noord-Holland take action against horizon polluting dike reinforcement"

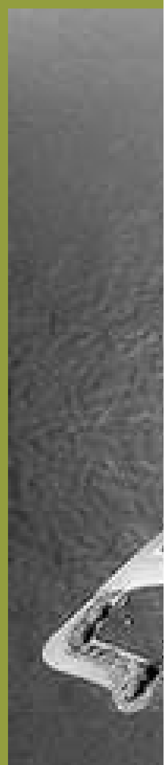
(Uitdammers vrezen water niet; Inwoners Noord-Hollands dorp in actie tegen horizonvervuilende dijkverzwaring)

Source: Markus (2012) in Trouw, 18 October 2012.



Possible implementations of the "climate dike", source: Grontmij Nederland B.V., s.d.

3. FROM THEORY TO PRACTICE


Actual implementati

on of climate dike (although not intentional), source: BVR & ZUS, 2011.

Figure 3.1.1: A building as a water defence; conventional and unconventional solutions for dyke reinforcements.

Source: Provincie Utrecht (2010: 38); PBL (2011: 25).

3.1 Physical measures on different layers of MLS to reduce flood risk

In this chapter first the urban and spatial factors that influence physical water safety are summarized. Following is a summary of the possible interventions in these factors according to type and layer of MLS. A full literature review paper on this subject can be found in appendix 8.6.

The overview was made based on literature review and the case studies from appendix 8.3. It is followed by the framework for comparative assessment. Finally, it is described which interventions for what reason whether or not have made the step from theory to practice, and what it takes to make this step. This can be taken into account when translating the interventions to the context of the Southern Flevopolder.

3.1.1 Urban and spatial factors that influence flood risk

Purpose of this chapter is to provide an overview of the spatial interventions that can improve the physical water safety on all the three layers of MLS. In order to do so, a quick understanding of urban and spatial factors that influence flood risk is needed.

Water safety depends on flood characteristics, the socio-economic value and the arrangement or organization of an area, and on how emergency services and inhabitants cope with a flood. Behind these variables are a number of urban and spatial factors, described below.

Water safety firstly depends on flood characteristics. The Province of Utrecht (2010: 15-21) lays out eight indicators that influence how high the water will come, where the water speeds are high, how fast an area will flood, and how long it takes until an area falls dry again. These are: frequency, arrival time, water depth, flow velocity, ascent rate, water pressure, flood duration and unexpectedness.

Besides flood characteristics, socio-economic characteristics play a role. In a flooded area with a lot of functions with high economic value or a high density of an urbanized area (in percentages of built area or number of inhabitants), the impact in terms of material damage and fatalities will be greater. Besides that, everyone tries to escape at the same time, which is more difficult in a densely populated area than in a thinly populated area.

The lay-out of an area is also important for water safety. For instance, the street height and the level of the ground floor related to the surface level determine the time people have to escape. Use of materials and way of constructing can also influence the way the water damages the buildings in the flooded area.

Flood characteristics influence also how emergency services and inhabitants cope with a flood – the third layer of MLS (disaster management). Whether people anticipate on floods, depends on the awareness of inhabitants and managers. Following sections will go further into this.

3.1.2 Spatial interventions per layer and type

The overview of physical measures on different layers of MLS to reduce flood risk is shown in figure 3.1.6. The interventions are organized based on the different layers of multi-layer safety as described in the National Water Plan 2009-2015 (VenW et al., 2009b), per approach and category of intervention (what does the intervention do to improve water safety on that layer?) and per scale they operate on. These scales – polder, neighbourhood and building/ person – are derived from Xplorelab (2008c). In the first layer interventions can also take place outside of the polder. In terms of approach of these layers, in the first layer outside the polder the hazard source can be reduced. Interventions in the polder itself can reduce exposure. In the second and third layer a rough division can be made between reducing exposure (by reducing the number of people or objects in a risky area or preventing the water from reaching the objects or people) and reducing vulnerability (by reducing or preventing damage of flooded objects).

Below per layer of MLS the different measures of

Figure 3.1.2: Building elevated: building elevated on poles, a non-livable ground floor, or a difference in level between street level and ground floor.

Source: Provincie Utrecht (2010: 42, 43, 60).

figure 3.1.6 will be discussed.

Layer 1: prevention

The prevention layer mostly includes interventions on a large scale, because in this paper prevention is defined as the prevention of a flood of the polder.

Firstly outside the polder measures can be taken to prevent the polder from flooding. A flood wave can be kept out by strengthening levees elsewhere, so that they will not breach. For the Southern Flevopolder this means for instance reinforcing the Houtribdijk between the Markermeer and the IJsselmeer. Another strategy for this is increasing the safety norms and reliability of storm surge barriers, and compartmentalization of big waters. By doing this, for instance by partitions underneath bridges, the inflowing water volume is reduced. Moreover, the flow rate[1] of rivers can be redistributed over existing river arms and canals, and additional canals and rivers can be dug (Pols et al., 2007: 94). To make sure that an embankment will not breach, extreme forces on water defences can be prevented, for instance by topping off the flood wave, and by other measures from the Room for the River program. An artificial island in front of the shore, emergency flood plains, increasing and deepening summer beds, artificial and natural water buffers can add to this (Meyer et al., 2009; Pols et al., 2007: 94-97; Xplorelab, 2008b: 14)

Preventive measures on polder level are mainly aimed on creating more or strengthening existing water defences. There are a lot of different types of water defences: natural (dunes), dams, retaining walls, quays, et cetera. Buildings can also function as a water defence (fig.3.1.1). Water defences can be strengthened by sand nourishment (dunes), or by broadening or heightening. In the light of future reinforcements, reserving space along embankments is required (see also next section).

A delta dike – also called super dike, climate dike, innovative dike or unbreachable dike – for instance is a broad dike with a very gentle slope. This is strong enough to exclude a breakthrough. Water can only flow over it, but cannot erode the dike. The dike can also be built on, eliminating the barrier between water and hinterland (fig. 3.1.1). A cascade of dikes, placing dikes in steps, is also reinforcement. Nowadays, so-called *'ijkdijken'* can indicate 48 hours in advance by electronic monitoring if there is a chance for a breach, which gives more time for warning and preparation.

1 The amount of m^3 water a second which passes a certain point in a river.

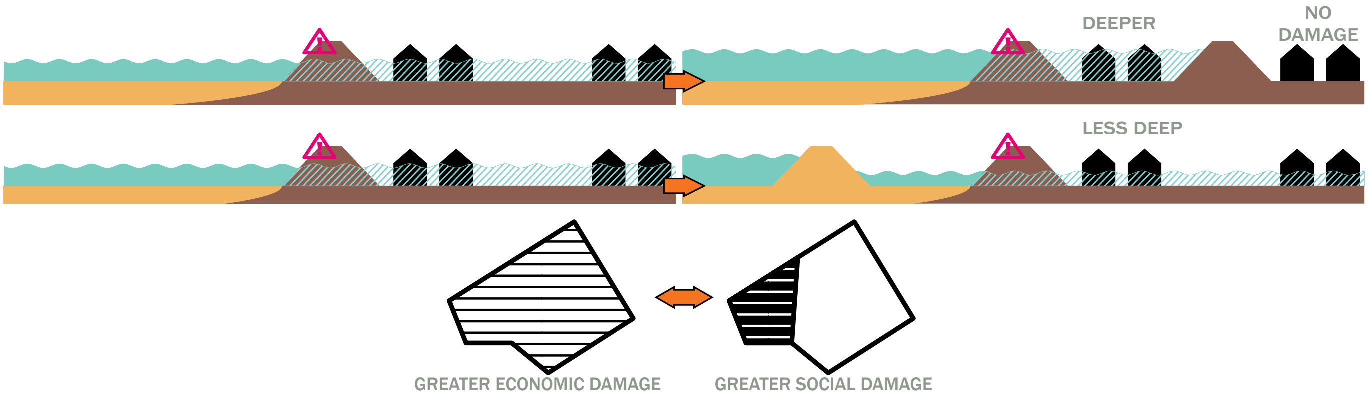
Layer 2: impact reduction by sustainable spatial planning

A sustainable spatial plan in layer 2 and the interventions to mitigate disasters in layer 3 know the same approach, i.e. reducing the consequences by reducing exposure and reducing vulnerability. The measures of layer 2 however are of a permanent nature, where the measures of layer 3 are temporary.

The number of objects and people in risky areas can be reduced by elevating the area, or by reconsidering location choices. Elevation can be on the scale of the polder, neighbourhood or building. There are natural high areas, but also artificial high grounds, such as the outer dike harbour areas in Dordrecht and Rotterdam. These grounds can be elevated by filling them up with sediment. To reduce flood risk, this should be done up until the calculated inundation depth. In very deep polders, this can also reduce problems with rising groundwater and seepage. At the level of the building elevation can be achieved by a difference in level between street level and ground floor, building elevated on poles, or a non-livable ground floor (figure 3.1.2).

By reconsidering location choice, certain vulnerable and vital functions can be relocated outside flood prone area, and program, land use and function changes can be zoned by building only on (physical) convenient locations in the polder – for example, the higher parts. Certain areas can be reserved. This is also important in the case of space reservation around

Figure 3.1.3: Illustration of the 'bath tub effect' in a polder without (left) and with (right) compartmenting elements, either of water or of land.



dikes. For this, the upper limits of the extreme climate scenarios should be used; this is a so called low-regret measure, which costs a little, but is very flexible. Mapping risky places makes people involved aware of the risk, so they might already choose another location themselves.

By compartmentalization and controlling flow inside the dike, water can be prevented from reaching objects. Compartmenting at polder level can be done by the double wall strategy – placing a second water defence behind the primary one – or by partitioning. This last strategy divides the polder into compartments, which fill up one by one. When constructing new infrastructure, the way they affect the flood course should be investigated, because compartmentalization is not always wanted. When a polder is divided into compartments, one compartment will fill up faster and deeper then when the water would be spread throughout the whole polder, and thus the situation here becomes more hazardous (see fig. 3.1.3). An alternative for this absolute compartmentalization is relative compartmentalization, by constructing a dike that is lower. Eventually the water will flow over, but this will not right away lead to dangerous water depths in the compartment that floods first, and gives the compartment behind more time.

Compartmentalization can also take place on a smaller scale, for instance by constructing a dyke around a neighbourhood or building. This way, valuable functions can be protected. These dykes can be used to redirect the water to lower, less valuable areas. Influencing the flow of water is also possible by placing steps between buildings (figure 3.1.4), or by flowing through the public space by adjusting street profiles and watershores. For this it is necessary to remove all obstacles. Buildings can be flooded to protect other parts of the area. These buildings then have to be designed floodproof. Facilities to store water can be of use, also to prevent water nuisance.

Floodproofing on the scale of the polder can be done by increasing pumping capacity, and by deriving water to emergency overflow areas, that can also be used during closed storm surge barriers and pumping stops. On the scale of the neighbourhood vulnerable and vital parts of roads and waterinfrastructure can be protected, to prevent economic damage and for the benefit of evacuation possibilities. Neighbourhoods can also be constructed in a flexible way, for instance on floating platforms. Flexible construction can also be done only at building level: floating, amphibious, on boats, pontoons, in demountable and temporary buildings. In addition, waterproof buildings can be constructed. In case of a dryproof building the water does not intrude the building. In a wetproof building the intruding water causes no damage, e.g. because of the choice and treatment of materials.

Layer 3: disaster mitigation

Depending on the size of a flood, measures such as

Figure 3.1.4: (l+m) Steps between buildings in Dordrecht; (r) design and interior of buildings.

Source: Gemeente Dordrecht & OCW (2009: 97); Bax et al.(2008: 35); Provincie Utrecht (2010: 34).

Figure 3.1.5: (l) Elevated infrastructure for evacuation; (m) temporary flood defences; (r) shelters such as Superdome in New Orleans.

Source: Provincie Utrecht (2010: 34).

evacuation outside the polder play a role in disaster mitigation as well.

The number of objects in a flooded area can be reduced preventive or during a disaster by evacuation. This concerns mobile objects such as valuable artwork, animals and humans. This can be partly or whole, horizontal out of the area, or vertical in the area itself. According to Kolen et al. (2012a: 17) the need for complete preventive (horizontal) evacuation can be examined depending on the characteristics of an area, such as the number of people, infrastructure, expected response of citizens and authorities, and the possible lead time. They argue that "the combination of available time for evacuation and required time related to a strategy are most important. [...] When time is limited, a vertical evacuation is expected to result in less loss of life" (Kolen et al., 2012a: 17).

Important vital functions, such as energy, food and drinking water supply, telecom/ICT and vital infrastructure, are crucial to reduce social disruption, but can fail due to a flood. To enable communication between the teams of security regions, water managers and inhabitants, a water robust communication network is needed. Therefore, essential equipment shall be installed elevated. Water robust infrastructure is also important. Elevated escape routes ensure people they have time to leave the area (fig. 3.1.5). Several exits from a neighbourhood are useful in such cases, but this is not always the case in for instance VINEX-neighbourhoods accessible by roundabouts or complex cauliflower-neighbourhoods.

When routes are flooded, marking by poles, buoys and reflectors on buildings can help. This way, routes stay recognisable and usable for evacuees, rescue services and military vehicles (Xplorelab, 2008a: 39). VenW et al. (2009a: 36) advise to pay attention to the spatial impact of disaster management in new structural visions and zoning plans. Besides this, local escape mounds can be arranged. Schools and sports halls often are designated as shelter, which have to be built or furnished floodproof. On the building level, for the purpose of evacuation of the dwelling, access to the house above the expected inundation level will be required.

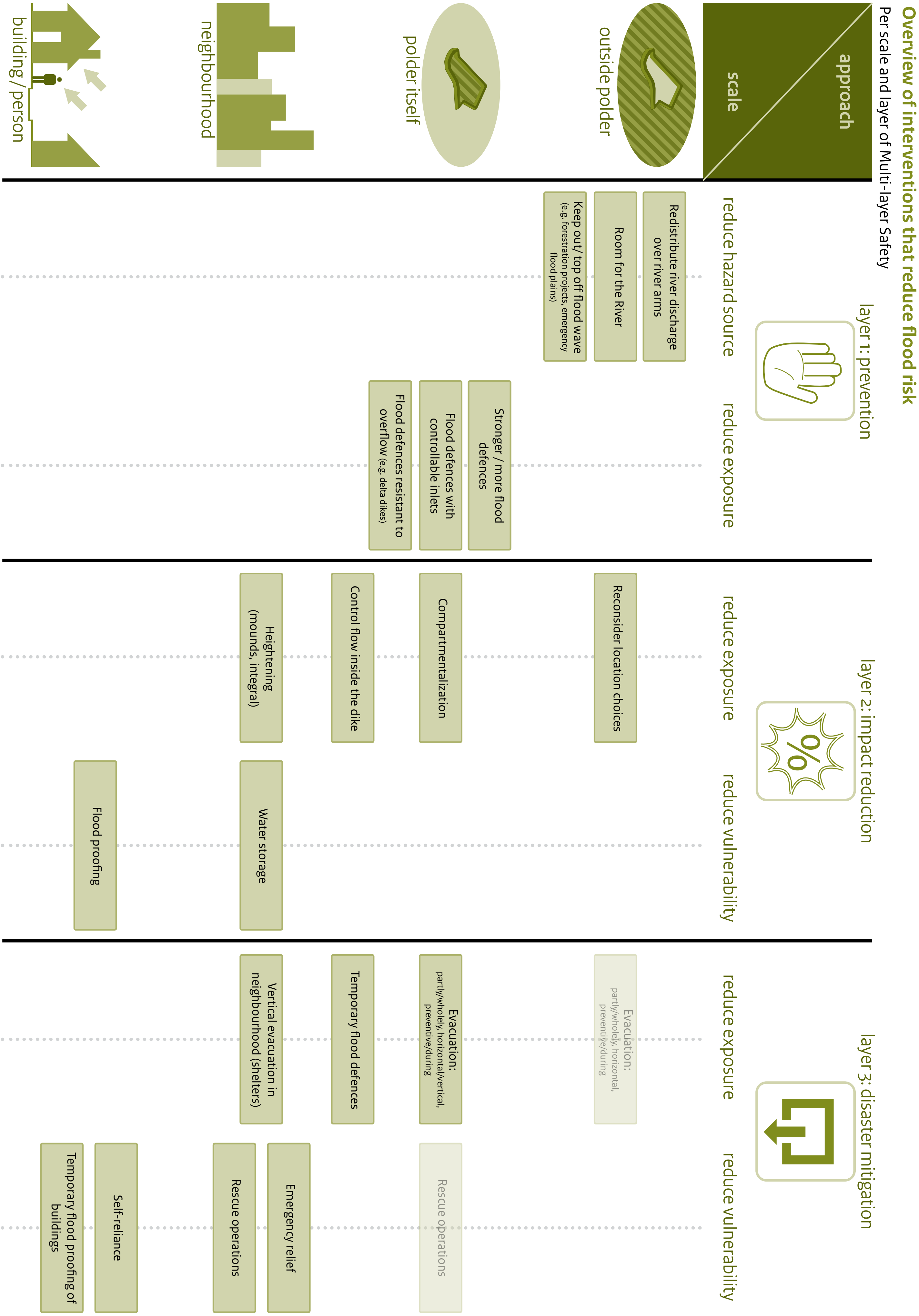
People can also be made aware of the fact that they are in a flood risky area, for instance by means of a water artwork or NAP-stickers on lampposts. This way, inhabitants get an idea of what it means to live in a deep polder or an outer dike area.

To temporarily prevent water from reaching objects, temporary water defences can be used. One can think of sandbags and a waterproof cover on the broken dam, temporary dikes in the neighbourhood (standing, inflatable, fillable and cellular defences), highway barrier blocks, and partitions in front of doors or windows.

Regarding reducing vulnerability, during a disaster self-reliance of citizens is important. Possible shelters – most of the time the higher parts of the area – have to be accessible and known to people who try to get themselves into safety.

Finally, vulnerability can be reduced by emergency relief and rescue operations. Rescue workers assist the evacuation, and evacuate non-self-reliant including disabled people, young children, elderly and animals. For operations like technical assistance to restore the breach and pump the land dry and humanitarian aid, accessibility of the area and evacuees is very important.

Figure 3.1.6: Overview of interventions that reduce flood risk, per scale and layer of MLS



Source: derived from Meyer et al. (2009), Pieterse et al. (2009: 15, 39-45, 61-62), Pols et al. (2007: 90-101), Provincie Utrecht (2010), Van de Ven et al. (2009: 33-39, 95-123), and Xplorelab (2008c).

3.2 Framework for comparative assessment

In order to make a proper comparative assessment, for this thesis a combination is made between a scenario approach with the three different alternatives and a framework for comparative assessment on multiple criteria. One of these criteria inevitably is the cost-effectiveness of the measures. Next to the cost-effectiveness, flexibility or possibilities to cope with future uncertainties, impact on spatial quality, the governmental feasibility and possibilities to link to other (climate) challenges are important. The operationalization of these criteria is discussed below, and eventually led to the framework which is shown in figure 3.2.1.

Cost-effectiveness

Economic attractiveness is measured by the ratio between costs and benefits, expressed in euros. The costs consist of investment and maintenance costs. For this, several general indicators can be used (already collected in e.g. Baan et al. (2008), De Grave & Baarse (2011) and VenW (2006)). When concerning a new or reconstructed levee, the cost estimation should take into account the design of the levee (height, width, etc.) and environmental characteristics such as the density in the area where the levee should be constructed. Because of cost considerations the possibilities to pair with certain functions should be examined, such as restructuring, accessibility of urban expansions, new business parks, strengthening the ecological structure or stimulating recreational development (Asselman & Alberts, 2008: 17,21).

Hoss (2010: 17, 90) states that the cost-efficiency of flood management measures is dependent on the characteristics of the area and the initial safety level. Flood management measures are most cost-efficient at the geographical scale they are applied at. For instance maintaining the quality of a dike for a whole dike enclosure is much less complex than for example ensuring all the houses in a neighbourhood to stay flood-proof.

The benefits of the proposed measures consist of risk reduction, or the decrease of the damage multiplied by the chance of a dike breach. These benefits can be determined through flood simulations, after which the resulting damage is determined. For the proposed alternatives for the Schaalsprong, these simulations have been executed by Deltares. These calculations have been made in SOBEK, the program for calculating inundation patterns. Damage is calculated at the PBL by the Damage Scanner, the program for calculating casualties and damage, which can take into account future land use (see also appendix 8.7). Other benefits, not expressed in euros, cover the threat of victims and the number of people affected: the number of people experiencing water nuisance because their homes are situated in the flooded area (Asselman & Alberts, 2008: 20). The effect on spatial economic developments may also be important in the assessment of the construction of certain interventions. If the construction is not combined with changes in spatial planning plans or building regulations, and the accessibility and mobility of the development area is kept at the same level, the construction does not affect the spatial-economic developments. However, it should not be ruled out that the application of certain interventions and even the planning process around it – partly due to attention paid to this in the media – will contribute to the awareness of citizens and businesses. This can lead to reputation damage as it affects the location behaviour of firms and hence employment in the polder. Also, households may take this into account when choosing a location to settle (Baan et al., 2008: 8).

Flexibility

Flexibility means that adaptation to changing circumstances (both physical and socio-economic) is still possible and that there will be no regret of things that are done. The latter can be understood as passing

Figure 3.2.1: Assessment framework.

<table>
<tr><th>Theme</th><th colspan="3">Criterion</th></tr>
<tr><td rowspan="4">Cost-effectiveness</td><td colspan="3">€ costs of realization (RBSO indicators/MKBA RRAAM), compared to:</td></tr>
<tr><td colspan="3"># reduction of risk of victims (HIS-SSM & SOBEK --> Deltares)</td></tr>
<tr><td colspan="3">€ reduction of risk of damage (Damage Scanner --> Deltares/PBL)</td></tr>
<tr><td colspan="3">Sensitivity to different breach locations</td></tr>
<tr><td rowspan="4">Flexibility</td><td rowspan="4">Sensitivity to uncertainties in assumptions or preconditions</td><td colspan="2">Sensitivity to uncertainties regarding probabilities of failure</td></tr>
<tr><td>Sensitivity to uncertainties regarding climate change</td><td>Phaseability of execution/ realization period</td></tr>
<tr><td>Sensitivity to uncertainties regarding socio-economic changes</td><td>Phaseability of execution/realization period</td></tr>
<tr><td colspan="2">Sensitivity to uncertainties regarding human action</td></tr>
<tr><td rowspan="4">Spatial quality</td><td colspan="3">Impact on cultural and landscape values</td></tr>
<tr><td colspan="3">Impact on Natura2000 and EHS</td></tr>
<tr><td colspan="3">Added relation with water</td></tr>
<tr><td colspan="3">Effect on usage, experiential and future value (Spatial Quality Matrix)</td></tr>
<tr><td rowspan="6">Governmental feasibility</td><td>Water management policy</td><td colspan="2">Governmental complexity and institutional conditions: number of parties involved</td></tr>
<tr><td rowspan="2">Spatial planning policy</td><td colspan="2">Mode of financing: is there a shift of tasks, adjustment of responsibilities and paying parties?</td></tr>
<tr><td colspan="2">Are adjustments to legislation needed?</td></tr>
<tr><td colspan="3">Realization period</td></tr>
<tr><td colspan="3">Governmental support</td></tr>
<tr><td colspan="3">Social support</td></tr>
<tr><td rowspan="3">Possibilities to link to other (climate) challenges</td><td colspan="3">Opportunities for water storage for intense rainfall</td></tr>
<tr><td colspan="3">Opportunities to reduce heat stress</td></tr>
<tr><td colspan="3">Economic and social consequences; link with Almere Principles</td></tr>
</table>

problems on to future generations, for example when they are faced with an unnecessarily large debt, with a great vulnerability, with irreversible damage to nature and landscape or with solutions that do not work and are not able to adjust to future needs (Baan et al., 2008: 9).

Due to the long time span between initial design and final completion of large urban developments, it is possible that there will be changes which are not anticipate on in the beginning. This could concern changes in the economic structure, in the labour and housing markets, in availability of technology and in lifestyle (Stouten, 2010: 224). This uncertainty of the future is even further enhanced by the current economic climate, although for coming decades still a growth is expected for Almere (De Jong & Van Duin, 2011). Uncertainties about climate change scenarios also call for flexible plans. For example, between 2050 and 2100 the level of the Markermeer can rise with 1 meter.

These uncertainties ask for a different role of the urban designer. An urban plan has to take into account the changing context and be able to anticipate on it. This means that an urban plan somehow has to be flexible, which in the case of urban design means being able to adapt to changes like the ones mentioned above. New development will occur more in a kind of spontaneous urban planning or 'organic growth': incrementally driven, varying and growing with time.

The different interventions and alternatives may vary in flexibility in terms of spatial and functional use over time. Flexibility can be found in the urban development process (in the content of policy, in methods and procedures, or of the organisation),

Inset 3.2.1: Goals & ambitions of the Schaalsprong.

On national level:

- Strengthen international competitive position of the Randstad

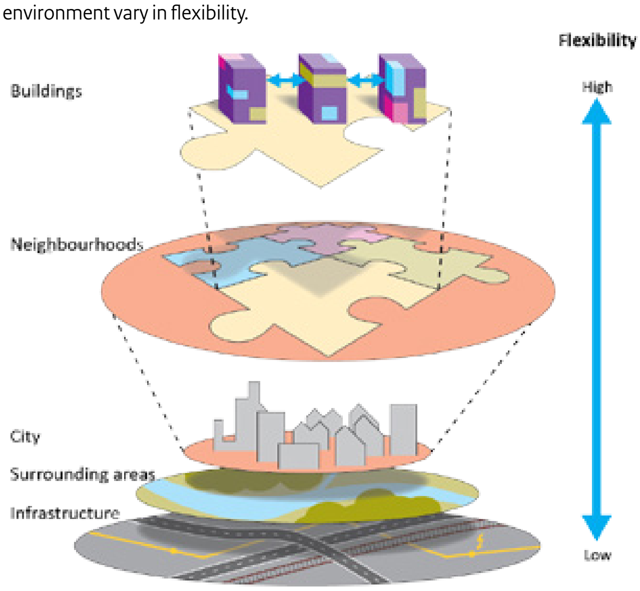
On regional level:

- Quantitive & qualitative need for housing Noordvleugel
- Preserve landscapes & strengthen green-blue structure

On local level:

- Develop a social, economic & ecological sustainable city, by following the **Almere principles** (Gemeente Almere, 2011):
  1. Cultivate diversity
     - *Differentiation housing supply*
     - *Diverse demographic composition*
  2. Connect place and context
     - *Enhance identity of city*
     - *Living-working balance*
     - *External accessibility*
     - *Level of amenities/facilities*
  3. Combine city and nature
  4. Anticipate change
     - *Incorporate generous flexibility and adaptability in plans and programs*
  5. Continue innovation
     - *Experimentation and exchange of knowledge*
  6. Design healthy systems
     - *'Cradle to cradle' solutions*
  7. Empower people to make the city

Figure 3.2.2: Various scales for adaptation measures within the urban environment vary in flexibility.



Source: PBL (2011: 49).

the urban structure and the built environment (the urban fabric and buildings designed to be able to adapt to changes of functional demand) (Voogd, 1995: 78). With the scale of an intervention, the costs and number of parties involved increase (fig. 3.2.2; PBL, 2011: 49). For example, measures taken in the infrastructure are less flexible than local measures in buildings. And this may be a factor that influences the choice for different interventions and the balance between the different alternatives. Therefore, the realization period and phaseability of implementation are important (Ruitenbeek, 2010: bijlage 3-7). Furthermore, an intervention has to be without too many complex structures, e.g. measures during a calamity that require human intervention such as closing up crossings of main roads and waterways in a compartmentalization dike (Asselman & Alberts, 2008: 21).

Spatial quality

The different alternatives generated may affect the spatial quality of an area, especially when the relation between water, buildings, infrastructure such as dikes, and public space changes. This effect and relation is different in every local situation, created by completely different elements. There is no general definition of the term spatial quality, the term is not easy to grasp, but attempts have been made. De Kort (2012: 12) states that "by designing the spatial and functional relation between water safety structures, the water itself, landscape and the built environment, spatial quality can be created." More operationalized, but also more general and not specifically related to interventions to increase water safety, is the matrix of spatial quality by Habiforum, as shown in figure 3.2.3. The exact criteria for the contribution to spatial quality of the alternatives will be established further during the research part of the graduation project.

Furthermore, integration into the landscape is important for the spatial quality. This relates to the extent to which is connected to existing structures. When an intervention cuts through a certain structure or landscape unit, this may result in reduced coherence or accessibility. Because of cost considerations the possibilities to pair with certain functions should be examined, such as restructuring, accessibility of urban expansions, new business parks, strengthening the ecological structure or stimulating recreational development (Asselman & Alberts, 2008: 17,21). Relating to this is ecological integrity, which involves the conservation and / or development of ecological values. Naturalness, diversity and connectivity are important aspects. Whether and to what extent

Figure 3.2.3: Spatial quality matrix.

	Economic efficiency	Social justness	Ecological sustainability	Cultural identity
Usage value	- Allocation efficiency - Stimulating effects - Mixed use - Accessibility	- Access - Equal distribution - Participation - Options of choice	- Clean environment - External safety - Water in balance - Ecological structure	- Freedom of choice - Cultural diversity
Experiential value	- Image/ appearance - Attractiveness	- Equity - Binding - Social safety	- Peace, quiet, space - Beauty of nature - Healthy environment	- Singularity - Beauty of culture - Contrasting surroundings
Future value	- Cumulative attraction - Agglomeration - Stability - Flexibility	- All aboard - Social support	- Provision of space - Sustainable ecosystems	- Cultural heritage - Integration - Cultural renewal

Source: Luttik, 2005.

flooding and protective measures have effects is not always clear, is strongly context bound, and can be described in qualitative terms at the most. Also cultural and historical values can be taken into account (Baan et al., 2008: 7-8; Ruitenbeek, 2010: bijlage 3-8).

Possibilities to link to other (climate) challenges

As mentioned before, with a strictly preventive strategy a lot of opportunities can be missed for an integral approach that adds to other values, such as realising desired program, water nuisance, as well as water shortages and heat stress. The proposed interventions also can have radiation effects to the (regional) economy and social circumstances. To put it in a more general way, the alternatives can contribute to the goals set on national, regional and local level (i.e. the Almere Principles; see inset to the left and page 48). These are all opportunities to recoup the extra expenses made for realizing measures in other safety layers.

Governmental feasibility

The complexness of governmental structures that accompany the proposed measures, have a huge influence on whether an intervention will take place or not. This is one of the reasons that the current policy is mainly focused on prevention, because the construction and maintenance of levees comes under the responsibility of one actor, and spatial planning behind the dikes is the responsibility of another (figures 3.2.4 and 3.2.5). When these responsibilities become mixed, the story becomes very complex and also the timeframe changes.

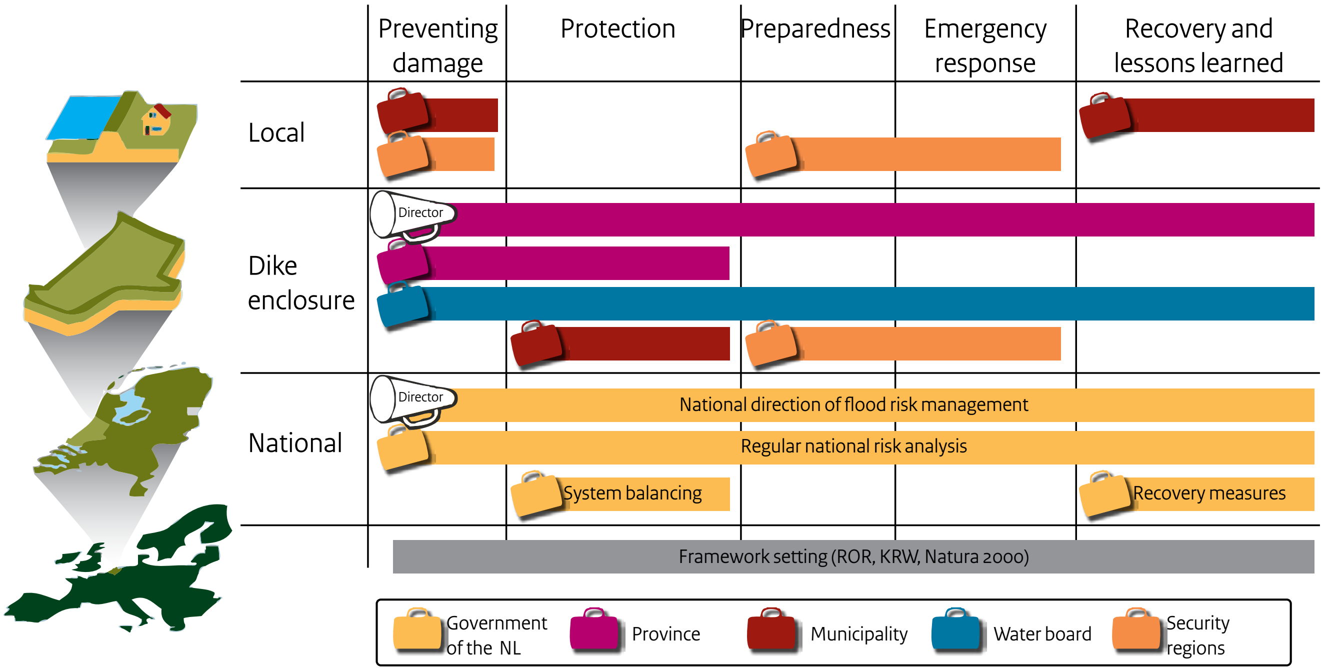
One of the criteria therefore regards the governmental complexity and institutional conditions in terms number of parties involved in both water management policy and spatial planning policy. Other important factors are governmental support, social support, and the method of financing and the recovery of costs. When there is a shift of tasks, an adjustment of legislation, an adjustment of responsibilities and paying parties, or a large implementation period transcending the bureaucratic periods, the feasibility of an intervention will decrease.

Geographical distribution managers and actors in the Flevopolder

Images 3.2.6 to 3.2.9 show the geographical distribution of the actors responsible for the water safety. What stands out is that in the rest of the area that surrounds the IJsselmeer, the area borders of the different actors are very different, do not fall together, whereas in the Flevopolder, those borders do fall together. This makes it a little less complex here. The actors responsible for water management and safety in the Flevopolder are the Province of Flevoland, the Municipalities of Almere, Zeewolde, Lelystad and Dronten, Water board Zuiderzeeland and Secutiry Region Flevoland.

Interviews and discussions with different stakeholders (shown in appendix 8.1) point out that there are a lot of different interests and positions of the parties involved.

Figure 3.2.4: Responsibilities of different parties/ actors.



Source: RLI, 2011: 15

Figure 3.2.5: An overview of the Dutch water management and spatial planning system.

Water management		***Spatial planning***
National level Ministry of Infrastructure and the Environment - Management of main water system - Development of national water policy and legislation - Implementation of European Guidelines for Water		*National level* Ministry of Infrastructure and the Environment - Broad strategic lines of spatial policy (self-binding) - Implementation of European Guidelines for the Environment (binding for other governments)
Provincial level Provinces - Development of groundwater plans, and regulation - Supervision of water boards		*Provincial level* Provinces - Regional strategic plan (self-binding) - Planning decrees (binding for local governments)
Local and regional level Water boards - Management of regional water system (flood defense, water levels) - Treatment of urban wastewater and water quality (licences)	*Local and regional level* Municipalities - Sewage system - Drainage system - Urban water policy	*Local and regional level* Municipalities - Local land use plans - Allocating and regulating local usage of land - Municipal structure plan (optional)

Source: Voogd & Woltjer, 2009: 188

Province Flevoland

The province has little money available, so can only talk about it, bring actors together and present an attractive image of their vision to persuade others to realize it. They don't want to scare away investors by implying "it is not safe here" by taking more measures than dikes only.

Municipality of Almere

The municipality does not have flood safety high on their agenda. Only two people responsible for water, of which only one knows something about or is involved with safety. Other tasks (such as program for the Schaalsprong and the image of Almere, A6 barrier) have a higher priority, and moneywise dikes are cheaper.

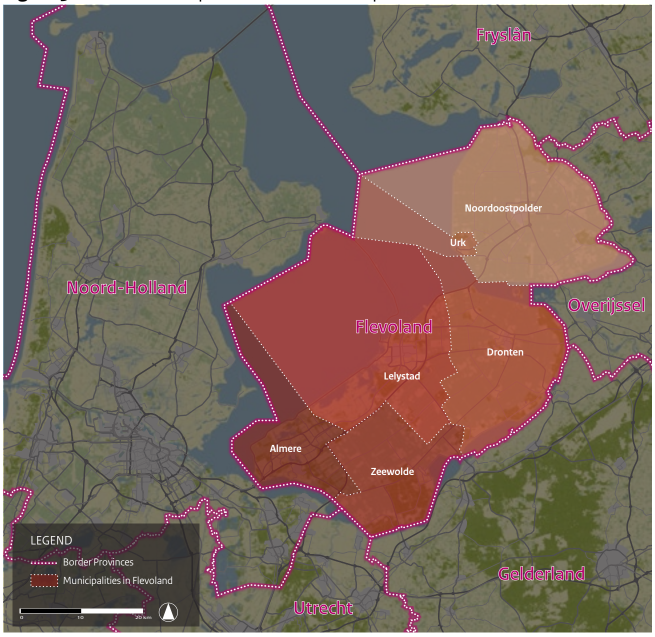
Water board Zuiderzeeland

The water board Zuiderzeeland has a very conservative attitude towards current flood control policies. They drive by the dikes once a day, and want to be able to see the whole dike, so no proponent of (multifunctional) delta dike. The problem of innovative solutions for the water board is: who is responsible for maintenance, and who is going to pay? They also see a difference between the circulation period of a dike (for at least 50 years) and municipal plans (10 years).

Security region Flevoland

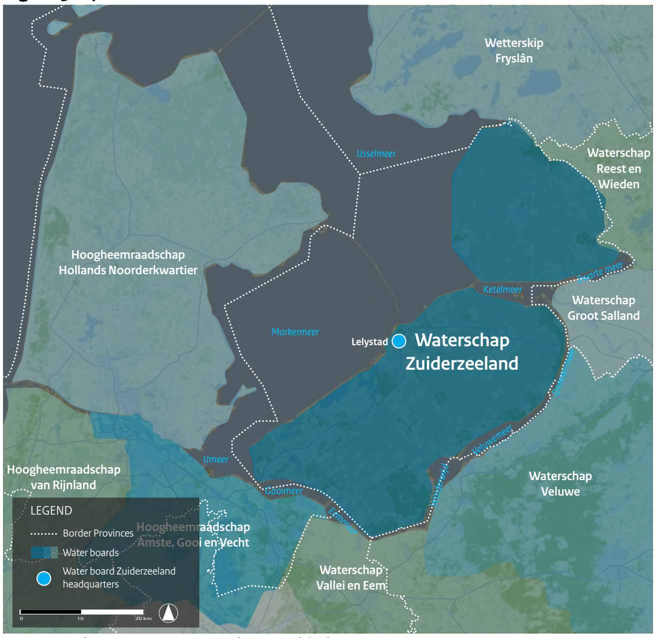
The security region is not very involved with flood risk. They for instance did not participate in the Task Force Management Floods (Dutch: *Task Force Management Overstromingen*, TMO). For flood scenarios, an incident

Figure 3.2.6: Borders of provinces and municipalities in the area.



source: Delta Programme IJsselmeergebied, 2010: 10.

Figure 3.2.7: Borders of water boards in the area.

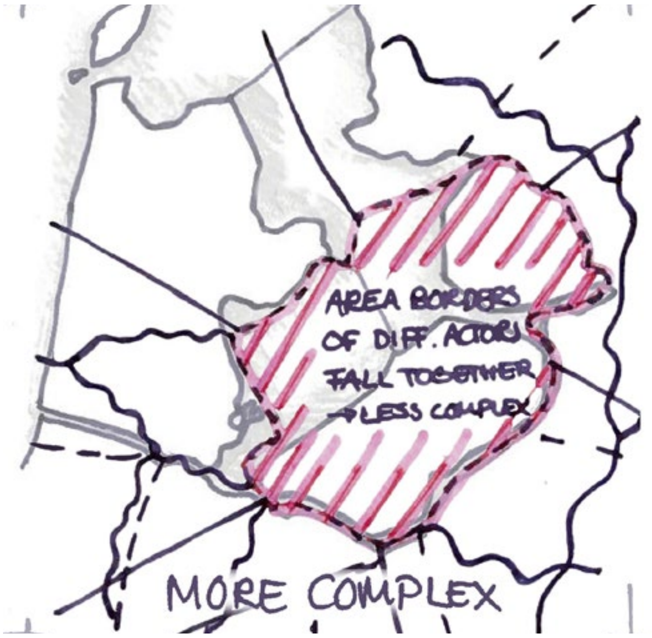


source: Delta Programme IJsselmeergebied, 2010: 12.

Figure 3.2.8: Borders of security regions in the area.

source: BZK, 2009: 7.

Figure 3.2.9: Conclusion - area borders of the different actors in the Flevopolder fall toghether, making the institutional conditions a little less complex.



response plan (Dutch: *indicentbestrijdingsplan*) describes who does what and when, the evacuation plan and the communication plan. However, it is not taken into account that some of the C2000 network poles are situated in the polder on ground level with a battery which will provide power for up to eight hours, and thus the communication system may fail in case of a flood. Before the decision is made to evacuate, the urgency must really be there. There is a whole chain of actors who have to make this decision, before the security region takes action. And even then, first the cattle and non-self-reliant people will be evacuated. There is a strong dependency on self-reliance of citizens. The vehicles of the Ministry of Defence can still drive when the water is up until 30 cm, but in the case of the storm scenario for Flevoland, it probably will be too dangerous also for the rescue workers to act.

Regarding large infrastructural plans advice should be sought from the security region, but this takes place in a late stage of the planning process, when permits have to be arranged. At the moment of the conversation with people from the Security region Flevoland, there had been no communication about for instance the plans for lowering the A6.

It is striking that probabilities are not very important for a security region. For example if you are in a car, the chances of you getting a car accident are 1:10000x, but for a security region the probability that a car accident takes place in their area is just one, because it's going to happen once, and then they have to take action.

3.3 From theory to practice

During this research it turned out the numerous sources regarding possibilities to increase water safety exist, but that these interventions almost never are implemented in plans. The fact that some interventions do not take the step from theory to practice, is because of administrative, economic, aesthetic, but also practical reasons. Some interventions are just not suitable for a certain location. Other interventions are rejected after a political and economic consideration. The interests of stakeholders play an essential role.

De Graaf (2009) studied the terms and conditions for governmental implementation using the case study Rotterdam Water city 2035. Defined is which factors determine whether institutions such as municipalities and water boards actually apply feasible innovations. It turns out that this depends on two conditions.

First, it is important that the innovation will be picked up in the process of spatial planning. For this, early cooperation between water managers, spatial planners and urban designers is needed. A possible way to do this is by means of long-term visions. This may lead to a shift in thinking. Thus, future climate change will be better integrated into planning. In the vision for Rotterdam Water City 2035 also the fact that the vision had no official status played a role. This made it possible to plan for a longer planning horizon than the usual five years. This led to extreme ideas and crossing of disciplinary boundaries. Responsibilities for the various aspects of the flood problem in cities are now highly fragmented. Institutional barriers in the research of De Graaf often are cited as the main cause of poor implementation of innovative measures (De Graaf, 2009: 102). Solutions related to water problems are realized sooner by embedding them in the process of urban renewal and climate change, because then they are linked with other urgent issues.

Secondly, water managers need to be open for innovation, see opportunities for their own institutions, and possess the knowledge and skills needed. The research of De Graaf points out that urban water managers are well aware of innovations, and expect that they will be applied in the near future, but personally have little experience with the application. New concepts are applied on a small scale and incrementally in demonstration projects, but their influence is limited and they are not included in the mainstream. Creating a support base is important, and can be found in the commercial market. These innovations will only break through if they are picked up by contractors and project developers, for example by facilitating social and economic incentives, such as stricter norms, awarding prizes and raising awareness among citizens. Decision making is mainly driven by rational, cost/benefit-based considerations.

The various reasons for using spatial planning by local authorities to reduce the impact of floods have also been looked into by Neuvel and Van den Brink (2009). The main reasons are according to Neuvel and Van den Brink linked to the requirements set by other governments, the played role and responsibilities of local authorities, previous experience with disasters, and previous experience with spatial planning in relation to flood risk policies.

In the Zuidplaspolder water has been put on the map by the creative and headstrong attitude of the water board Schieland en de Krimpenerwaard (HHSK). The HHSK has pointed out possibilities and constraints from the earliest planning phase on, that went along with the scale of the Interregional Structural vision, the Intermunicipal Structure plan and the Zoning plan. In the case of plan DUIN, the solution of a multi-functional unbreachable dike was not proposed because of water safety, but because of an attempt to improve the relation between new residents and the water. This shows that a smart link to other assignments can sometimes work as a catalyst.

Following the Hotspot Zuidplaspolder a bundle of ideas has been published with 52 adaptation measures (Xplorelab, 2008c), of which 23 increase water safety. These interventions are evaluated on necessity, applicability and current presence. Five of the 23 measures are deemed non-applicable because of practical reasons.

An unbreachable dike around the Zuidplaspolder for instance is not suitable, because of the lack of space and the characteristics of the weak subsoil. Compartmentalization strategies are rejected because of high costs and the passing of the risk to other parts. Conversations with the project manager of HHSK learned that also solutions were suggested for problems that did not exist. A certain company for example wanted to build a floating greenhouse complex. In order to achieve this, a hole would have to be dug specially to obtain water. A floating greenhouse complex could better be realized in existing waters.

Also for other measures there are practical objections. When including roads in the evacuation plans, one must pay attention to the development of an undesirable bathtub effect, and the possible scenarios; in case of a long warning time, low lying roads can also be used for evacuation, and the desired height of an evacuation route depends strongly on the inundation height. Furthermore, temporary water defences for example are not really temporary, because they have to be installed on a fixed location. Again here the unpredictability of the possible scenario plays a restrictive role.

Certain interventions are more suitable for outer dike locations, and less for inner dike locations in a deep polder. That is why for Tiel East for example a climate dike was the only final measure. Heightening integrally, one of the other suggested measures, was dismissed. “This requires the whole district to be broken down and rebuilt. That gives a lot of nuisance, it is very expensive and hard to implement” (Gemeente Tiel, 2008: 43). The probability of a flood does not outweigh the lifespan of a building or a structural measure. Floating or amphibious houses will probably never get off the ground for hundreds of years, making the mechanism stop working at some point. The same goes for temporary dikes. The effect of this is dependent on regular maintenance and testing. When however, as is the case in the outer dike areas in Dordrecht, the water reaches residents every three years, these impact reducing measures are preferable to preventive measures.

Policy recommendations

Regarding policy it can be stated that many different parties are responsible for numerous small parts that are relevant for water safety. The available knowledge is hardly shared among them. Implementing various measures to increase water safety requires the integration of water management in spatial planning. A link to other pressing issues, such as urban renewal and spatial quality, can ensure that water safety is taken into account in the planning process. A wide variety of actors such as insurance companies, contractors, municipalities and residents should be involved to make a robust adaptive strategy successful. Now, different organizations are responsible for the coherent components of urban water systems and water safety. Urban development is fragmented in steps of policy, planning, design, construction and maintenance. For each step other stakeholders are responsible who are not involved in previous or subsequent steps. Also the responsibility for the different layers of multi-layer safety is spread. Primary responsibility for prevention rests with the Dutch ministry of Infrastructure and the Environment (IenM) and water boards. Provinces, municipalities and IenM are responsible for safe and sustainable spatial planning. The safety regions and the ministry of the Interior and Kingdom Relations (BZK) coordinate disaster management (VenW et al., 2009a: 16,19,28).

Between these layers there is little sharing of knowledge and collaboration. There is hardly any feedback on the spatial planning, everyone takes care for another aspect and does not know what important aspects for another policy field are. Sharing knowledge between the different sectors and parties within a municipality is important, but also the exchange of knowledge between municipalities with the same problem, or internationally, is highly recommended.

Difficulty is that responsibilities and money are often divided between different actors, but a clear communication of knowledge and interest can lead to interesting new solutions that link these interests, and to innovative ideas that integrate spatial planning and water management in the future.

View of farms and windmills in Almere Oost, source: Flickr.com

4. MASTERPLAN: ALTERNATIVES

View of development around Noorderplassen, provided with green energy coming from solar panels, source: Flickr.com/Nuon

4.1 Interventions applied individually

The different interventions per layer from chapter 3.1 have been applied to the context of the Southern Flevopolder. An alternative was made for each remaining intervention separately, as is shown in figure 4.1.2 to the right. Interventions that have not been taken into account are the interventions in the first layer outside the polder, like keeping out or topping of a flood wave, because this leaves no specific assignment for the Southern Flevopolder different from the baseline alternative of dikes and building behind it. Reconsidering location choices is also not an option, because of the valuable green areas in the region and the urban pressure from Amsterdam and Utrecht (see also appendix 8.5.4). Temporary interventions in layer 3, like temporarily flood proofing buildings, rescue operations and emergency relief, are too unpredictable and hard to take into account when designing.

Firstly, an alternative was made for each remaining intervention separately. It however turned out that most of the first 'pure' alternatives do not solve the problems in existing built areas. Smart combinations of the interventions increase feasibility and quality of the alternatives significantly (figure 4.1.1). Therefore, a number of favoured alternatives has been established, which are to be assessed, and which will be discussed in the next sections.

Figure 4.1.1: Relation between the safety layers, interventions and the integral alternatives.

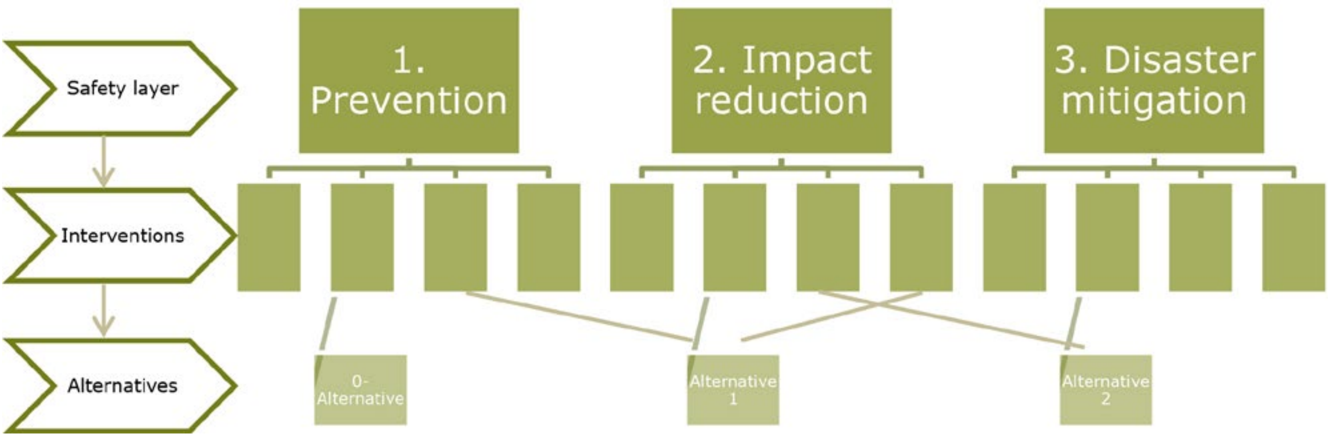


Figure 4.1.2: overview of interventions applied to the context of the Southern Flevopolder individually, classified per layer of MLS.

Figure 4.2.1: First combination of interventions to a 0-alternative and 4 alternatives.

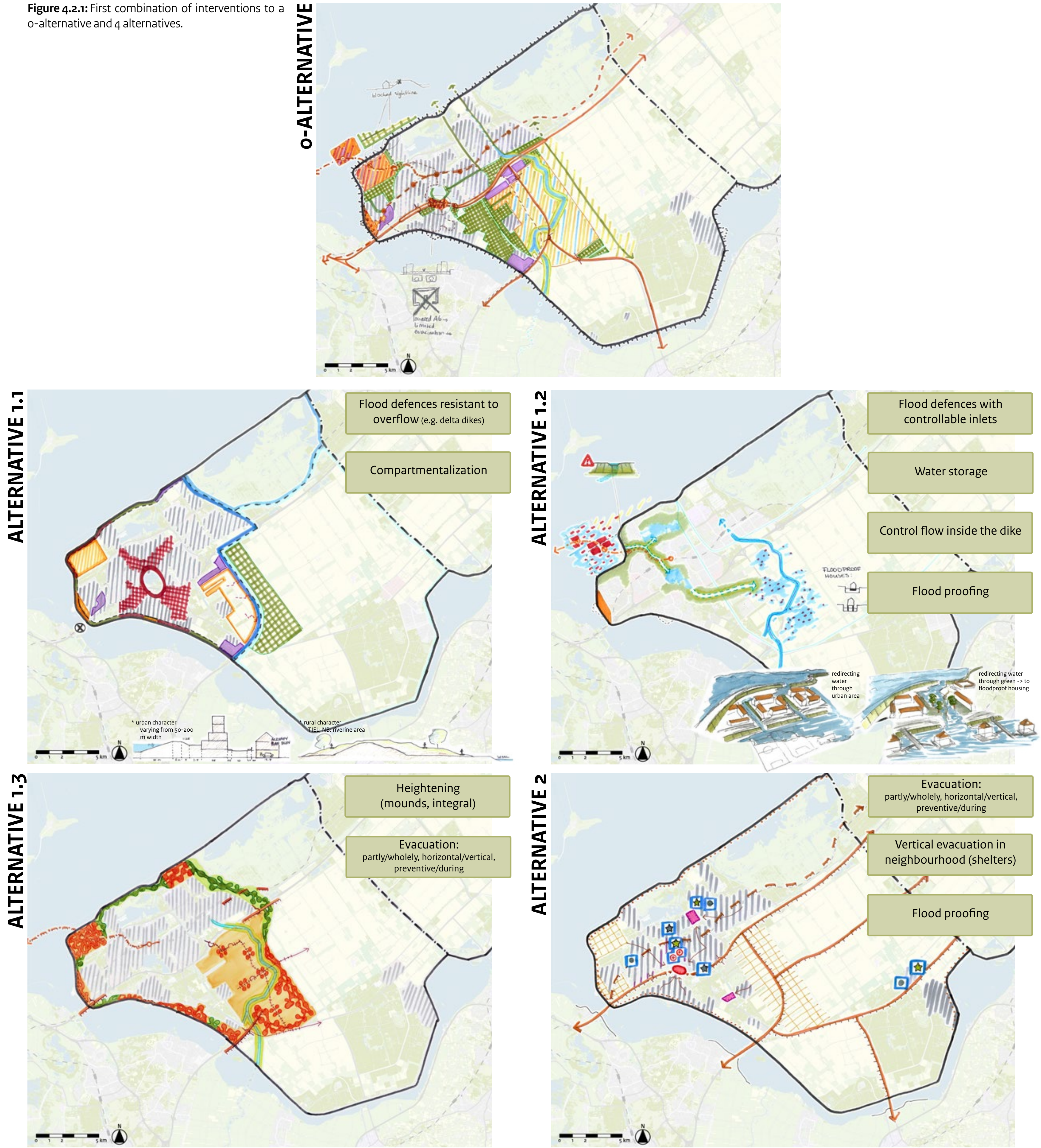


Figure 4.2.2: Legenda.

4.2 First steps towards smart combinations

Initially, a 0-alternative and four alternative strategies were established, as shown in figure 4.2.1. The **0-alternative** is the baseline of a pure prevention strategy: only the dikes and safety standards will increase (by decreasing wave impact, raising the dikes, or realizing unbreachable dikes). Behind the dikes everyone goes their own way in spatially developing the polder, ignoring the chance of a flood, according to the existing plans for Almere 2.0 derived from the Structure vision by the Municipality of Almere (Gemeente Almere & MVRDV, 2009).

Alternative 1.1 was the further elaboration of the Compartmentalization study (originally in Dutch: Compartimenteringsstudie) executed by Deltares and Rijkswaterstaat Waterdienst (Asselman & Alberts, 2008). This is one of the elaborations of building according to MLS. Asselman and Alberts (2008: 49) state that compartmentalization without combining it with strengthening the primary defences in front of the densely populated compartment is not economically viable. This alternative therefore can be a smart combination of a promising track for compartmentalization and safety standard differentiation by strengthening the primary defences on logical places, for instance by an unbreachable dike. This safety standard differentiation is necessary, because in case the dike in the densely populated compartment breaches, the water depth will raise even quicker and higher (so called "bath tub effect") (Asselman & Alberts, 2008: 7) At some points, where the unbreachable dike meets the built environment, a multi-functional unbreachable dike can be realised.

Alternative 1.2 was that of transforming some of the built area inside the polder to outer dike area by moving part of the dike inward. In this new part of the dike, a controllable inlet can be realised, combined with the strategy of controlling the water inside the dike, leading this water towards less vulnerable places such as the lake areas, sports fields and flood proof building in Almere East. The new living environments that emerge will be rich of water, adding to spatial quality. It also solves the water nuisance and heat stress problems.

Alternative 1.3 was a strategy of building according to MLS which is explored in the Compartmentalization study: the construction of mounds (for dwellings or vulnerable objects like hospitals et cetera), in combination with floodproof building (Dutch: "waterrobuust bouwen") in areas that are put more at risk, combined with making evacuation roads accessible at all times (Asselman & Alberts, 2008: 47-53). This strategy involves the creation of water retaining landscapes.

Finally, **alternative 2** is based on the study of water robust design for new buildings and vital and vulnerable functions by DHV (Ruitenbeek, 2012). For this study, Almere-Oosterwold has been taken as an example of an inner dike development in a deep polder. The chosen approach for a water robust design in a deep inner dike area is focused on victims and permanent damage. The people in the area will all have to be evacuated. By making it possible to stay temporarily in the flooded area, time is gained for everyone to evacuate. Prevention of major damage to buildings, infrastructure, housing etc. shortens the recovery time after the flood.

4.3 Final alternatives

The 0-alternative and 2 alternative strategies

The 0-alternative and the initial four alternative strategies all have their own implications for hydraulic engineering, water management and urban development (see fig. 4.3.1). However, alternative 1.1, 1.2 and 1.3 turned out to be not mutually exclusive; one can create a 'river' guiding water through the urban area from a controllable inlet, which reduces the water nuisance and heat stress problems (1.2), while also creating a superdike and compartment to reduce flood risk (1.1). And creating a water retaining landscape by placing interconnected mounds (1.3) basically also creates a compartment protected by a super levee (*terpendijk* in Dutch). Therefore, doing a multi-criteria analysis for these alternatives proved to be impossible. So, for the final assessment, it was chosen to combine alternatives 1.1, 1.2 and 1.3 into one alternative: from here on in called alternative 1. The final alternatives thus are the 0-alternative, alternative 1 and alternative 2 (figure 4.3.2). They are to be assessed and for each a detailed design for a key intervention is made. The final alternatives are described in this section, using three logo's:

0-ALTERNATIVE | *continuing current practice*

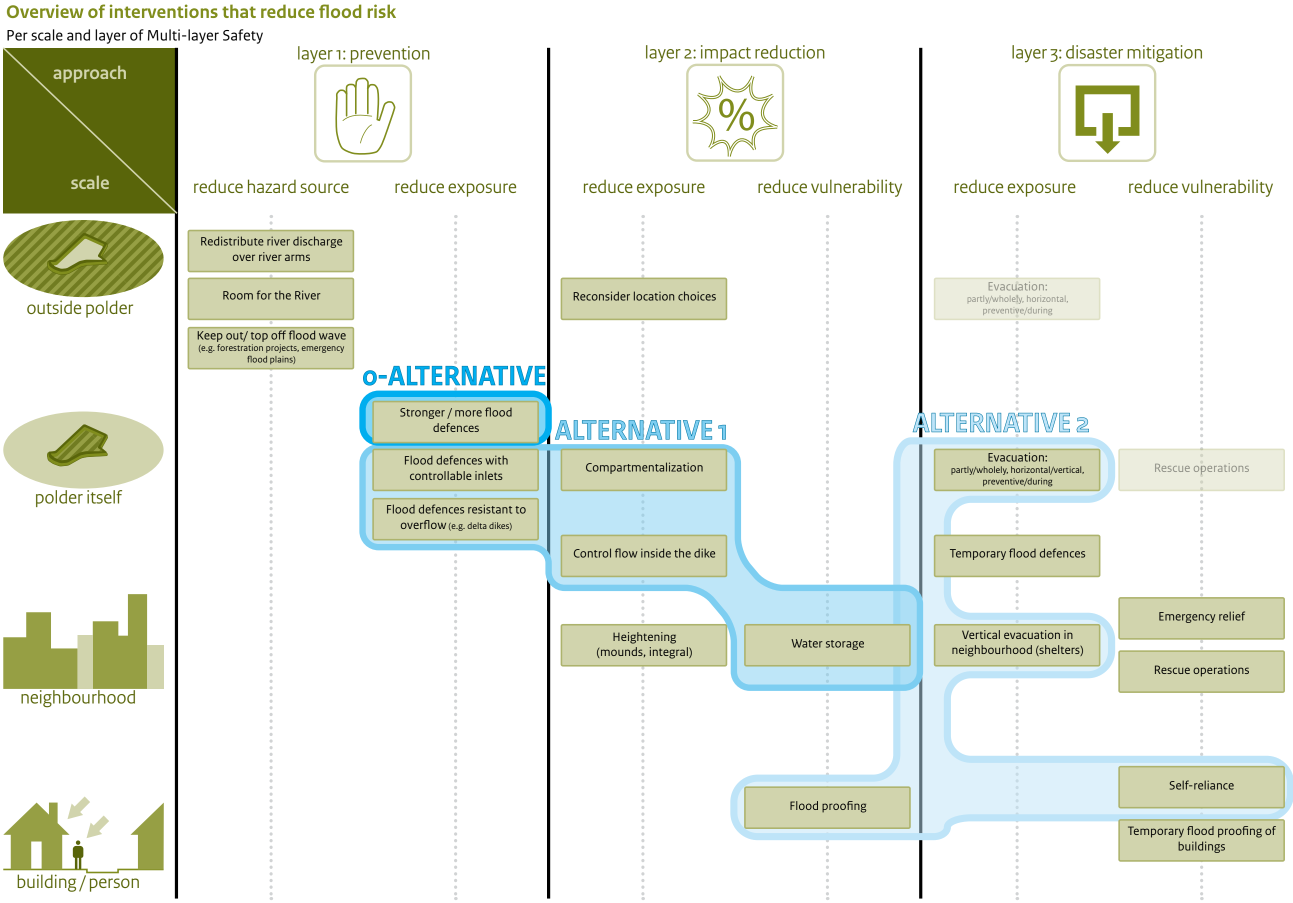
ALTERNATIVE 1 | *compartmentalization, (multi-functional) unbreachable dike & water storage*

ALTERNATIVE 2 | *floodproofing vulnerable and vital objects and functions & complete evacuation of inhabitants*

Figure 4.3.1: From 4 to 2 alternatives; characteristics of hydraulic engineering, water management and urban development.

Layers of MLS	Alternatives	Hydraulic engineering/ Waterbouw	Water management	Urban development/ Stedelijke ontwikkeling
Layer 1: prevention	0-alternative	Weak spots of dike have been solved	Open water	Separated from water safety +dike reinforcement on weak spots
Layer 1+2: Impact reduction by sustainable spatial planning	Alternative 1.1	Dike + compartmentalization		Phase 2: intensifying
	Alternative 1.2	New dike with controllable inlet	Storage open water	Phase 1: living surrounded by water (*waterrijk*)
	Alternative 1.3		Elevated living	Phase 1: mound High building heights/ dwelling densities in the centre of the polder/compartment
Layer 2+3: disaster mitigation	Alternative 2	Risk zoning	Open water	-Vulnerable and vital infrastructure and functions floodproof -Rules for building: adjusted accessibility neighbourhood + shelters & evacuation routes - Risk zoning: High building heights at the edges of the polder (in zones with high risk), lower building heights in the middle of the polder

Figure 4.3.2: Overview of the flood risk reducing interventions that are combined in the final alternatives.



0-alternative

Continuing current practice (Multi layer Safety: focus on layer 1)

This alternative continues current practice. Only the decisions already made are taken into account: Schaalsprong Almere 2.0 is accommodated and dikes minimise the probability that a flood may occur, following the standard procedure (increase level of protection dike enclosure 8 according to the economic value behind it; this means a low probability, but large consequences). A residual risk is accepted.

The 0-alternative is based on expansion of Almere with 60,000 houses in the period 2010-2030/2040, of which there are 20,000 intended for dealing with the autonomous development of Almere, 15,000 for meeting the demand from the region Noordvleugel Utrecht and 25,000 to meet the demand from the Amsterdam metropolitan area. In line with Ecorys (2012) the Hollandse Brug variant is chosen, which scored the highest in the social cost-benefit analysis. For this variant, 20,000 houses will be built in Pampus, 17,000 in Oosterwold, 4,000 in the city centre and along the Weerwater, and 19,000 in the existing city (including Poort, Duin and Nobelhorst). This development will take place along the axis Poort-Pampus-Centrum-East, which will be supported by the realisation of a high quality public transport line. In terms of accessibility coming years investments will take place in the road network (project Schiphol Amsterdam Almere, SAA) and railway corridor Schiphol-Amsterdam-Almere-Lelystad (OV SAAL). An extra intercity stop at Poort, and high-speed trains can be beneficial. The urban accessibility of Almere is based on the package *Stedelijke Bereikbaarheid Almere* (SBA), and the high quality public transport line. The ecological conditions of the Markermeer/IJmeer will be improved by measures from the *Toekomstbestendig Ecologisch Systeem* (TBES) project, such as the wave shelter measures near Hoornse Hop.

Goals & ambitions of the Schaalsprong:

On national level:

- Strengthen international competitive position of the Randstad

On regional level:

- Quantitive & qualitative need for housing Noordvleugel
- Preserve landscapes & strengthen green-blue structure

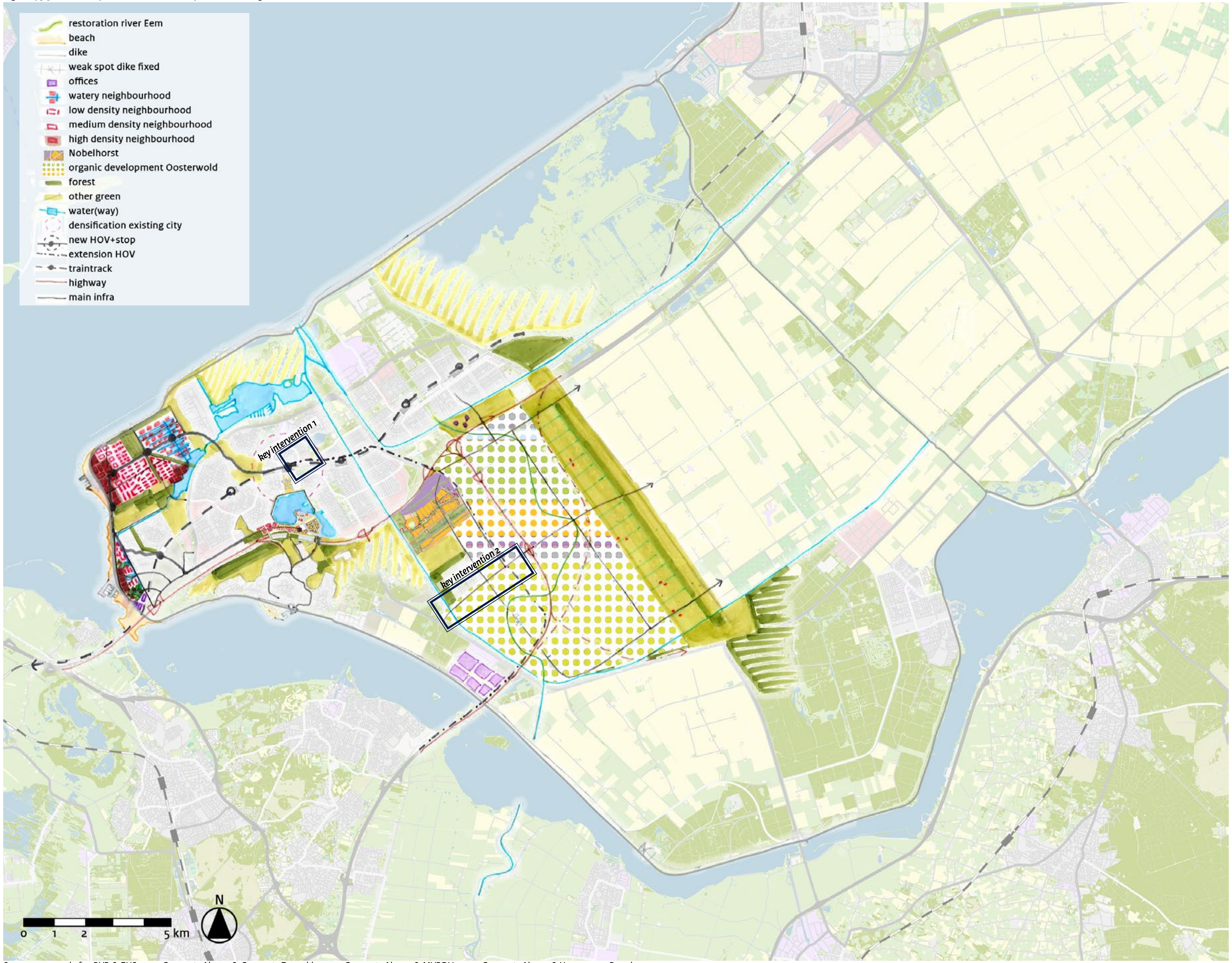
On local level:

- Develop a social, economic & ecological sustainable city, by following the **Almere principles** (Gemeente Almere, 2011):
  1. Cultivate diversity
     - *Differentiation housing supply*
     - *Diverse demographic composition*
  2. Connect place and context
     - *Enhance identity of city*
     - *Living-working balance*
     - *External accessibility*
     - *Level of amenities/facilities*
  3. Combine city and nature
  4. Anticipate change
     - *Incorporate generous flexibility and adaptability in plans and programs*
  5. Continue innovation
     - *Experimentation and exchange of knowledge*
  6. Design healthy systems
     - *'Cradle to cradle' solutions*
  7. Empower people to make the city

These ambitions on different levels are not one-dimensional, no hierarchy is given to them (national versus regional versus local).

Note that these ambitions in the current situation do not include specific water safety goals. There is no relation between the urban development and the hydraulic engineering and water management layer (fig. 4.3.4).

Figure 4.3.3: overall map of the Southern Flevopolder according to the 0-alternative.



Source: composed after BVR & ZUS, 2011; Gemeente Almere & Gemeente Zeewolde, 2013; Gemeente Almere & MVRDV, 2009; Gemeente Almere & Ymere, 2011; Posad, 2012

Pros and cons:

+ Possibilities for water storage in Oosterwold
+ Administratively less complex; separated responsibilities
+ Probably less expensive

- Less exciting living environments
- Less contact with water behind dike
- Dependence on construction IJmeerlijn
- Lowering the A6 means an important evacuation route is gone
- Developments in lowest part of the polder, with most (future) water nuisance and land subsidence
- Structure of cores separated by green arms is maintained, not giving Almere the chance to become a proper city
- If something goes wrong, the consequences will be disastrous, in terms of both economic damage and casualties

For a full assessment of this alternative, see appendix 8.8.

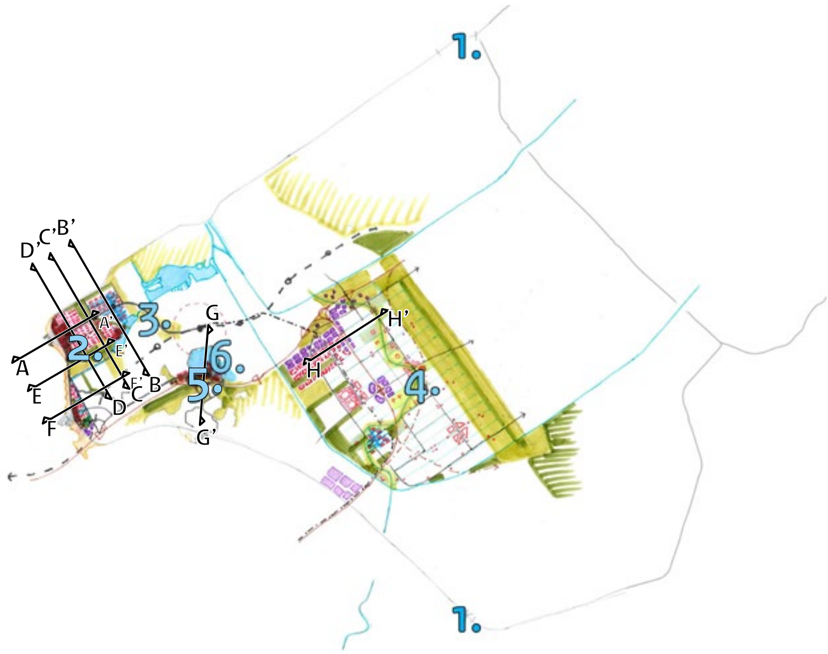
Key interventions

1. Strengthening dike sections 5, 34 & 35
2. Campus and knowledge industry at Pampus
3. High quality public transport line Weerwater-Poort-Pampus-Central Station
4. Organic development Oosterwold
5. Covering A6 Haven-Weerwater-Stad
6. Rondje Weerwater

Example of elaboration KI5

CENTRE/ WEERWATER

source: Posad, 2012: 25

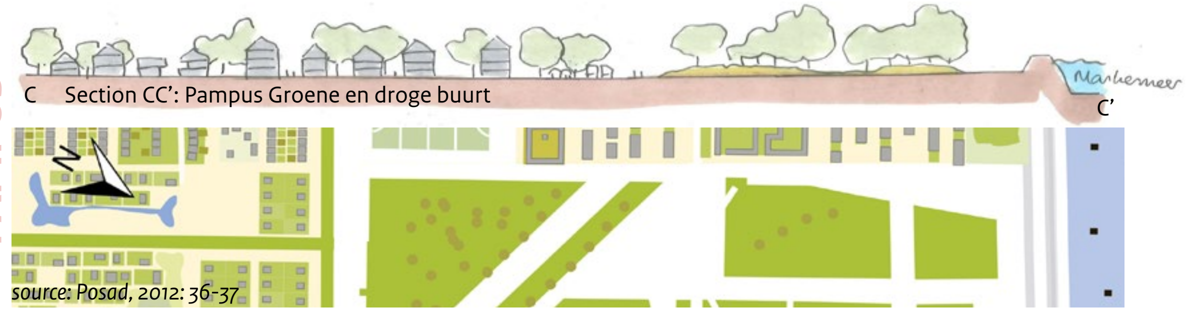


Sections of important parts of the *current plans* for the Schaalsprong

PAMPUS

source: Posad, 2012: 36-37

PAMPUS

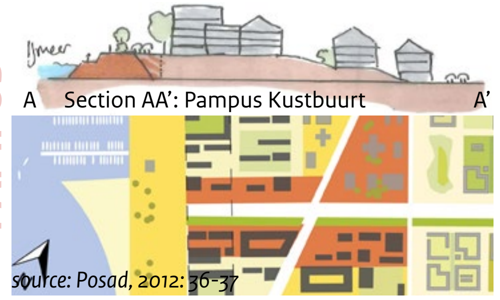


source: Posad, 2012: 36-37

PAMPUS

source: Posad, 2012: 36-37

PAMPUS



source: Posad, 2012: 36-37

source of sections: own images

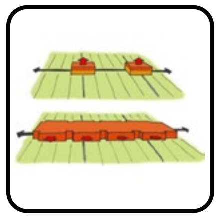
Rules & Tools

GENERAL

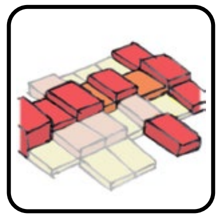
keep separated cores

PAMPUS

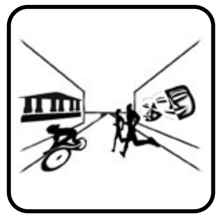
no barrier effect dike



develop along public transport line

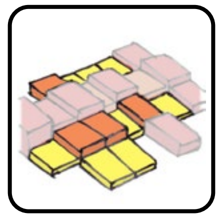


high densities

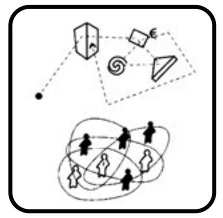


stimulate sports and culture

OOSTER-WOLD

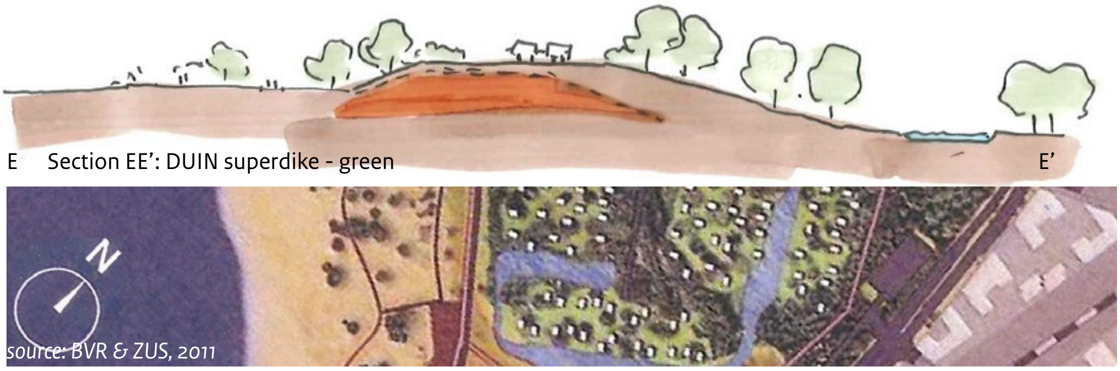


low densities

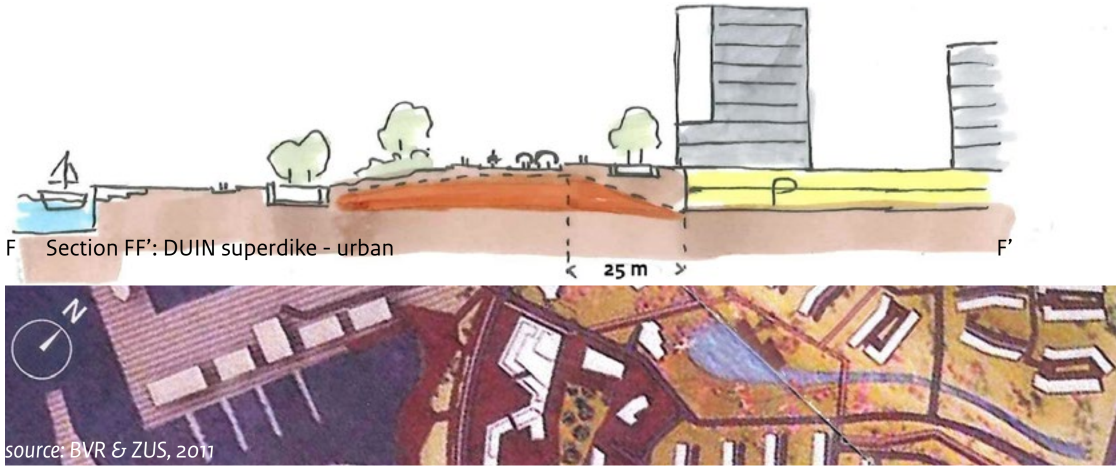


organic development

DUIN



DUIN



CENTRE/WEERWATER

OOSTERWOLD

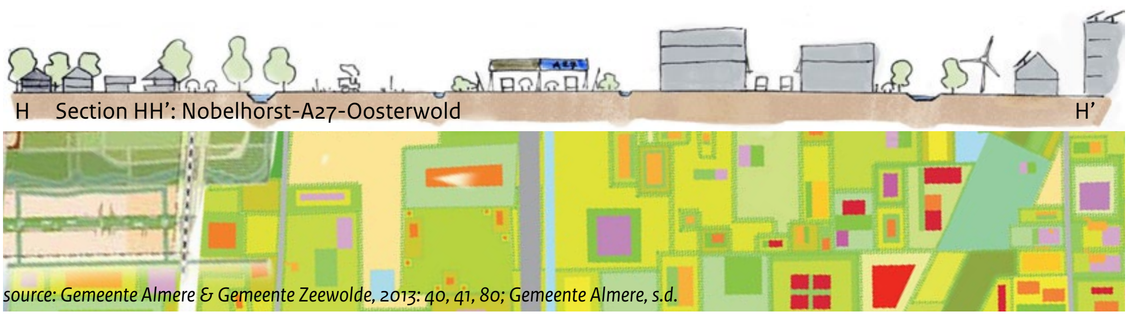
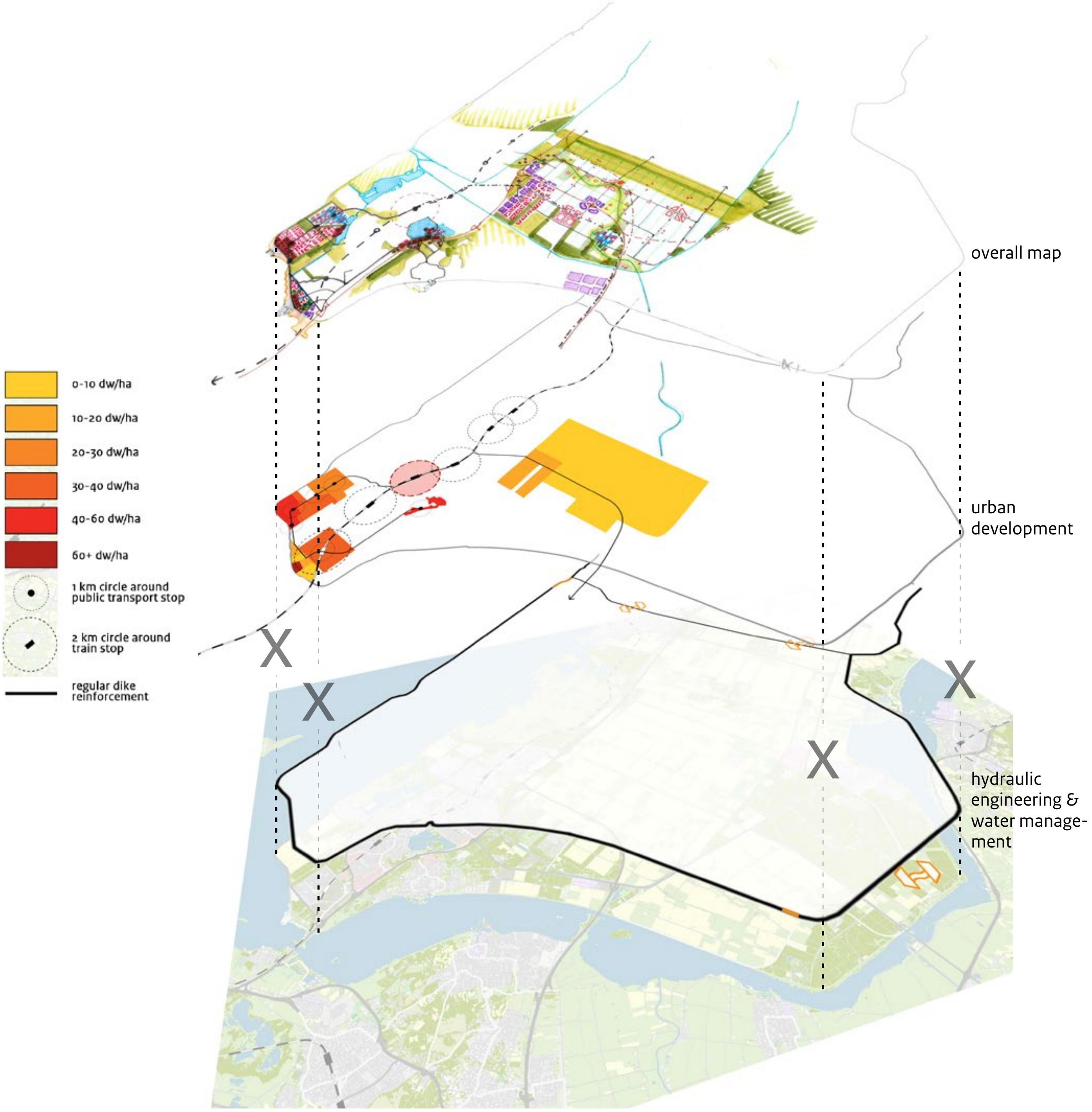


Figure 4.3.4: Layered structure of the overall map: hydraulic engineering and water management interventions don't have any influence urban development. Rather, it is the other way around: the planned development influences the safety standards of the dike enclosure.



Phasing

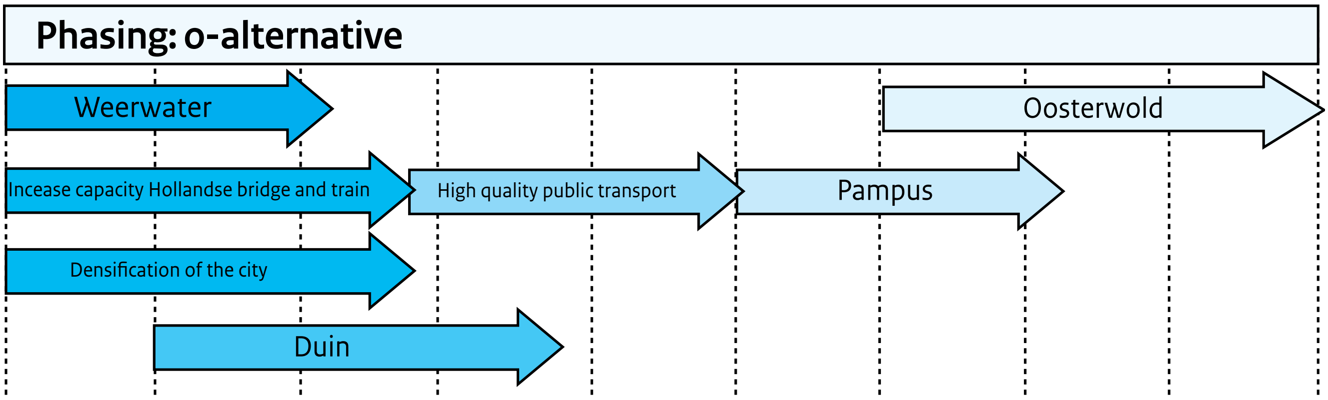
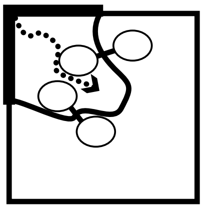


Figure 4.3.5: The area in the 0-alternative, normal situation.

Figure 4.3.6: The flooded area in the 0-alternative.

Flood simulations with waterdepth; see also appendix 8.7.1.



Alternative 1

Multifunctional unbreachable dike, compartmentalization and water storage (Multi Layer Safety: focus on layer 1 and 2)

In this alternative, flood risk is dealt with by drastically reducing the probability a dike breach occurs and the consequences of a flood by realizing unbreachable dikes. This may be linked to urban development. At least 17 km unbreachable (multifunctional) dike is needed, of which 4 km unbreachable (multifunctional) dike will already be realised within project DUIN. A compartmenting sluice is created underneath the Hollandse Brug, separating the water from the Markermeer/IJmeer and the Gooimeer/Eemmeer/Nijkerkernauw. This way, in case of a breach near Zeewolde, less water flows in.

Associated to the unbreachable dike, a compartmentalization dike is recommended. The first phase of this dike will consist of a bicycle path on a 1 m high dike. This dike will only have a retarding effect, delaying the arrival time of the water for the most densely populated/built areas. The height of one meter makes sure that in the compartment that is flooded first, no dangerous water depths will occur soon (bath tub effect), because when it will get higher than one meter, water will start to flow over to the second compartment. Second phase of this compartmentalization is the incremental (organic) development of mounds of 3 m high, which gradually grow together forming a full compartment.

Third important intervention is the control of the flow inside the polder through a guiding river (Dutch: '*geleidingsrivier*'), for extra water storage. The development in Oosterwold will have to be able to store this extra water, and therefore will be a watery living environment (Dutch: '*waterrijk milieu*').

The complete program for the Schaalsprong has to be realized in this compartment, so in order to make room for this extensification, the green buffers between the different cores have to be intensified. Hence, more program is realised in the existing city compared to the 0-alternative.

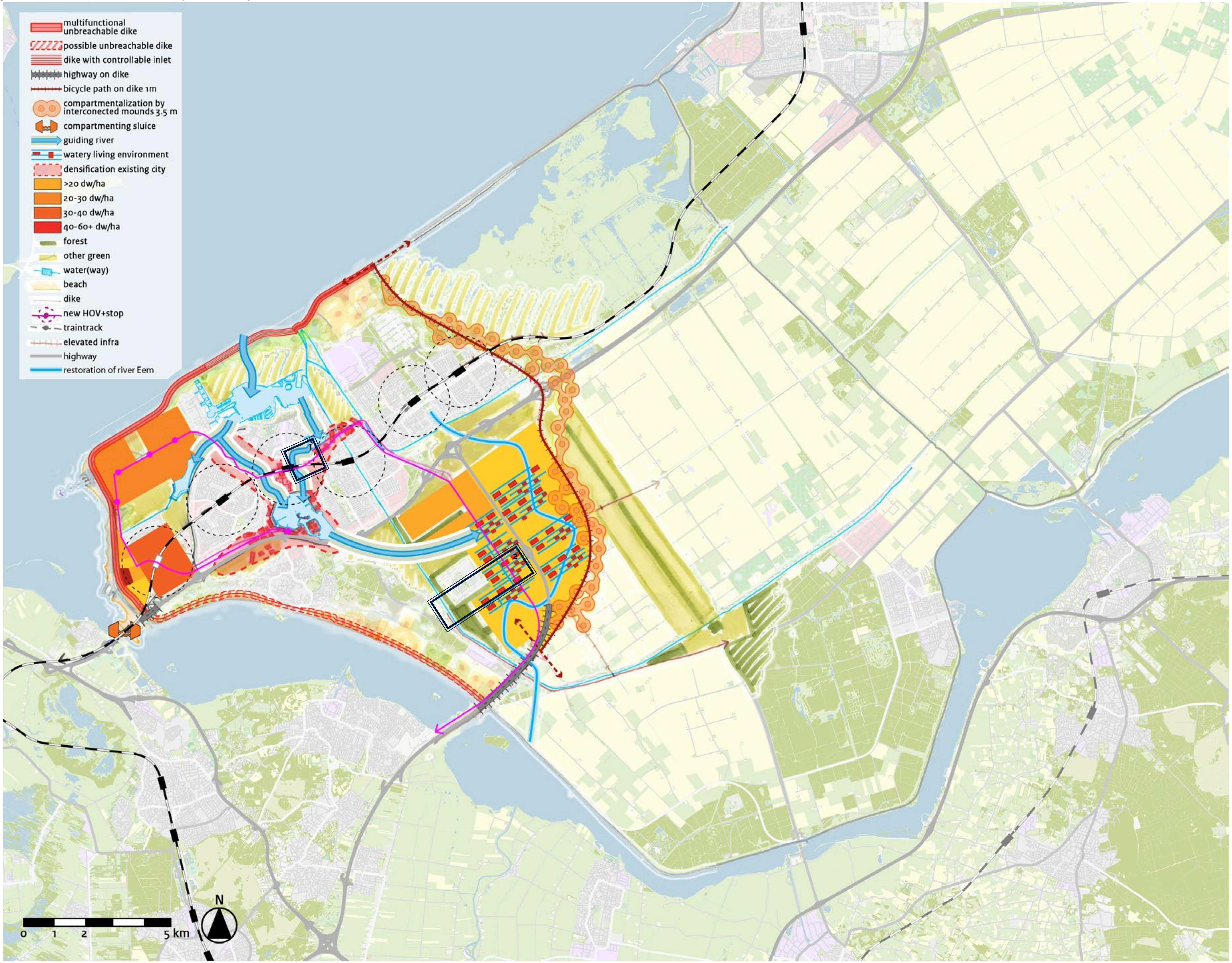
Pros and cons:

+ Compartmentalization Gooimeer/Eemmeer and Markermeer limits the surface of waterbodies from which the water can flow in with 5 %
+ Combination with compartmentalization reduces amount of unbreachable dyke needed
+ Takes away 'bath tub' effect
+ Intensification inside safest compartment unifies split city
+ Current built area also safe
+ Vulnerable and vital objects and functions will remain dry at all times
+ Connects to plan DUIN
+ Contact with the water and unique living environments increase spatial quality
+ Possible water storage, link to water nuisance/heat problem; solves the problem of having to build in the lowest part of the polder

- Possibly expensive
- Some parts are too close to existing dike to be able to realize an unbreachable dike
- Raising all the infra for compartmentalization and mound structure is expensive and possibly creates barriers
- Administratively complex (e.g. DUIN)

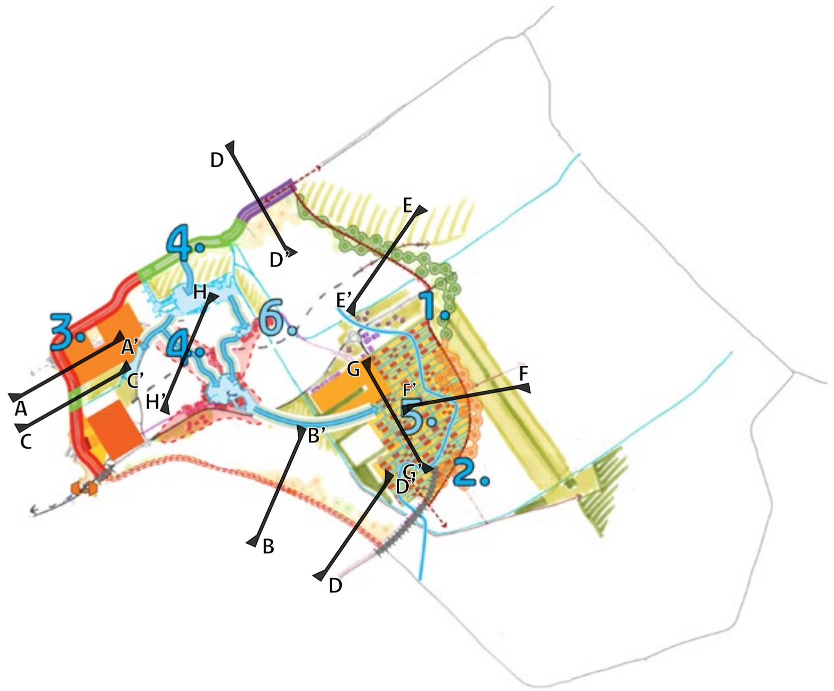
For a full assessment of this alternative, see appendix 8.8.

Figure 4.3.7: overall map of the Southern Flevopolder according to alternative 1.



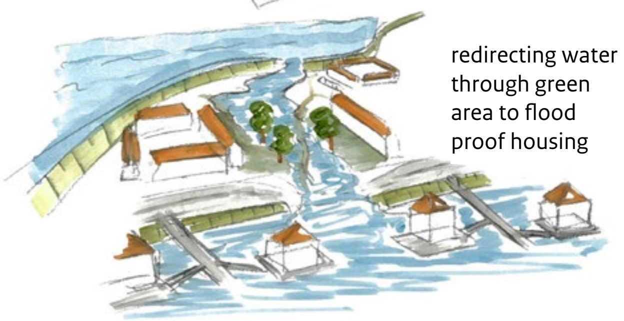
Key interventions

1. 1 m high bicycle path compartmentalization
2. Mound structure compartmentalization
3. Multifunctional unbreachable dike
    - transition high and low areas
    - transition urban functions to green functions
    - transition to parts where dike is built already
4. Water storage by controllable inlet and controlling flow inside polder
5. Water storage by watery living environment lowest part
6. High quality public transport line and densification along it



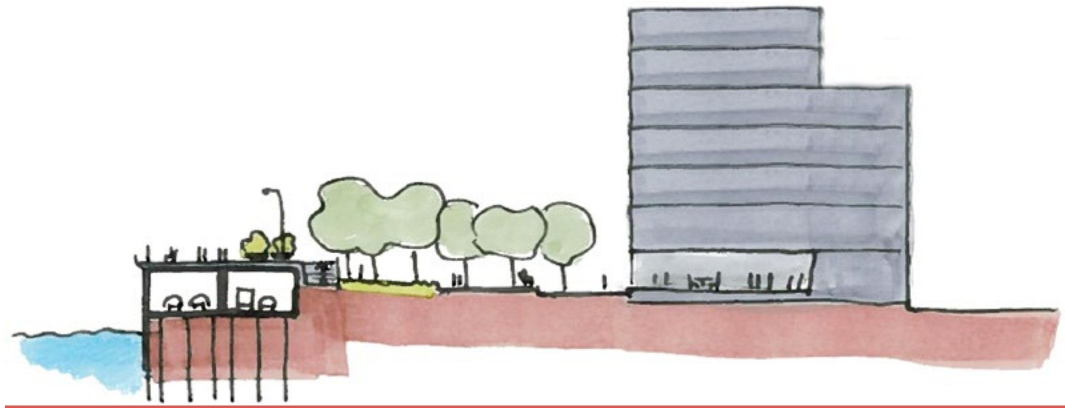
Example of elaboration

redirecting water through urban area

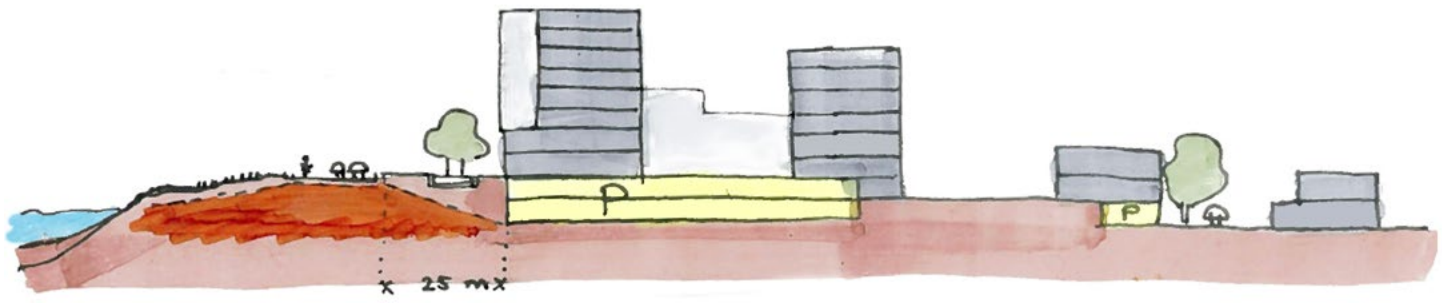


redirecting water through green area to flood proof housing

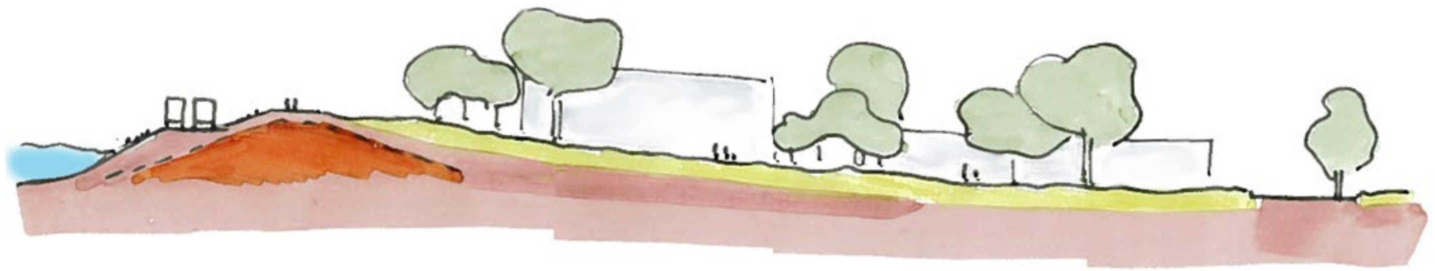
Sections



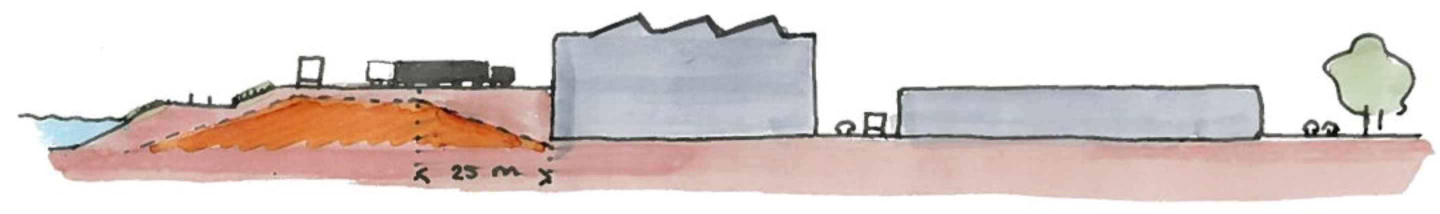
A Section AA': Pampus 'city balkony' (urban multifunctional unbreachable dike) A' SUPERDIKE



B Section BB': 'promenade' (urban multifunctional unbreachable dike) SUPERDIKE B'



C Section CC': 'park dike' (green multifunctional unbreachable dike) SUPERDIKE C'



D Section DD': 'loading and unloading' (industrial multifunctional unbreachable dike) SUPERDIKE D'

Rules & Tools

SUPERDIKE

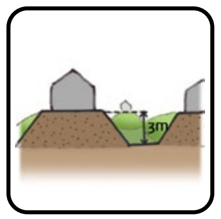
no barrier effect dike

multifunctionality dike

space reservations dike

COMPART-MENT

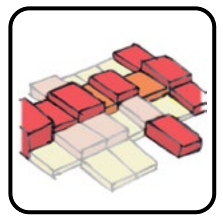
bicycle path on 1m high dike



mounds +3m from ground level

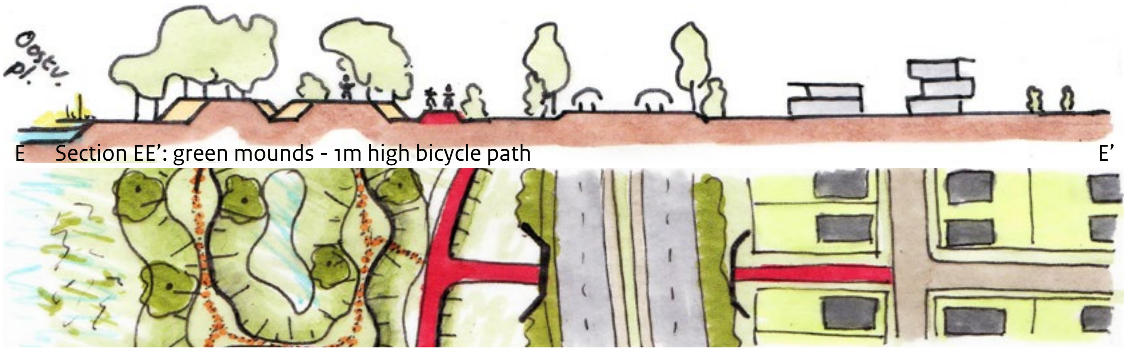
INTENSIFI-CATION

possibilities for water storage



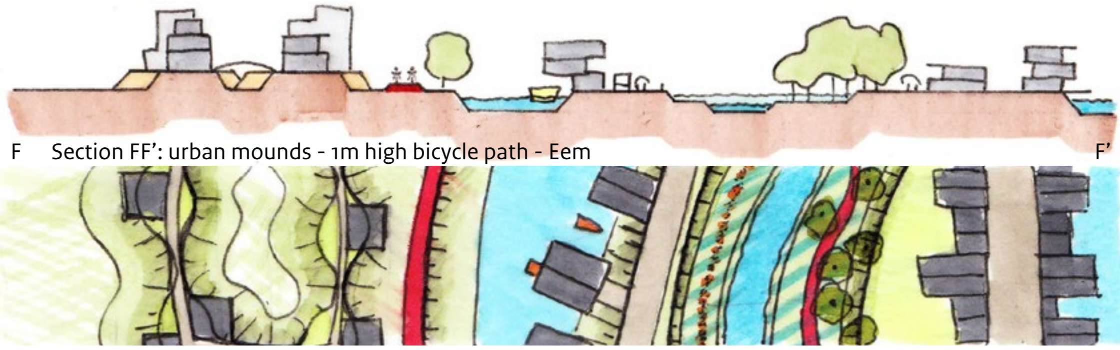
high densities

COMPARTMENT



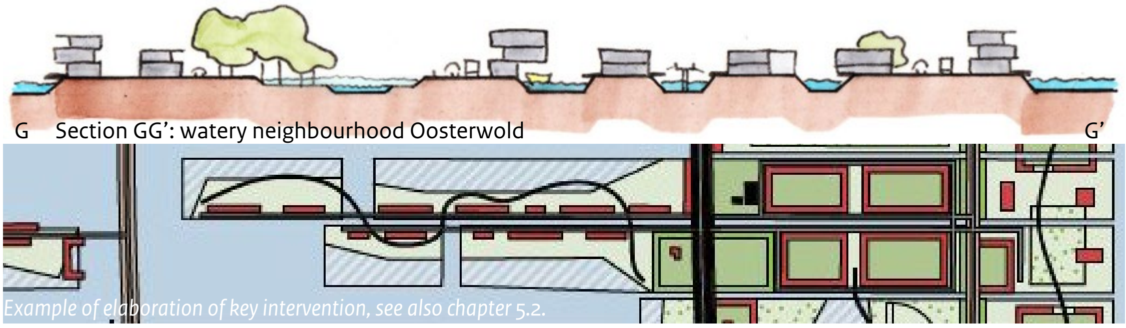
E Section EE': green mounds - 1m high bicycle path E'

COMPARTMENT



F Section FF': urban mounds - 1m high bicycle path - Eem F'

OOSTERWOLD



G Section GG': watery neighbourhood Oosterwold G'

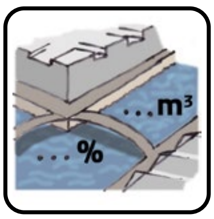
Example of elaboration of key intervention, see also chapter 5.2.

INTENSIFICATION

H Section FF': densification along 'river' for water storage H'

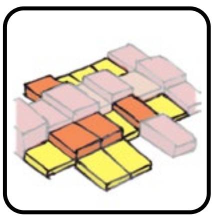
Example of elaboration of key intervention, see also chapter 5.1.

OOSTER-WOLD



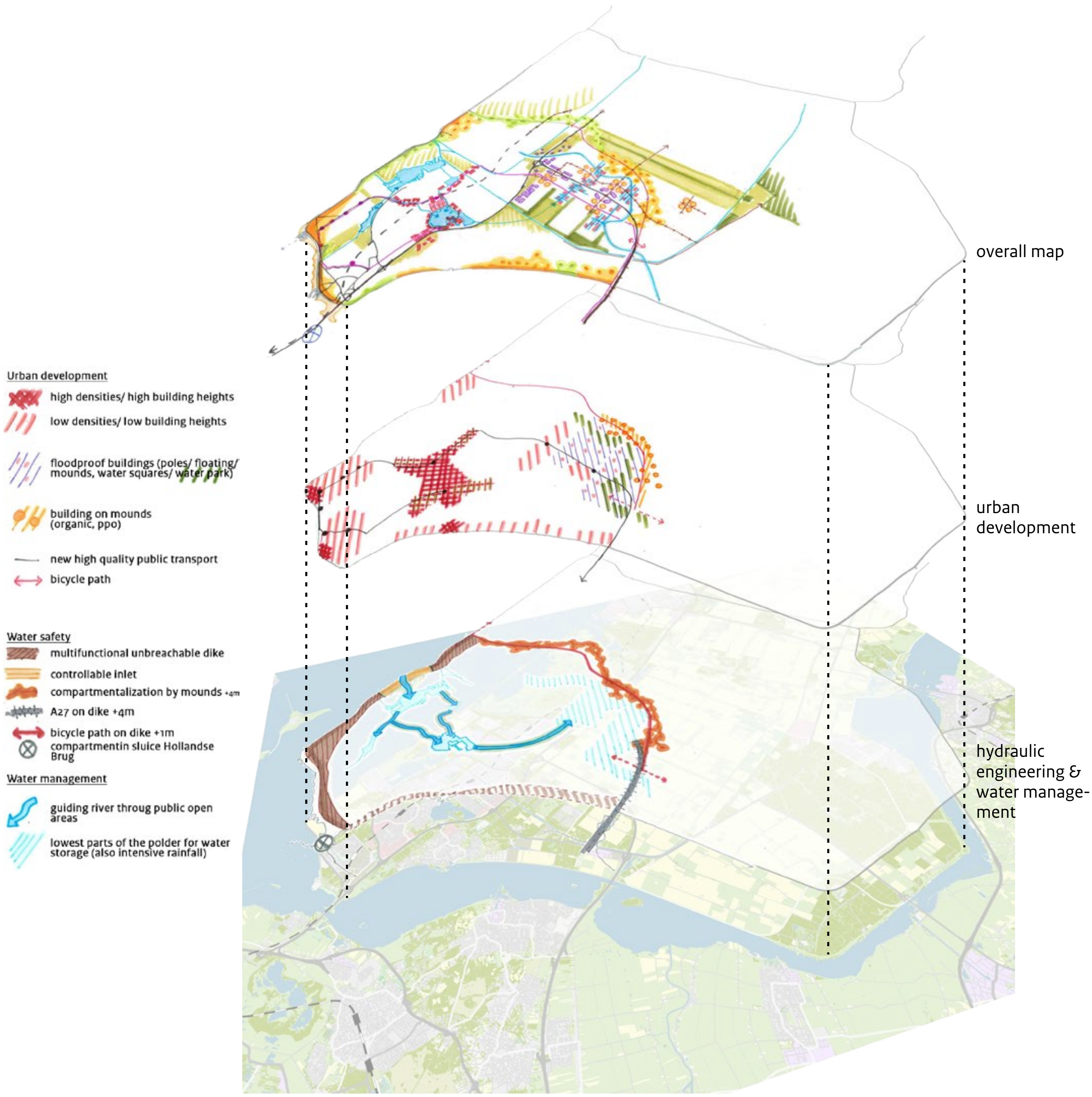
minimum %/m³ surface water

possibilities for water storage



low densities

Figure 4.3.8: Layered structure of the overall map: hydraulic engineering and water management interventions influence urban development.



Phasing

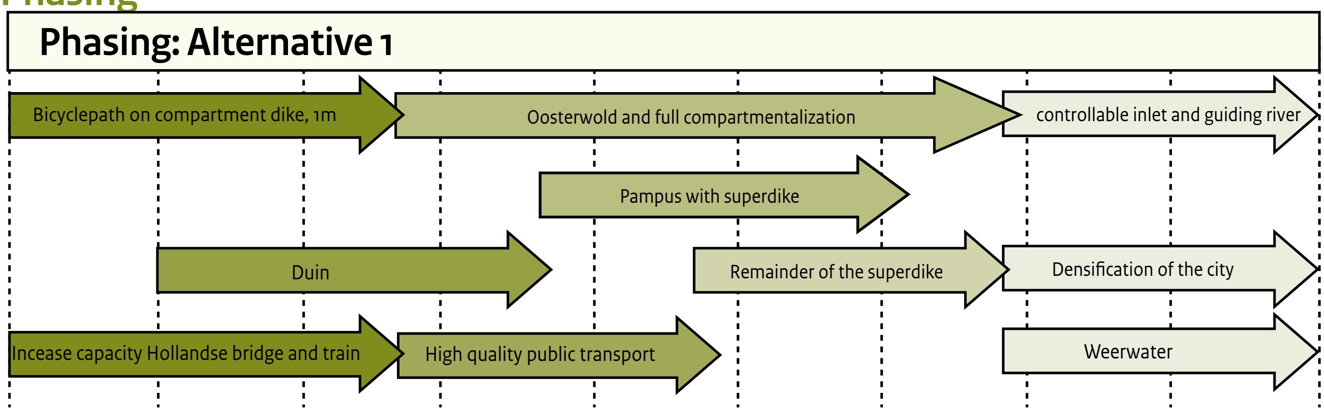
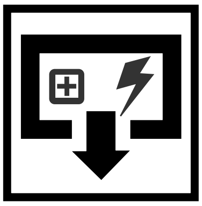


Figure 4.3.9: The area in alternative 1, normal situation.

Figure 4.3.10: The flooded area in alternative 1.



Alternative 2

Floodproofing vulnerable and vital objects and functions, and accommodating (full) evacuation (Multi Layer Safety: Focus on layers 2 and 3)

The essence of this scenario is that the arrival of a flood wave in urbanized area is delayed and that inhabitants are provided with the opportunity to safe themselves (self-reliance). To do this, the impact of a flood will be changed through adjusting exposure and vulnerability. This is done by an elevated construction of vulnerable and vital objects such as hospitals and electricity supply. Evacuation (self-reliance) is promoted by simple adjustments in the street pattern and routing. Some roads have to be constructed on a higher level, to give inhabitants more time to evacuate. Risk zoning, determined by the arrival time and the maximum water depth, forms the basis of urbanization. Therefore, rules for urban development are very important in this alternative. For example, nature and water storage locations are planned in strategic places where the water comes immediately and deep (along the edges of the dike, Hoge Vaart and Lage Vaart). In areas where the water arrives fast and deep, high rise is planned, allowing vertical evacuation (shelters). In general, escape areas must be elevated, free of obstacles. Higher buildings, or buildings with the same, notable colour or materialization, mark the primary escape routes. The structure of infrastructural network in a neighbourhood is very important for this strategy. This means not too many turns, no dead ends, and no funnel effect by roundabouts. This comes down to a grid structure. This structure may not be perpendicular to the source of the flood, because streets directly perpendicular to flood source with buildings parallel at both sides can create a channel-like area that makes waves move faster and reach more area inland (Fakhrurrazi, 2010).

A strategy as this alternative strongly relies on self-reliance of inhabitants. Interventions which require human action are a huge uncertainty factor during the event itself. This means that proper education and awareness is required, based on risk zoning. Codes of conduct are linked to the type of risk zone in which people live.

In this scenario, there is a high certainty that the number of victims is limited, but the economic damage may rise from unknown to high (maximum).

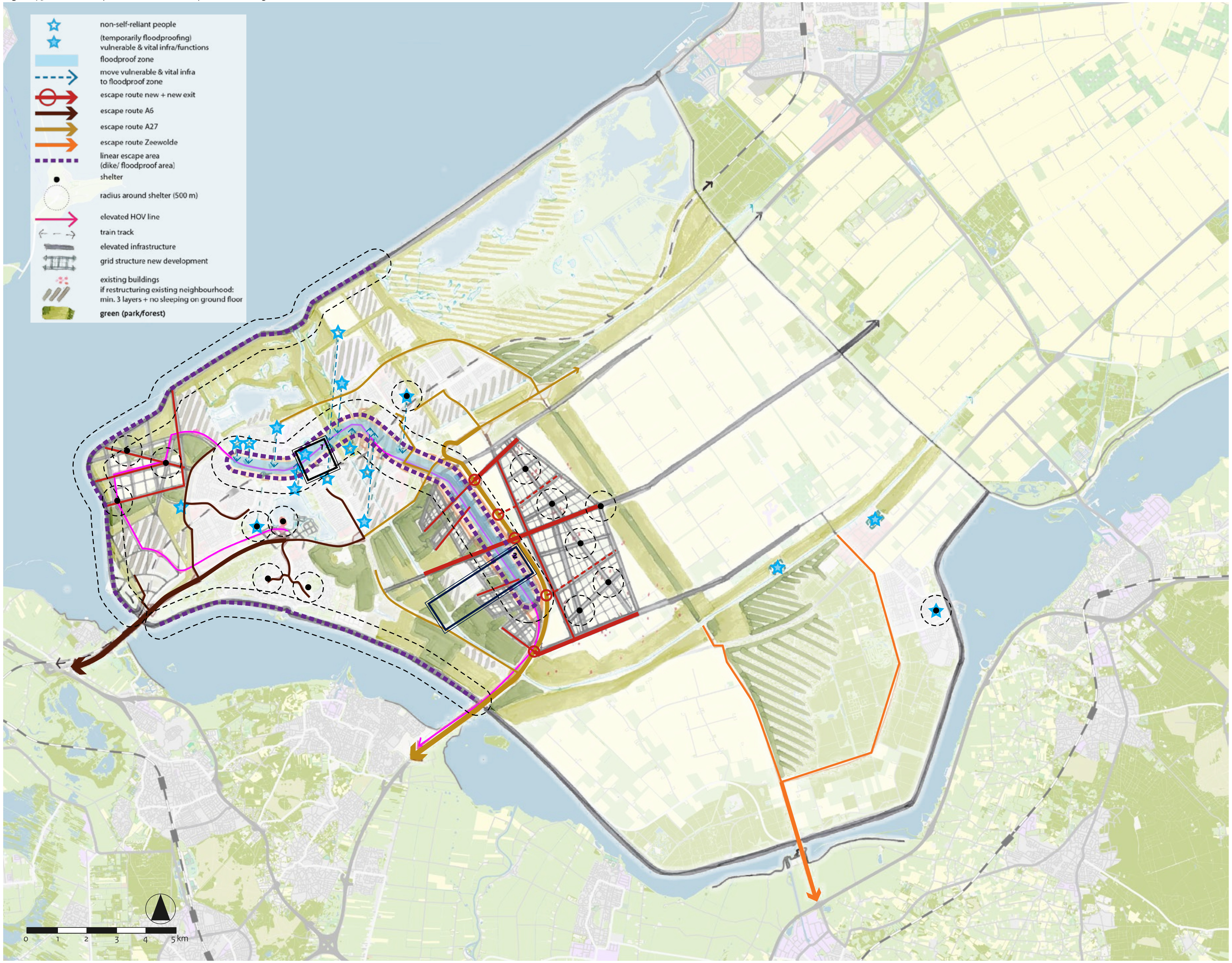
Pros and cons:

+ Vital facilities will function during flood for evacuees
+ Greatly reduces amount of victims, e.g. by shelters that accommodate people that could not evacuate in time
+ Lowest parts of the polder and high risk zones are not built
+ Differentiation of living environments; working with gradients - when designed well - can add to experiental value and ecological diversity

- Raising the infra to create escape routes is expensive and creates barriers
- Because the flood duration is over a year, eventually everyone needs to be evacuated; will they return?
- Economic damage still will be maximal
- Interventions require human action, which is an uncertain factor during the event itself
- This strategy really requires different practice and different discourse; governmental complexity is very high
- Junctions without roundabouts might cause more traffic victims in a regular situation

For a full assessment of this alternative, see appendix 8.8.

Figure 4.3.11: overall map of the Southern Flevopolder according to alternative 2.

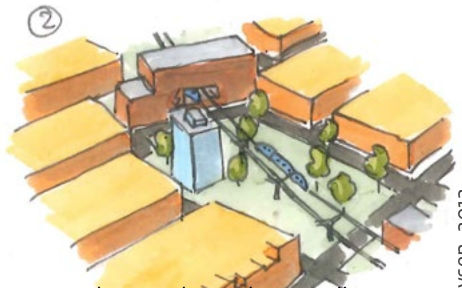


Key interventions

1. Risk zoning and corresponding planning regulations for building
2. Floodproof existing vulnerable & vital objects/infrastructure and floodproof elevated zone
3. Shelters and escape route indication towards shelters
4. Skew grid structure new neighbourhoods
5. Evacuation route upgrade: NOT lowering A6, added exit ramps, reverse laning and signs
6. Elevated high quality public transport line and densification along it

Example of elaboration

phase 1: tramline

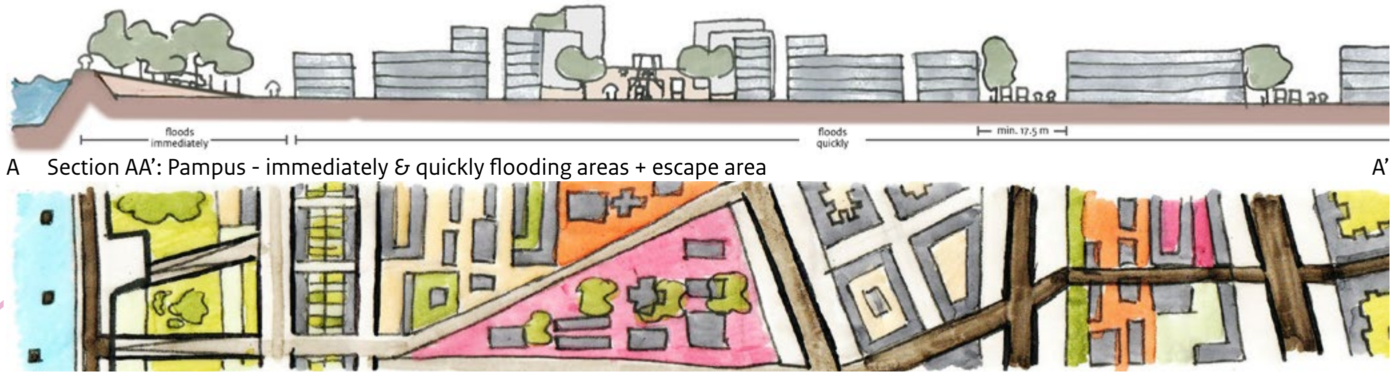


phase 2: elevated monorail, densification along line, shelters in high buildings

source: Lysen, 2012

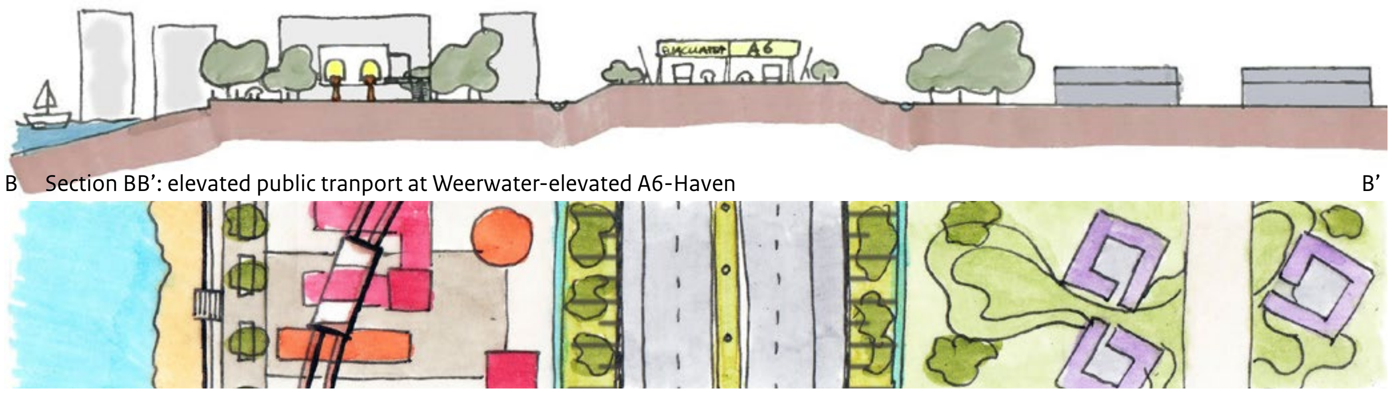
Sections

QUICK & DEEP



A Section AA': Pampus - immediately & quickly flooding areas + escape area A'

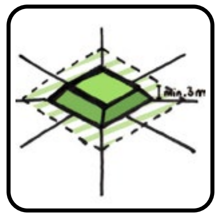
SLOW & DEEP

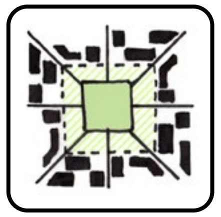


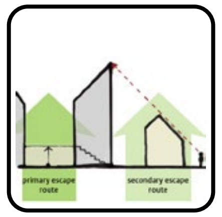
B Section BB': elevated public tranport at Weerwater-elevated A6-Haven B'

Rules & Tools

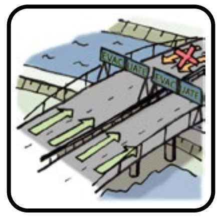
GENERAL

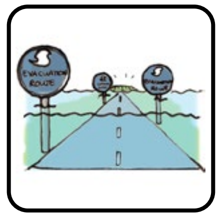

elevated escape area

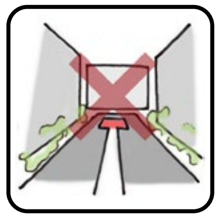

escape area clear from obstacles

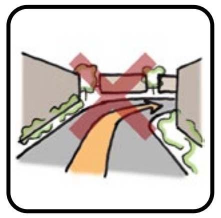


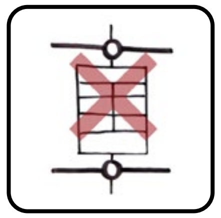
high buildings indicate primary escape route

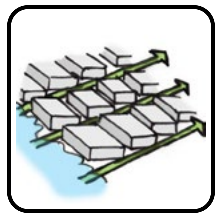

reverse laning


mark escape route

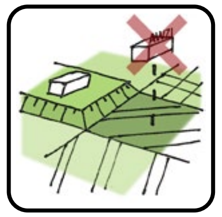

no dead end streets

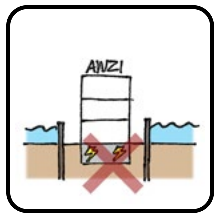

not too many turns


no funnel effect by roundabouts


skew grid structure of neighbourhoods

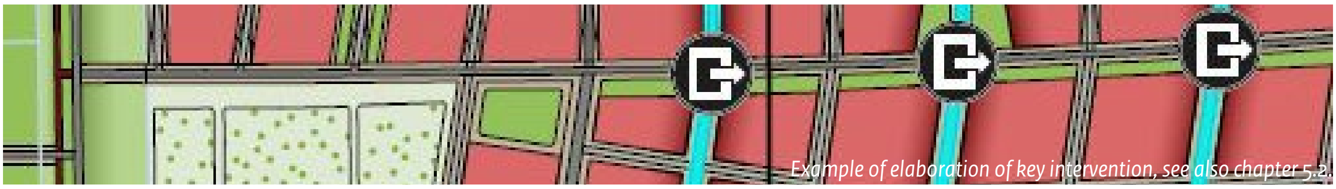
VULNERABLE & VITAL FUNCTIONS


steering location-choices


floodproof

SLOW & DEEP

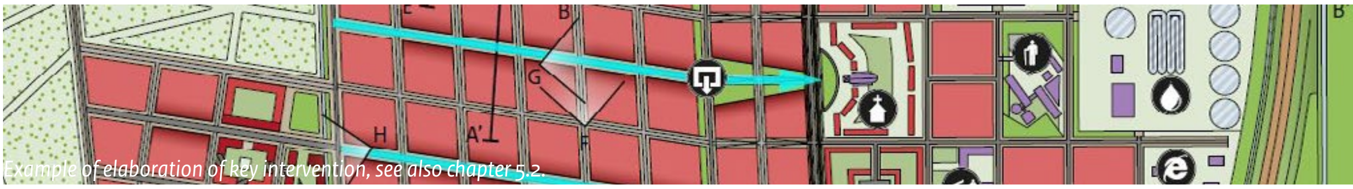
C Section CC': primary and secundary escape routes along skew grid Oosterwold C'



Example of elaboration of key intervention, see also chapter 5.2.

VULNERABLE & VITAL FUNCTIONS

D Section DD': floodproof zone Nobelhorst-A27-Oosterwold D'

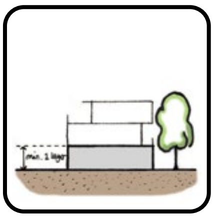


Example of elaboration of key intervention, see also chapter 5.2.

IMMEDIATE & DEEP

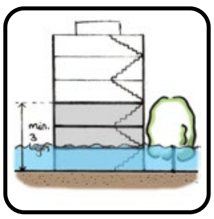
no buildings, only green/blue functions

SLOW & DEEP



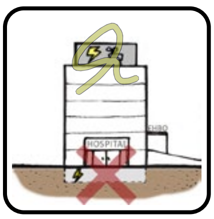
low building height, low density

QUICK & DEEP



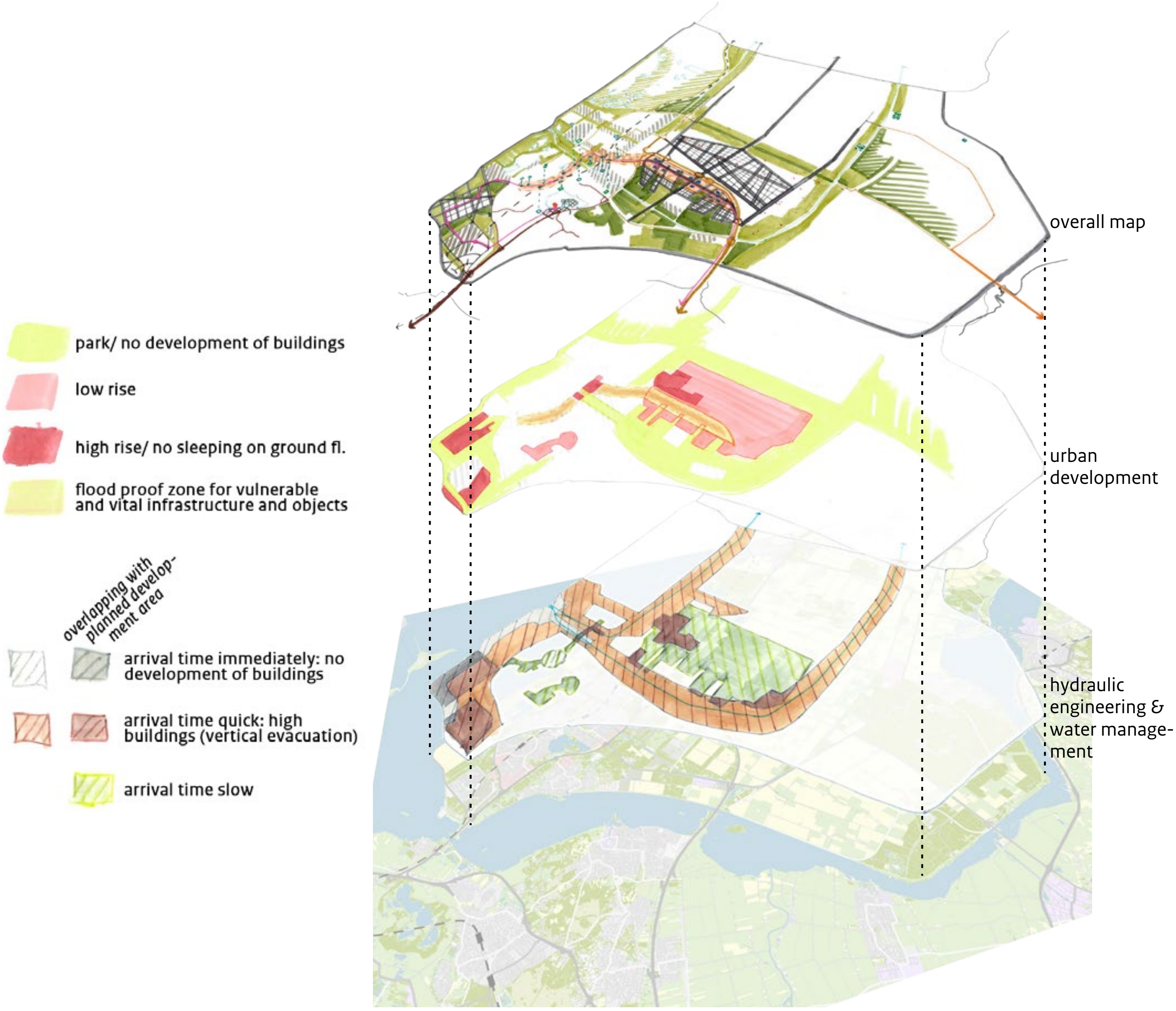
minimum of 3 building layers

no sleeping on ground floor



energy/water supply elevated in building

Figure 4.3.12: Layered structure of the overall map: hydraulic engineering and water management interventions influence urban development.



Phasing

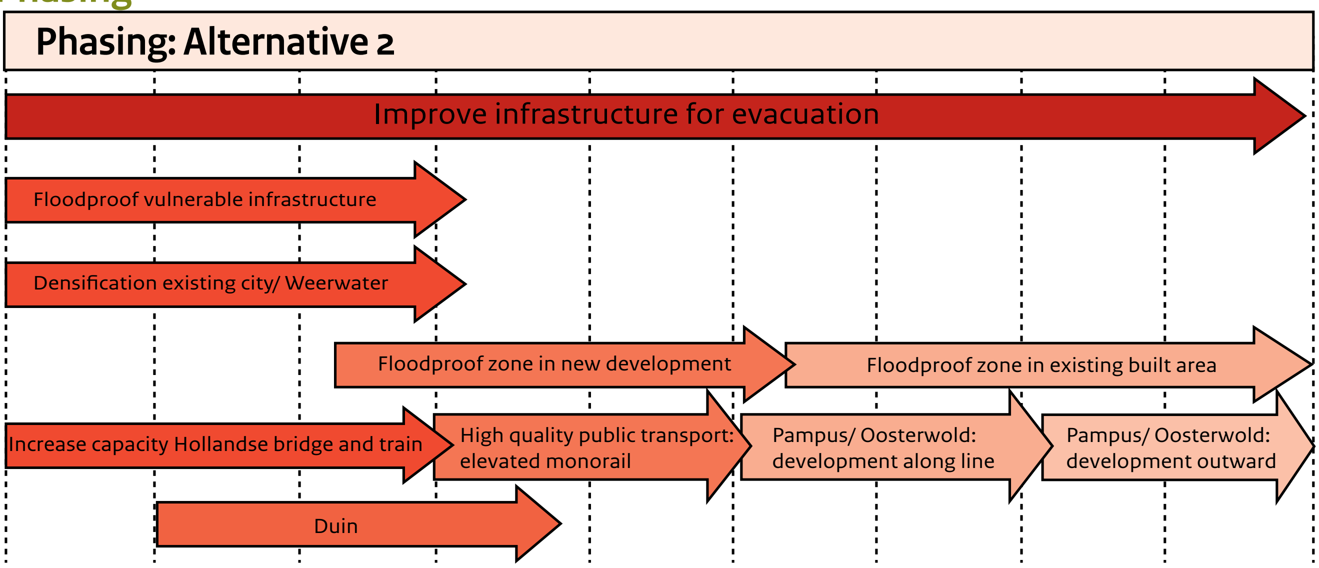


Figure 4.3.13: The area in alternative 2, normal situation.

Figure 4.3.14: The flooded area in alternative 2.

Next steps

All these alternatives have been evaluated based on the criteria that together form the framework for comparative assessment. With help from Deltares, the different alternatives have been inserted in the flood simulation program SOBEK, to calculate the impact on course of the flood. The economic and social impact have been determined by means of the Land-Use Planner and Damage Scanner, at the PBL (see appendix 8.7).

Regarding governmental feasibility, numerous people, including Joost Tennekes (PBL), Peter Otten (Municipality of Almere), Martin Nieuwjaar and Jeroen Doornekamp (Province of Flevoland), mr. Hupsel and mr. Walters (Security region Flevoland), and Joan Meijerink (Water board Zuiderzeeland) have contributed to the assessment.

A session for expert judgement with experts from of the PBL helped to assess the effects on spatial quality, flexibility and possibility to link to other (climate) challenges. Next to that, an own expectation is described, using literature review (Asselman & Alberts, 2008; Baan et al., 2008; Kolen et al., 2012b; Ruitenbeek, 2010).

In relation to flexibility and uncertainties in the future, the following considerations are important: which option lends itself most for flexible urban planning? How does such an incremental new building look, i.e. what reference images do we have? Who are the initiators? What are the requirements for the spatial planning? How do you monitor the social value here, so how can you prevent that places become unpleasant? Other effects on e.g. water nuisance (caused by intense rainfall), water shortage (too low groundwater level due to drought) and heat stress also have been established.

To test the effect on spatial quality, a spatial elaboration two key interventions is made (figure 4.3.16). The question “what is desirable?” has been leading for choosing those two locations.

Almere is to become a rather big city for 350,000 inhabitants, but still functions like a large village. This is partly due to the separation of the cores by green arms. When expanding the city for the Schaalsprong, it is thus not desirable to maintain this structure of multiple cores divided by green. The first key intervention is therefore a design study of possibilities for inward expansion instead of outward sprawl in the different alternatives.

When planning a large amount of program in a deep polder, it is – both from a flood risk and from a water management perspective – undesirable to plan a great part of that program on exactly the deepest spot of the polder, which is the case for the plans for Oosterwold. Therefore, as a second location for a key intervention a part of the new development east to Almere has been chosen, but not the deepest part.

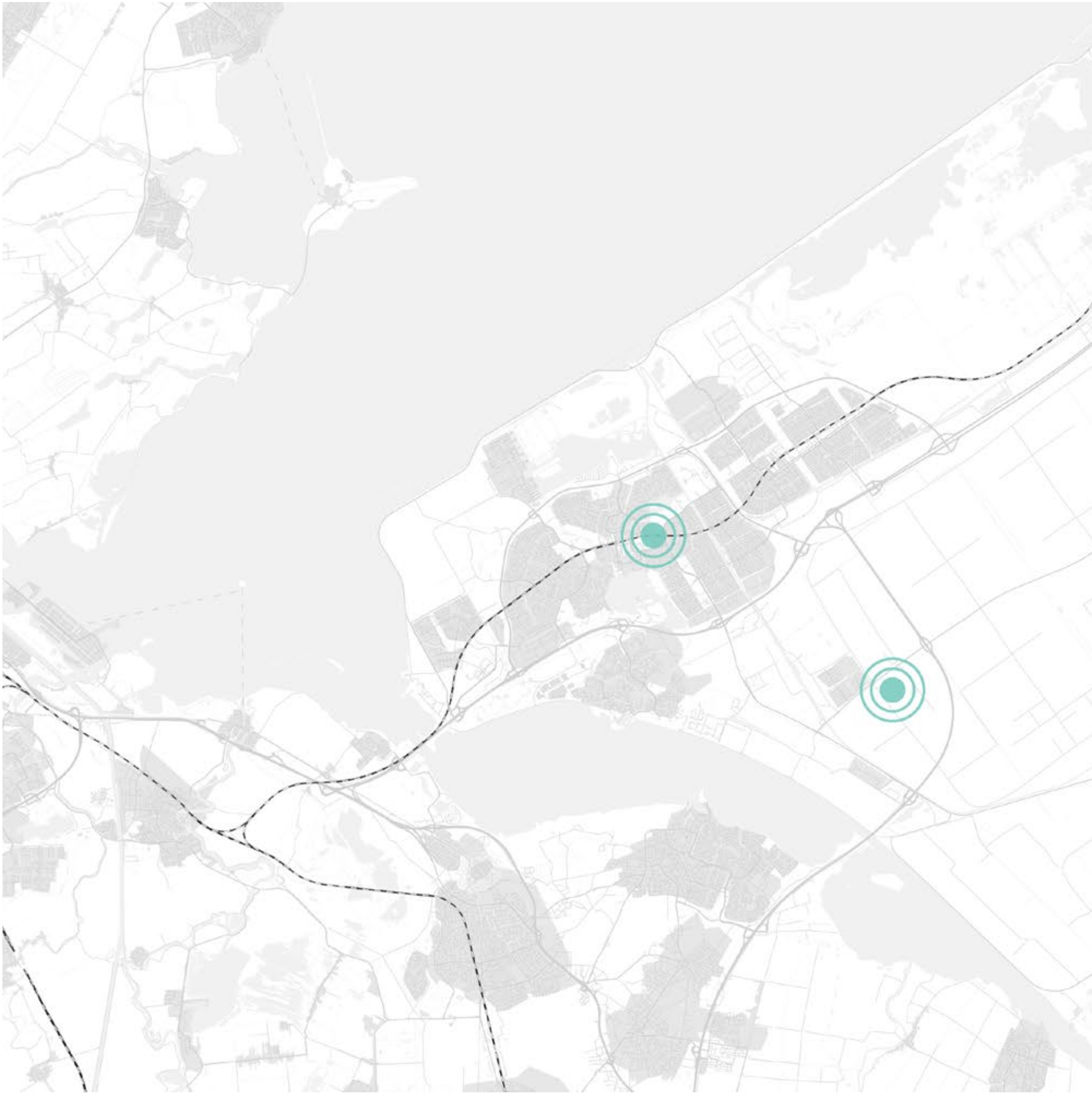
Ultimately, a multi-criteria analysis has become the result, as is shown in figure 4.3.15. The full assessment can be found in appendix 8.8.

Figure 4.3.15: Multi-criteria analysis output.

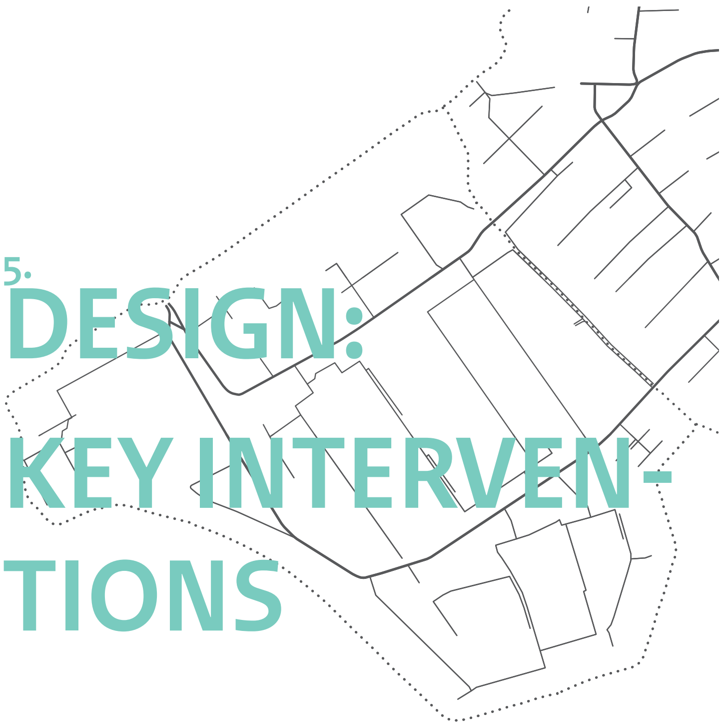
	Cost-effectiveness	Flexibility	Spatial quality	Governmental feasibility	Link to other challenges
0-Alternative	0	0	0	0	0
Alternative 1	+	+	+	-	+
Alternative 2	0/+	+/-	+/-	-	+/-

++ = high
+ = more than average
0 = average
- = less than average
-- = low

Figure 4.3.16: Locations of key interventions which are further elaborated in a design.



Location of key intervention in the existing city
source: Bing Maps, s.d.



5. DESIGN: KEY INTERVEN- TIONS

Location of key inter

vention in the new development in the polder east of Almere

source: Bing Maps, s.d.

Figure 5.1.1: Large open field in close proximity of city center.

5.1 KI 1: Current situation

Figure 5.1.2: Map of structuring elements.

Structuring elements

Almere Stad has relatively many industrial estates in close proximity to the centre. Some of these areas were once the edge of town. Now however they are valuable ground with a high potential to develop into more than just industry. Also in close proximity of the shopping centre are a few parking lots and a large open field without any program (not even nature development or recreation, just an open field) This will be the location for the first key intervention.

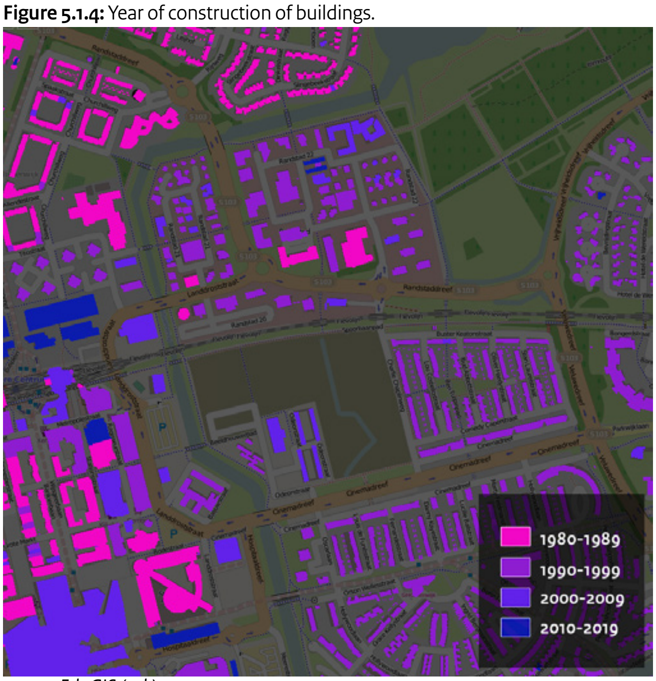
Coming from the east to the city centre, there are only backsides and closed facades, so there is no real entrance (fig. 5.1.3).

The cores of Almere Stad, Waterwijk, Filmwijk and Verzetswijk are separated by a green arm.

The train track is positioned on a dike, with passages every 150-300 meter.

Figure 5.1.3: Backside of the shopping disctrict.

Figure 5.1.4: Year of construction of buildings.



source: EduGIS (s.d.)

Expected life span of buildings

Problem with existing built areas in relation to multi-layer safety is the fact that buildings most of the time have a large lifespan. This means that in the same rate the buildings are renewed, interventions in layers 2 and 3 can be implemented.

Therefore, it is important to know the age of the buildings in the area (fig. 5.1.4). Normally, dwellings have a life span of 50-100 years (Verbiest, 1997: 17). However, the monotonous housing from the 1970ies and 1980ies of which a large part of Almere exists, is already renewed and restructured in most other big cities in the Netherlands, so this provides opportunities to also restructure parts of the existing city if necessary.

Figure 5.1.5: Example of ground floors in the area: invulnerable function on the ground floor (parking).

Vulnerable and vital objects and infrastructure

One of the reasons for choosing this location for the first key intervention is the fact that there are several vulnerable and vital functions present (fig. 5.1.6). First, one of the locations of SARA/Vancis is situated here. SARA has several functions, such as internet hub for the Amsterdam Internet Exchange (AMS-IX, since 1995) and the Almere Internet Exchange (ALM-IX, since 2001). SARA also serves as a data centre for many companies. This data would could go lost when the equipment is affected by water in a flood (N.B.: the backup is placed in the Watergraafsmeerpolder, another deep polder in a flood risky area; fig 5.1.7).

Figure 5.1.6: Vulnerable and vital functions in the area.

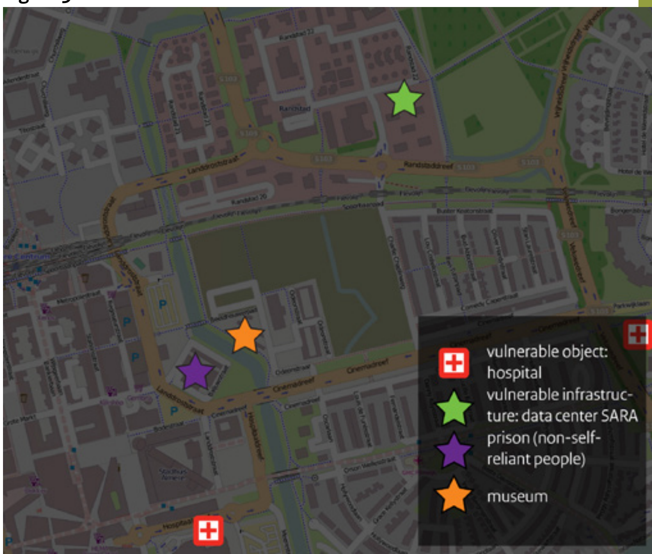
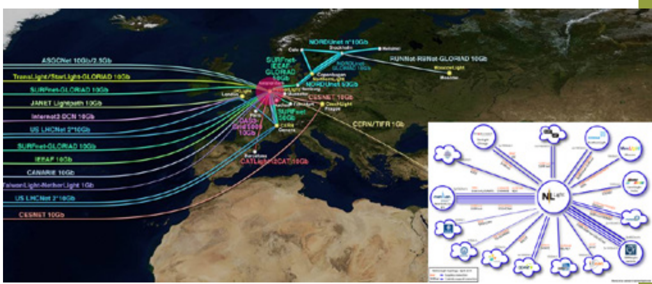


Figure 5.1.7: The Global Lambda Integrated Facility network; Amsterdam is marked red.



Vulnerable ground floors

A site visit provided some interesting examples of functions on the ground floors of buildings in the area (fig. 5.1.5 and 5.1.8). Some buildings have an invulnerable function on the ground floor, such as parking for bicycles and cars. Others already have an elevated ground floor, or stand on poles (unintentional, and still below the maximum water depth in case of a flood in the worst case scenario). Some houses however have a common format, possibly with sleeping on the ground floor.

Figure 5.1.8: Sample of ground floors in the area: [1] Invulnerable function on the ground floor (parking); [2] [3] [4] [5] elevated ground floor; [6] vulnerable functions on gf.

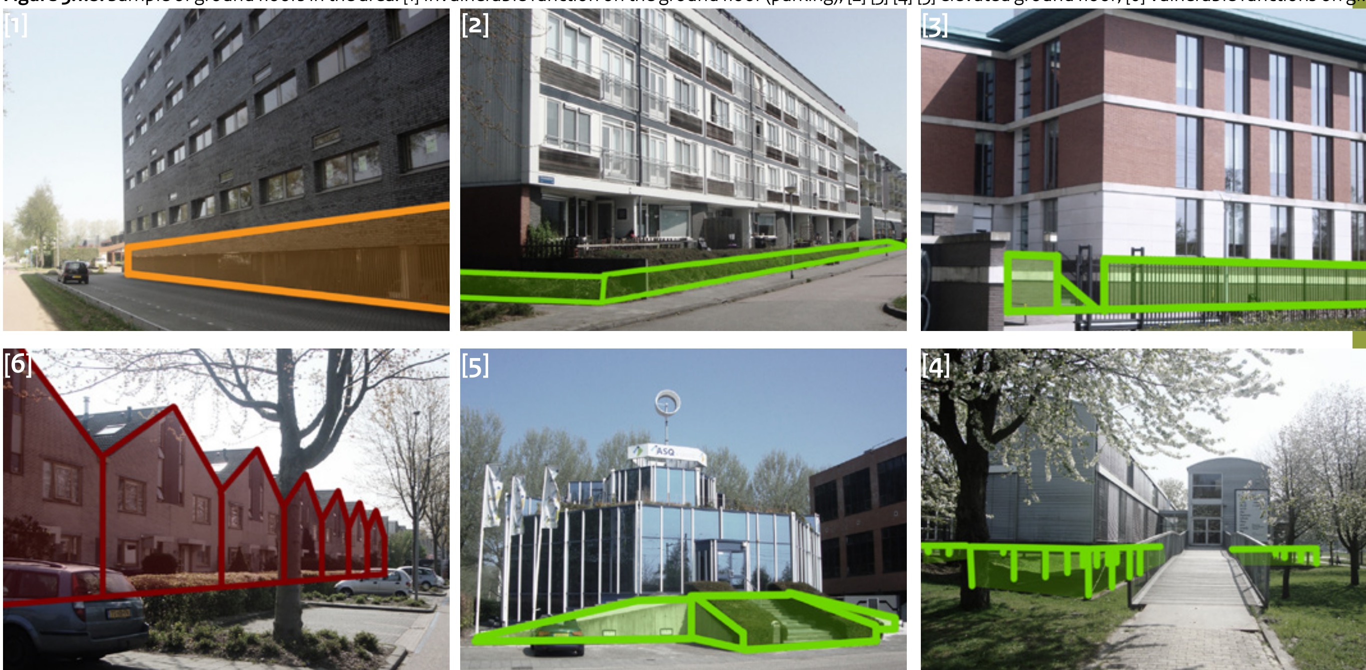


Figure 5.1.9: Large open field in close proximity of city center.

Project scan of the subsurface layer

Archaeology

Regarding archaeology, there are no archaeological sites worth preserving (yet). However, there could be shipwrecks from ancient times in the subsoil, so at some places archaeological research is obligatory (fig. 5.1.10).

Figure 5.1.10: (Expected) archaeological values in the area.

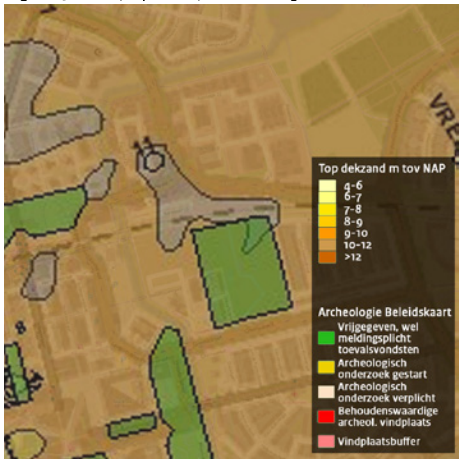
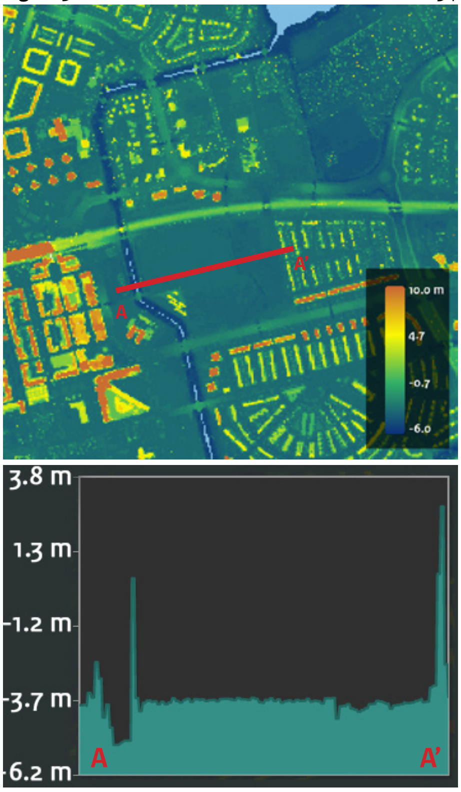


Figure 5.1.11: Ground floor levels in the area; around -3.7 m below NAP.



Aspects regarding constructions

Regarding constructions, the height of the ground level relative to NAP and different ground layers such as Pleistocene and Holocene is important. The area is situated around -3.7 m below NAP. The roads and train track are placed higher. In Almere, al development areas are elevated with 1 m of sand. Land subsidence between 30 and 40 cm until 2050 is expected.

Water system

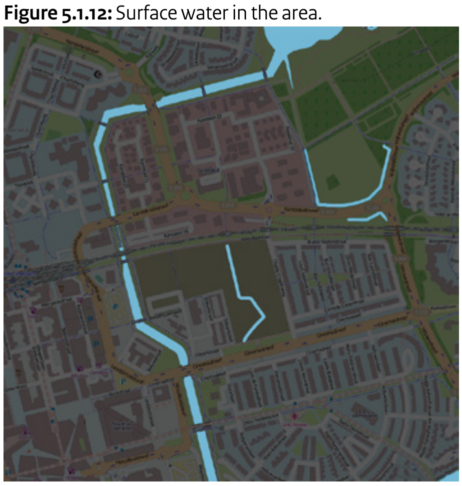
The polder water level of the area is -5.7 m below NAP in the summer. The water is pumped out via the Hoge Vaart at pumping station Colijn.

The water already running through the area (the Stadswetering between Weerwater and Leeghwaterplas) is part of the blue framework as indicated in the municipal structural vision. The green arms form important ecological corridors.

Sustainable energy

The city of Almere is already provided with an urban heating system, so it is the question whether things as geothermal energy and WKO are an option.

Figure 5.1.12: Surface water in the area.



Cables, pipes, foundations and external safety

Cables and pipes are often forgotten in an urban design, but have a strong influence on for instance the road profile and where trees are placed (trees cannot be placed too close to cables and pipes, because of their roots).

Cables and pipes for utility services are placed parallel to the bus lane, as is common practice in Almere. The surrounding neighbourhoods all have a separated sewer system. They are also connected to the city heating network.

Most information has been found in zoning plans (Ruimtelijkeplannen.nl, 2011; Ruimtelijkeplannen.nl, s.d.-a; Ruimtelijkeplannen.nl, s.d.-b), because contacting people at the municipality in a time of holiday has proven not to be fruitful.

Figure 5.1.13: open area in the city center without any function.

source: Google Maps, s.d.

Figure 5.1.14: collage of situation after densication.

source: made after own insights

In the 0-alternative

Maintaining the structure of multiple cores divided by green arms

Almere Stad has relatively many industrial areas in close proximity to the city centre. Some of these areas were once on the edge of town. Because of their location near the centre they will offer more and more space to social and commercial facilities (Gemeente Almere & MVRDV, 2009). This transformation process will continue because of the Schaalsprong.

At the moment, Almere Stad consists for the largest part of a suburban environment with little diversity.

In the current plans for this area, a little densification is planned, mostly in the direct surroundings of Almere Central Station. East of the current shopping area the 'East Lots' are developed into urban residential blocks above shops and amenities (see a free interpretation in figure 5.1.2). Space is reserved for the extension of the high public transport line which runs from Weerwater via Poort and Pampus to the Central Station. The separation of the cores by green arms is maintained.

There are no specific ideas yet about the development of this area.

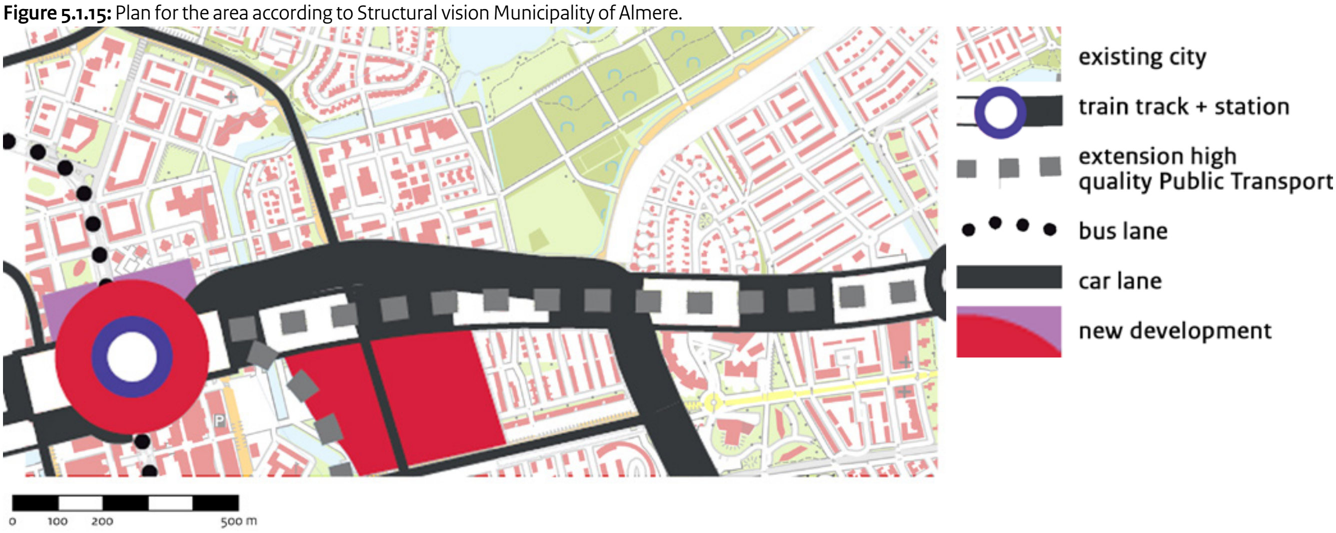
>>> facts & figures

Program:
Facilities, industry, housing, high quality public transport, train station.

Rules applied:
Keep separated cores, high densities.

Stakeholders:
Municipality of Almere, local residents and future residents, project developers, transport operators (among others NS), companies on industrial area 'Randstad'.

Figure 5.1.15: Plan for the area according to Structural vision Municipality of Almere.



source: after Gemeente Almere & MVRDV (2009)

Figure 5.1.16: Impression of guiding river in normal situation.

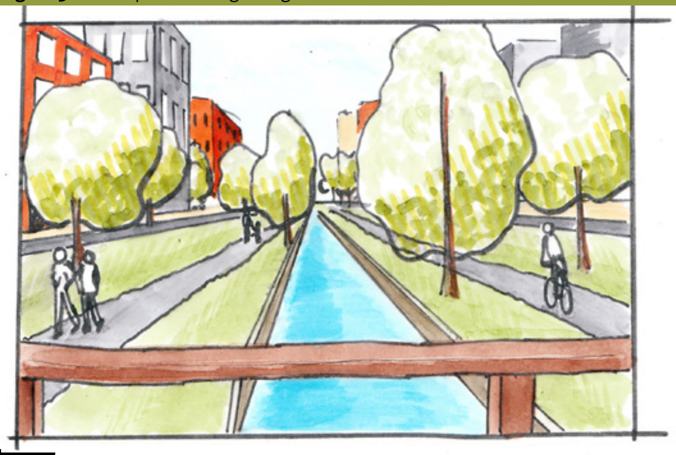
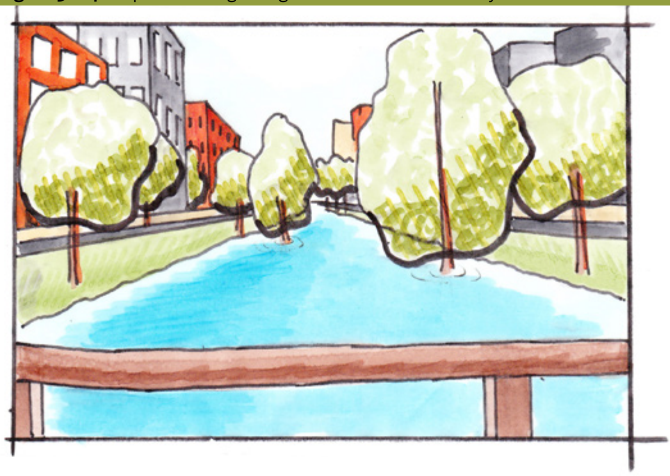


Figure 5.1.17: Impression of guiding river in situation of heavy storm.



In the 1st alternative

Densification along the river that guides water through the area

This key intervention will be the project that will be further elaborated on in the context of the *Aqua Terra* course, so what is described here is only a first design idea.

In the scenario of compartmentalization combined with an unbreachable multifunctional levee and a 'river' that guides water through the city in times of a storm, two planning rules for building are valid in this area: possibilities for water storage and high densities. To strengthen the and functioning of the city and create a highly urban character, densification takes place in the open areas, along the guiding river. The connections with the city centre and shopping district will be strengthened, so that the relation between both areas will be more open. Extra and/or wider passages underneath the train track decrease the barrier effect.

In this scenario, it is assumed that this area will never get wet, so no extra adjustments to the vulnerable functions need to be done.

>>> facts & figures

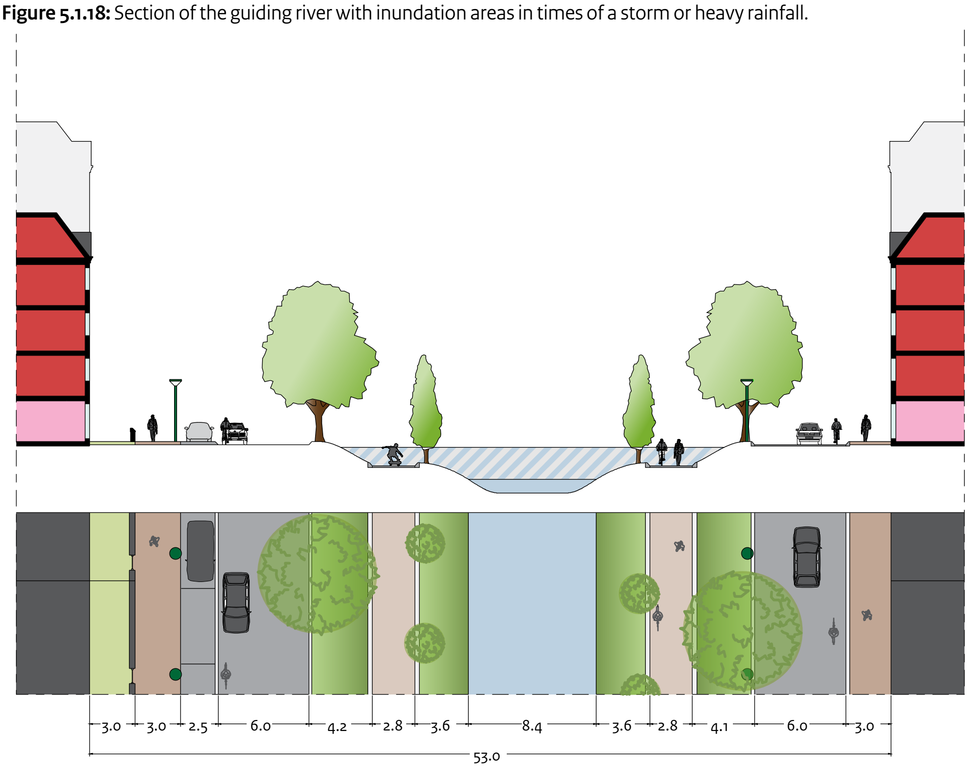
Program:
Dwellings in watery environment with guiding river, mixed with non-housing (facilities, offices, industry), bicycle network with good connections to city centre, high quality public transport line.

Rules applied:
High densities, possibilities for water storage.

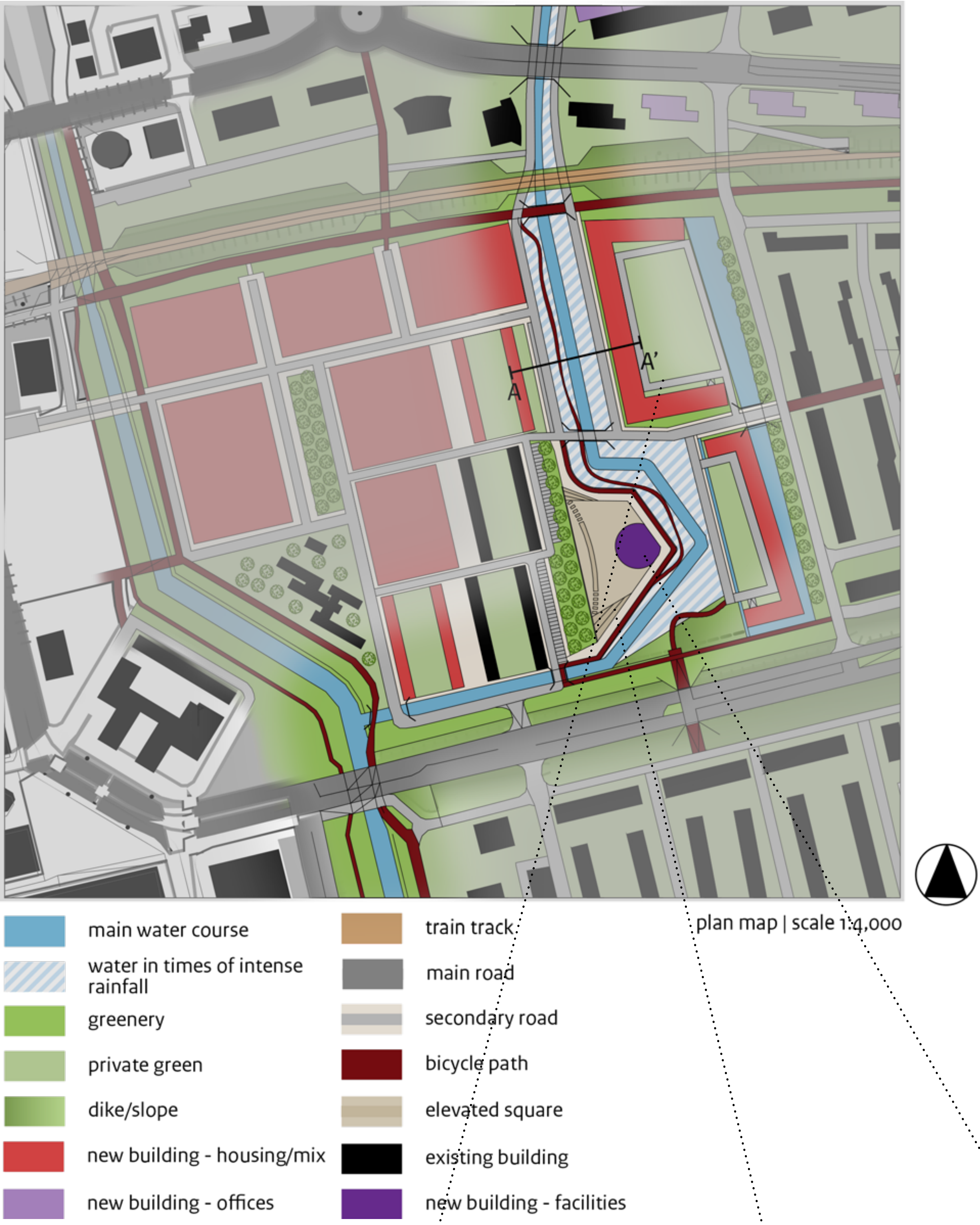
Stakeholders:
Mun. of Almere, local residents and future residents, transport companies.

Aimed effect:
Strengthening/ creating identity of Almere as a real city, with a lively, high ly urban city centre (with mix of functions and high density).

Figure 5.1.18: Section of the guiding river with inundation areas in times of a storm or heavy rainfall.



section AA' | scale 1:500



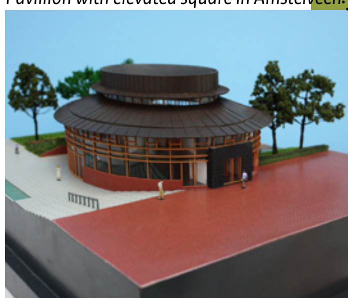
References

Semi-open building block in Alkmaar

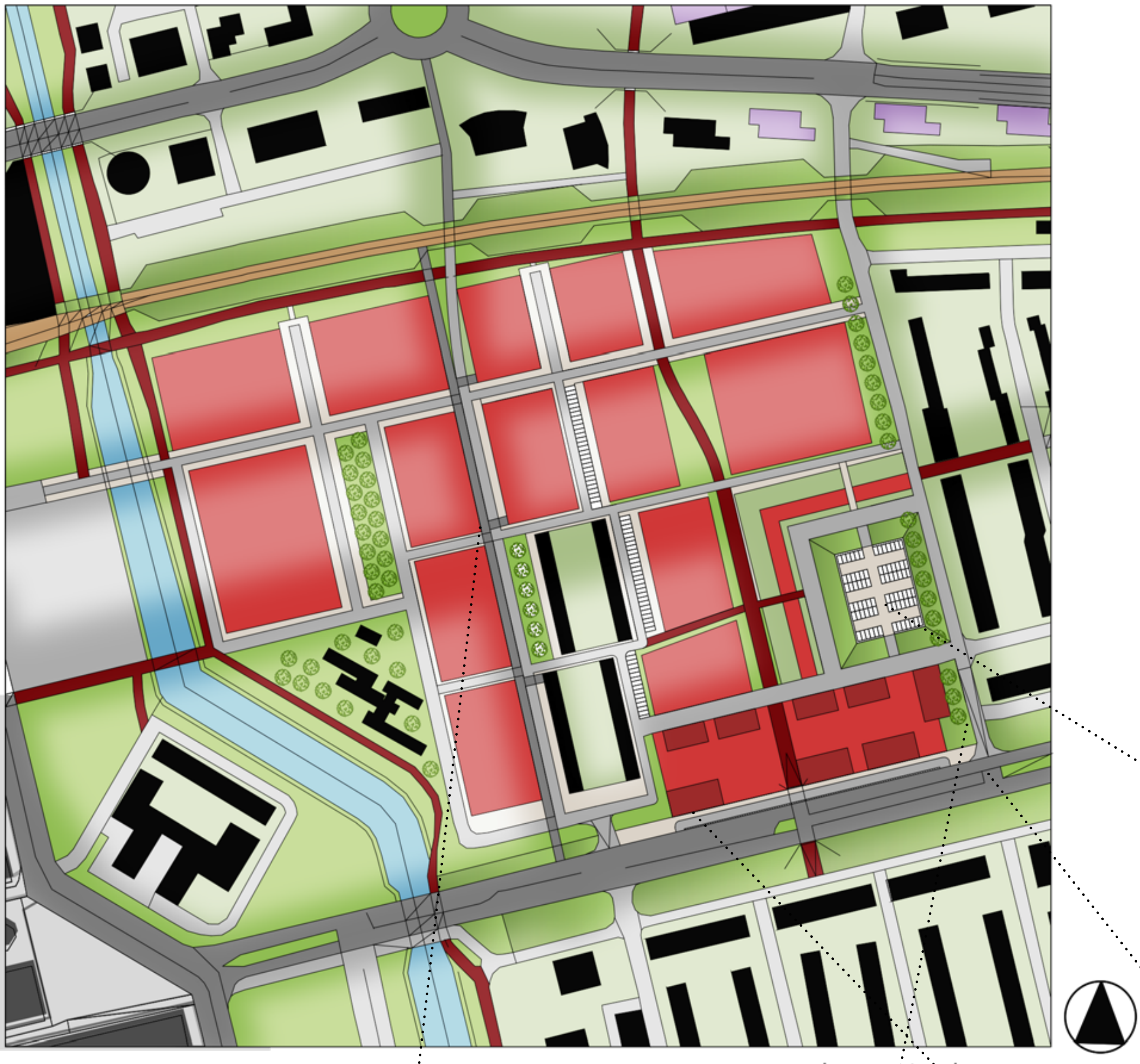
Elevated square of the Beestenmarkt, Delft

source: Flickr.com

Pavillion with elevated square in Amstelveen.



source: Flickr.com



plan map | scale 1:4,000

- main water course
- greenery
- private green
- dike/slope
- new building - housing/mix
- new building - offices
- train track
- main road
- secondary road
- bicycle path
- elevated square
- existing building

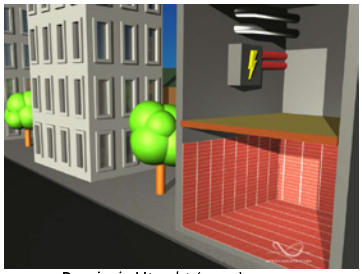
References

source: Provincie Utrecht (2010: 17)

source: www.bannecentrum2013.nl

source: www.bannecentrum2013.nl

source: Provincie Utrecht (2010)



source: Provincie Utrecht (2010)

In the 2nd alternative

Evacuation routes, shelters and floodproof vulnerable functions

In an existing city in this scenario first one should take a good look to the current network: are there any dead end streets, unclear turns? What are current escape routes? What are already high parts?

Locating the vulnerable functions and analyzing the functions on the ground floor is the next step. In this area, the museum is already floodproof, as it is built on poles. For the building of SARA this is more difficult. Here the computers are on the first floor, but the power and electricity supply is on the ground floor. Somehow the water must be prevented from entering the building (see above).

Two main axes can be used as escape route, as they are already a little bit elevated. This can be enhanced. Along these routes, high buildings should serve as landmarks. One perpendicular route, which is also elevated after the reference of Speicherstadt in Hamburg (see left), connects the two main elevated axes.

Then in the neighbourhood places should be made where people could escape to and find shelter. This could be an elevated parking lot, or a building made flood proof.

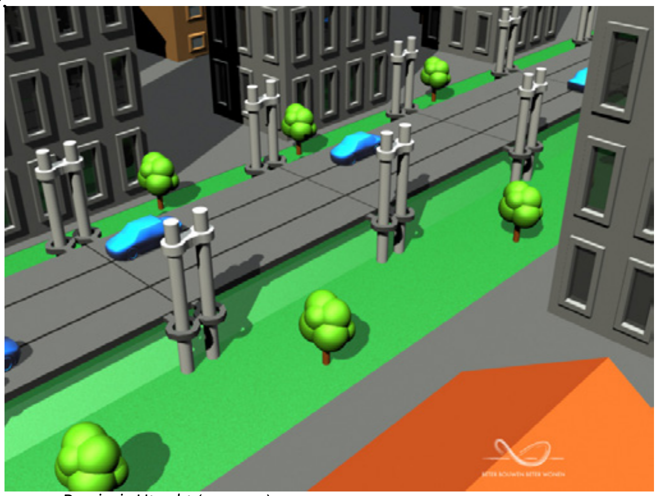
>>> facts & figures

Program:
p.m.

Rules applied:
Mark escape route, steering location choices, floodproof vulnerable functions

Stakeholders:
p.m.

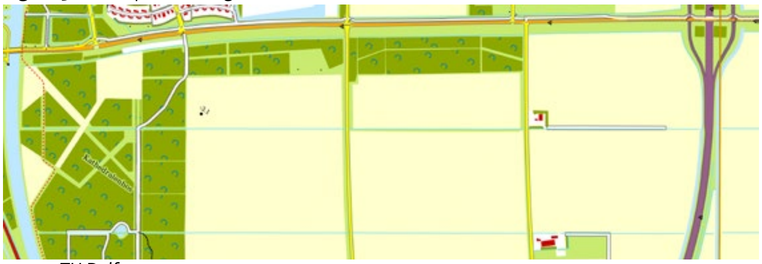
Aimed effect:
Enhance self-reliance.



source: Provincie Utrecht (2010: 53)

source: Provincie Utrecht (2010: 54)

Figure 5.2.1: map of existing situation.



source: TU Delft, 2011

Figure 5.2.2: bird's eye view of polder.

source: Gemeente Almere & Gemeente Zeewolde, 2013: 56,57

5.2 KI 2: Current situation

Ribbon development and grid structures in an open agricultural polder landscape

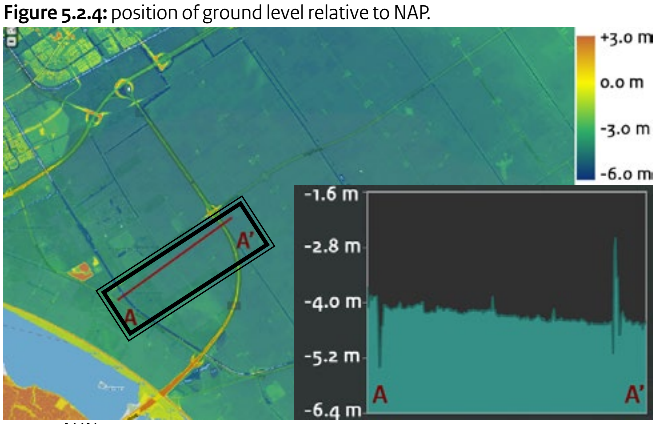
The location chosen for elaboration of the second key intervention is of the new developments in the east. Here, several key elements and rules from the different alternatives come together. It is the place where in the first alternative the river guiding water through the city in times of a storm meets the new development. This development is characterized by the dominant presence of surface water and possibilities for water storage. In the second alternative the area crosses three different zones of the risk zoning, and part of the floodproof zone for vulnerable functions. It is also an area where in the 0-alternative the plans of the municipality can be better; now a lot of program is planned in a deep polder with additional land subsidence and water assignment, without taking extra measures or even thinking about it at all. The deepest part (more to the north) is deliberately not chosen, as it should be avoided to build here.

The area is characterized by a grid structure of large plots of open agricultural land with ditches along them, ribbon development of farms (3 in total), windmills and artificial forest. The area is demarcated by the canal *Hoge Vaart* in the west, and the plots along the highway A27 in the east. The Vogelweg runs from east to west in the area, and there are two axes from north to south: the Goudplevierweg/Paradijsvogelweg and Tureluurweg/Kievitsweg.

Figure 5.2.3: windmills, forest & farm along A27.

source: Bing Maps, s.d.

Figure 5.2.4: position of ground level relative to NAP.



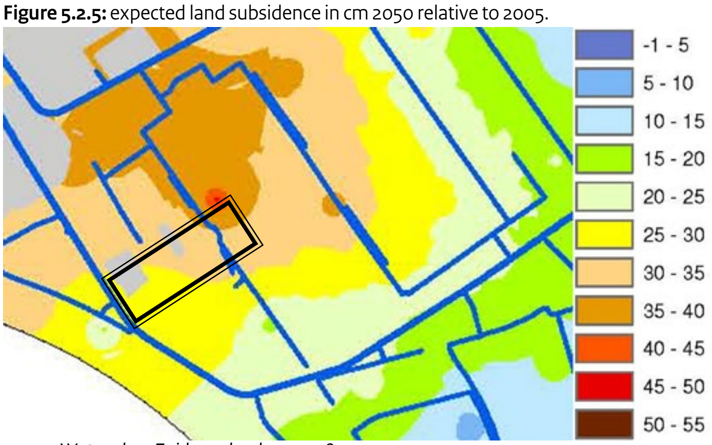
source: AHN, 2012

The ground level height, in meters relative to NAP (Normal Amsterdam Water Level) in the location for the key intervention in Almere East this varies from -3 to -5.5, shown in section AA' on the left.

Figure 5.4.3 shows the differences in height. It shows that the ground level in the south is relatively high, because it is on the edge of the Utrechtse Heuvelrug/Veluwe. The ground level in the northern part is lower - this is where most of the program is planned, and the water assignment is highest (see also appendix 8.5 local analysis of Almere and Southern Flevopolder).

Because it is a relatively new polder, a reasonable amount of land subsidence will occur. Figure 5.3.5 shows the expected land subsidence until 2050. This will vary from 15-50 cm, relative to the ground level in 2005. What stands out is that the part which already has the lowest ground level, will subside the most (35-40 cm until 2050).

Figure 5.2.5: expected land subsidence in cm 2050 relative to 2005.



source: Waterschap Zuiderzeeland, 2010: 185

Figure 5.2.6: Examplary elaboration of the steps of organic development of a standard plot with a higher density.

source: Gemeente Almere & Gemeente Zeewolde, 2013: 74

In the 0-alternative

Organic development in a deep polder

For the whole area the programme is established of which Oosterwold should exist after a period of time. This roughly comes down to 15,000 dwellings, 20,000-30,000 jobs, nature and agriculture on 4,300 hectares of land. This programme has no spatial binding: in the area of the key intervention mainly offices, industry, dwellings, agriculture or nature can be placed, dependent on how the private developers fill in the plots. An indication is given of where a new village center is planned, but no rules as to how this center will be realized (fig. 5.2.7).

A general plot has to consist of 20% built area, 6.5% pavement, 20.5% public green, 2% water and 51% (urban) agriculture. There are specific plots with greater emphasis on green or agriculture, or on higher densities of housing. Individuals, groups and companies decide on the size and shape of the plot themselves. The initiators are expected to commit themselves to the area for a long time.

Everyone constructs their own part of access roads, realizes a part of a continuous network of footpaths and cycle tracks, contributes to the water system and provides for their own energy supply.

Considering the low position of the area, and the expected land subsidence, question is how this enormous amount of freedom regarding water system and construction of infrastructure and buildings will turn out without enough overall guidance (Werkmaatschappij Almere Oosterwold, 2012; Gemeente Almere & Gemeente Zeewolde, 2013).

>>> facts & figures

Program:
Nobelhorst:
- 4,300 dwellings | ~25 dw/ha
- Inner city business area, facilities

Oosterwold:
- 15,000 dwellings | 3.4 dw/ha
- 20 ha offices (<1% of total 4,363 ha)
- 135 ha industrial area (3%)
- 25 ha facilities (<1%)
- agriculture (41%)
- nature (17%)

Source: Gemeente Almere & Gemeente Zeewolde, 2013; Gemeente Almere, s.d.; Gemeente Almere & Ymere, 2011)

Rules applied:
Organic development

Stakeholders:
Mun. of Almere, Ymere, local residents and farmers, future residents, small private entrepreneurs

Figure 5.2.7: combination of the current plans for Nobelhorst and Oosterwold by the municipalities of Almere and Zeewolde.

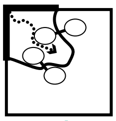
source: Gemeente Almere & Gemeente Zeewolde, 2013: 40, 41, 80; Gemeente Almere, s.d.

Figure 5.2.8: Examplary elaboration of the steps of organic development of an agricultural plot.

source: Gemeente Almere & Gemeente Zeewolde, 2013: 76

References: peninsulas, fluctuating water level in the public space, plank footpath

Source: Nieuwbouw-Nederland.nl, 2013; Palmbout Urban Landscapes, s.d.; TravelGroom, 2011; De Urbanisten, s.d.



In the 1st alternative

A watery living environment

In the scenario of compartmentalization combined with an unbreachable multifunctional levee and a 'river' that guides water through the city in times of a storm, three planning rules for building are valid in this area: a minimum amount of surface water, possibilities for water storage and low densities. Together they result in a watery living environment mainly for housing, with incidental non-housing in terms of facilities, offices and industry. The water and nature and a slow traffic network can be used for recreation. The rural, agricultural character and the grid logic of this area will be followed.

A high quality public transport line in the form of a tram carries the development. Along this axis, the first phase of the development will take place. From there, peninsulas will be created into the polderlake. These peninsulas have inundation areas and the canals are designed in such a way that the water level can fluctuate, in times of heavy rainfall or when water from the Markermeer is let in through the dike with a controllable inlet (see section CC' & plan map).

In the 0-alternative a lot of program is planned here, on the lowest part of the polder, and also the part subject to the most land subsidence coming years. By building in low densities and making water carrier of the design, this problem is solved. A watery environment also contributes to spatial quality, living comfort and possibilities for recreation and nature development.

>>> facts & figures

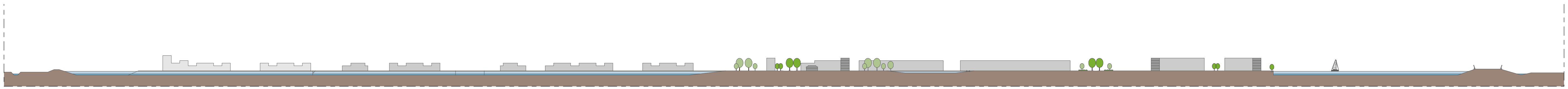
Program:
Dwellings in watery environment, recreational network, incidental non-housing (facilities, offices, industry), open agriculture, high quality public transport line

Rules applied:
Low densities, water storage, high percentage of surface water

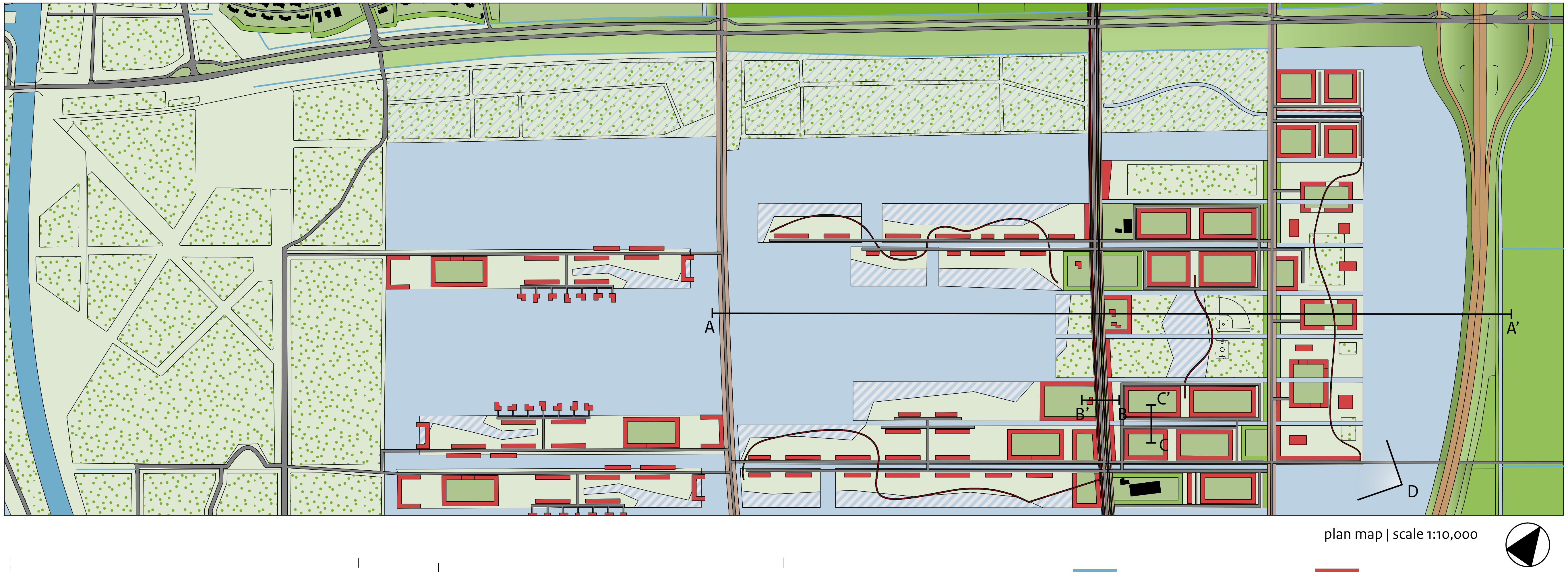
Stakeholders:
Mun. of Almere, local residents and farmers, future residents, small private entrepreneurs

Aimed effect:
Develop the residential and environmental programme in the area in such a way that building in this deep location will not harm the water system
Keep both rural and town identities vibrant, following grid logic

D bird's-eye view of the area

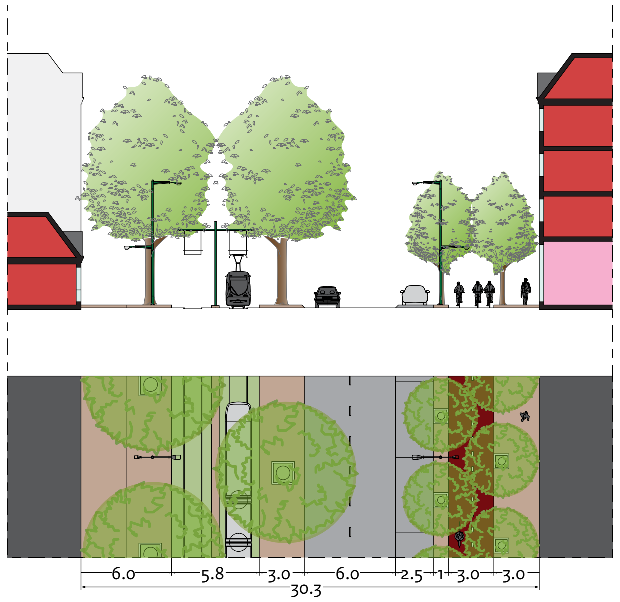


section AA' | scale 1:5,000

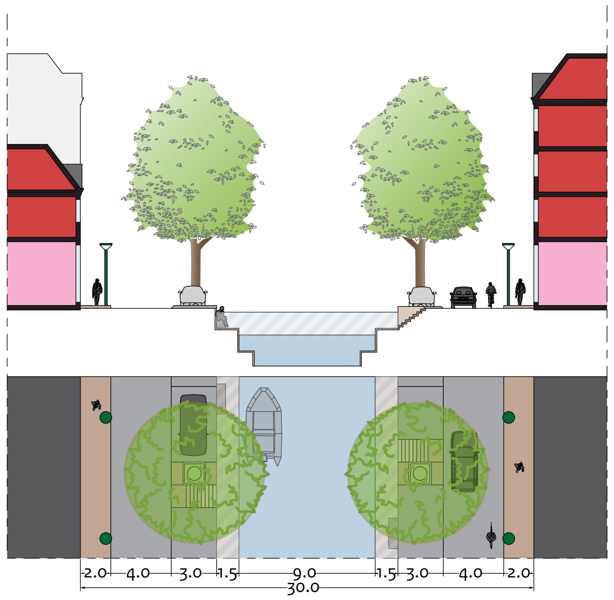


plan map | scale 1:10,000

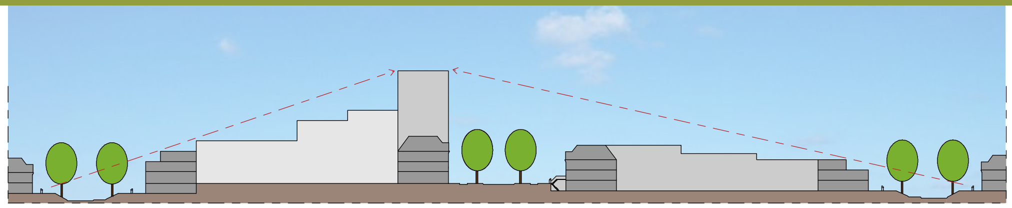
- main water course
- other water
- water in times of intense rainfall
- pier
- park
- greenery
- private green
- new building
- existing building
- highway
- main road
- tram
- bicycle path



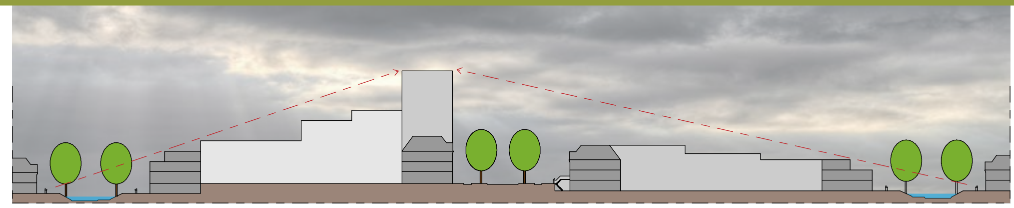
section BB' | scale 1:500



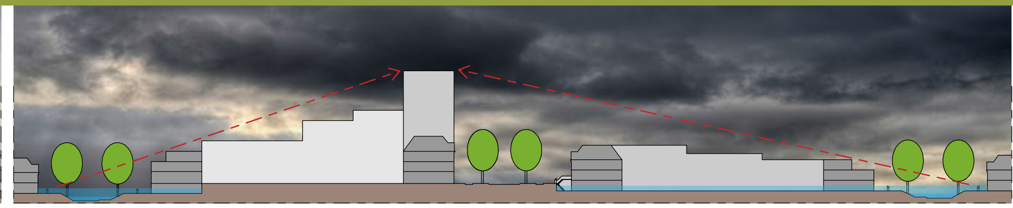
section CC' | scale 1:500



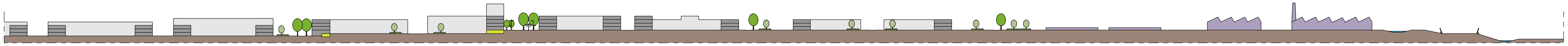
section AA' | scale 1:1,500 | normal weather



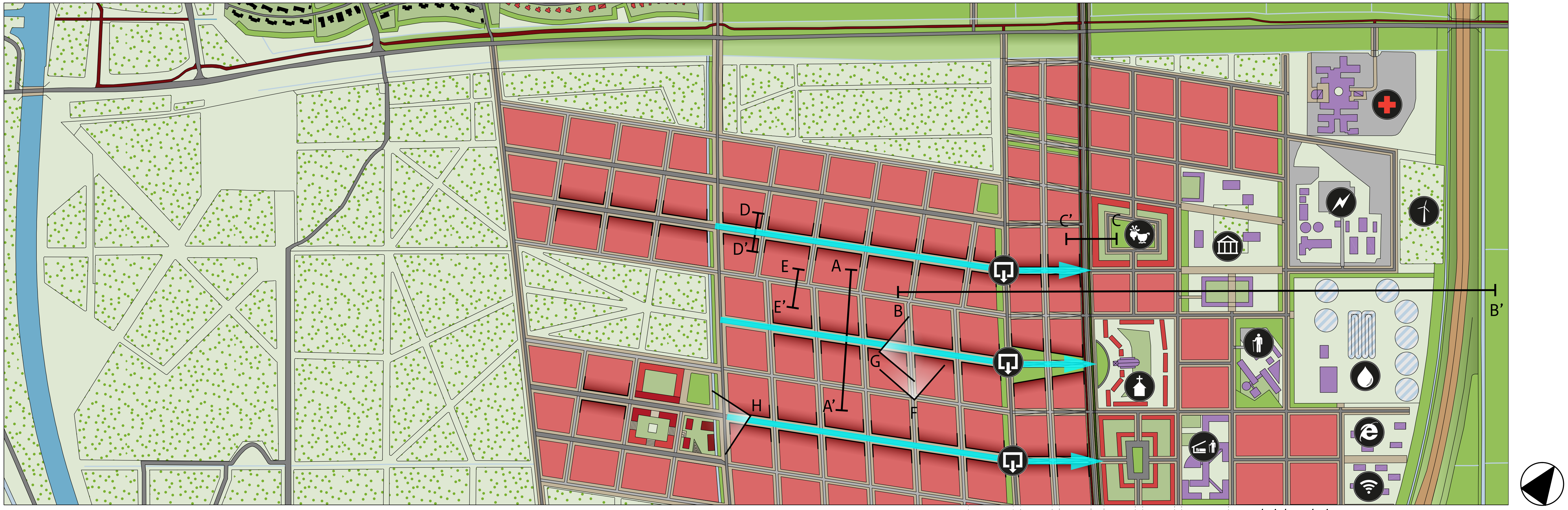
section AA' | scale 1:1,500 | rainfall; water led throug the public space

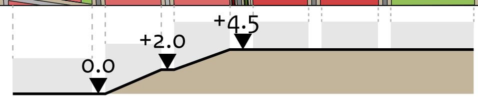


section AA' | scale 1:1,500 | heavy storm; escape route still accessible



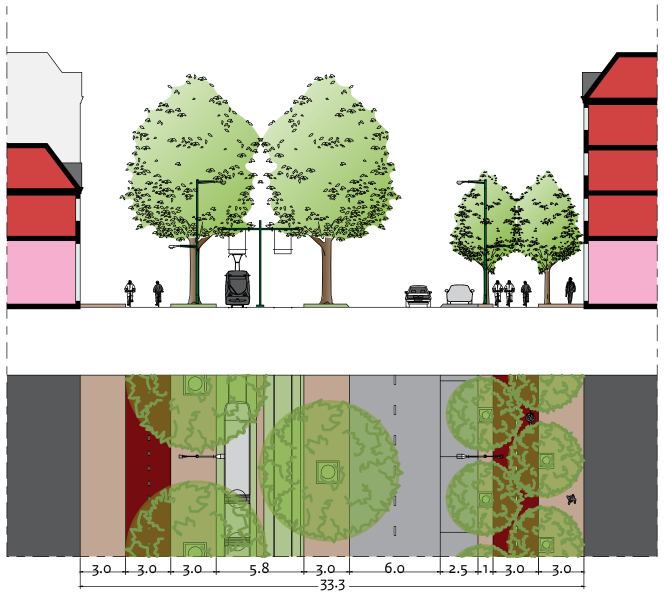
section BB' | scale 1:4,000



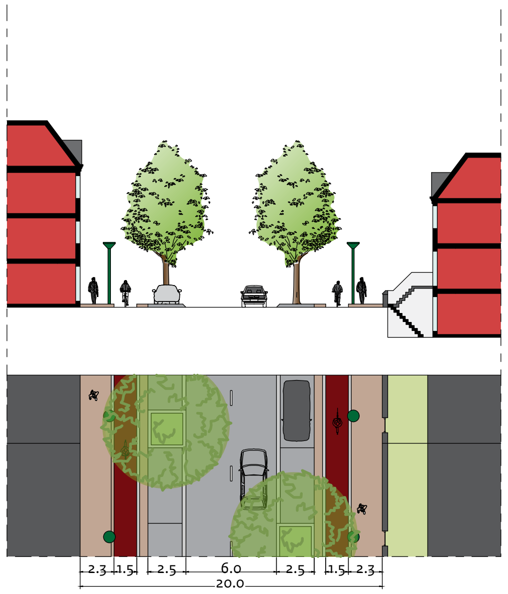


area height, relative to ground level (vertical scale exaggerated)

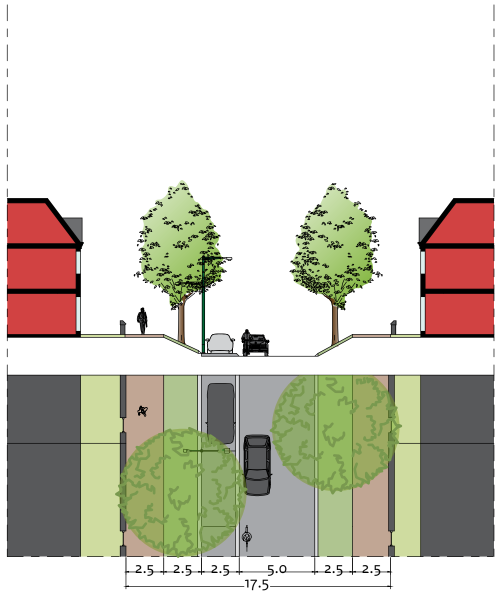
plan map | scale 1:10,000



section CC' | scale 1:500



section DD' | scale 1:500



section EE' | scale 1:500

- main water course
- other water
- park
- greenery
- private green
- existing building
- vulnerable & vital function
- museum
- church
- hospital
- home for elderly
- primary escape route
- new building 2-3 layers
- new building 4-6+ layers
- highway
- main road
- secondary road
- tram
- bicycle path
- water supply
- electric supply
- sustainable energy generation
- internet hub
- petting zoo

F | view from secondary roads towards red buildings indicating primary escape route

G| Along a primary escape route

In the 2nd alternative

A flexible grid and floodproof zone

The essence of this scenario is that the arrival of a flood wave in urbanized area is delayed and that inhabitants are provided with the opportunity to safe themselves (self-reliance). To do this, the impact of a flood will be changed through adjusting exposure and vulnerability. This is done by an elevated construction of vulnerable and vital objects such as hospitals and electricity supply.

Evacuation (self-reliance) is promoted by simple adjustments in the street pattern and routing. By using a grid, there will be no funnel effect by roundabouts, dead ends or blind curves, so people who want to escape in case of a flood can find their way easily. Some roads have to be constructed on a higher level, to give inhabitants more time to evacuate (see images below and section AA'). These primary escape routes are marked by higher buildings. Also, there has been made use of colour. The buildings along the primary escape route all consist of a brightly coloured brick, so that in times of a flood, people should "follow the red buildings" (see images above). To prevent the plan from becoming too monotonous, the building islands in the grid can be filled in in a flexible way, with a park, a square, and other functions like offices or facilities, or by playing with building volumes (see below and fig.5.2.9).

Risk zoning forms the basis of urbanization. In relation to the 0-alternative, in the second alternative a larger area will be kept free from program and people, so that there is a high certainty that the number of victims is limited. The economic damage on the other hand may rise to the maximum. However, the vulnerable and vital functions and objects will be safeguarded from a flood, and thus have no damage.

>>> facts & figures

Program:
Dwellings, incidental non-housing (facilities, offices, industry), high quality public transport line, vulnerable & vital functions (hospital, AWZI, sustainable energy supply, datacenter, museum, home for the elderly)

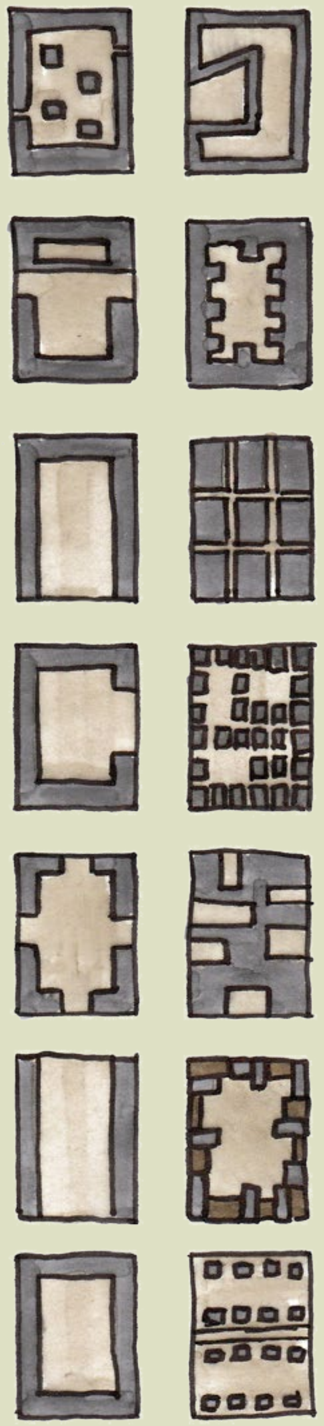
Rules applied:
No building in immediate and deep risk zone, skew grid, high buildings indicate primary escape route, steering location choice of vulnerable and vital functions, elevated escape area

Stakeholders:
Mun. of Almere, local residents and farmers, future residents, inhabitants of Almere dependent on working vital functions, owners of vulnerable and vital functions

Aimed effect:
Delay arrival time of water by skew grid, improve evacuation by marking the primary escape routes by high buildings and by use of coloured materials ("follow the red buildings"), reduce amount of program and people in high risk zones

H| Elevated primary escape route stays dry in times of flood

Figure 5.2.9: Possible elaborations of grid.



source: based on own ideas and Heeling et al. (2006: 131)

F | view from secondary roads towards red buildings indicating primary escape route

G| Along a primary escape route

In the 2nd alternative

A flexible grid and floodproof zone

The essence of this scenario is that the arrival of a flood wave in urbanized area is delayed and that inhabitants are provided with the opportunity to safe themselves (self-reliance). To do this, the impact of a flood will be changed through adjusting exposure and vulnerability. This is done by an elevated construction of vulnerable and vital objects such as hospitals and electricity supply.

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Risk zoning forms the basis of urbanization. In relation to the 0-alternative, in the second alternative a larger area will be kept free from program and people, so that there is a high certainty that the number of victims is limited. The economic damage on the other hand may rise to the maximum. However, the vulnerable and vital functions and objects will be safeguarded from a flood, and thus have no damage.

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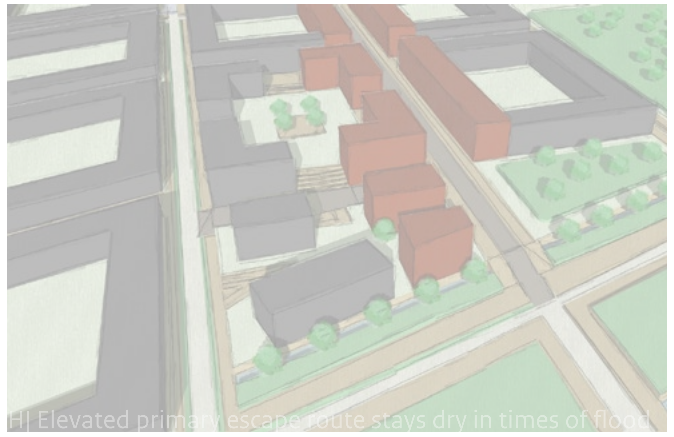
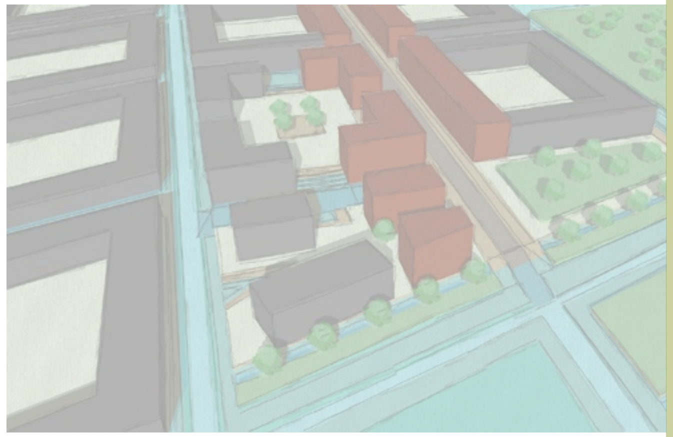




H| Elevated primary escape route stays dry in times of flood

Land subsidence in the polder, Vogelweg; source: Streng, 2012.

6. CONCLUSIONS AND RECOMMEN-DATIONS

Land subsidence in the polder, Vogelweg; source: Streng, 2012.

Conclusions and recommendations

The best balance

This graduation research shows that choosing the most suitable balance between the three layers of multi-layer safety (MLS) will always be a human consideration. The consideration is the result of weighing the different aspects of the framework for comparative assessment that was developed for this graduation project, based on case specific circumstances; there is no rule of thumb.

The test case of Almere 2.0 in the Southern Flevopolder learns us that purely from a water safety perspective, in terms of costs related to gained economic damage reduction, the 0-alternative of stronger/more flood defences around the Southern Flevopolder proves to be most cost-efficient. Both alternatives generated for the design however show that working through the different layers of multi-layer safety (MLS) not only increases water safety, at the least with regard to mortality risk, but also provides many opportunities to increase spatial quality, flexibility, to anticipate on other climate challenges.

How this conclusion has been reached, is summarized below.

The thesis deals with three questions. First, a theoretical framework deals with "what is *imaginable*" in terms of interventions in the three layers of MLS. Second, an analysis of the project location resulted in different alternatives for the Southern Flevopolder and designs of key interventions which point out "what is *possible*". Third, the framework for balancing the proposed measures based on multiple criteria applied to the three alternatives provides an answer to "what is *desirable*" in the Southern Flevopolder. This process is shown in figure 6.1.1.

What is imaginable in terms of interventions?

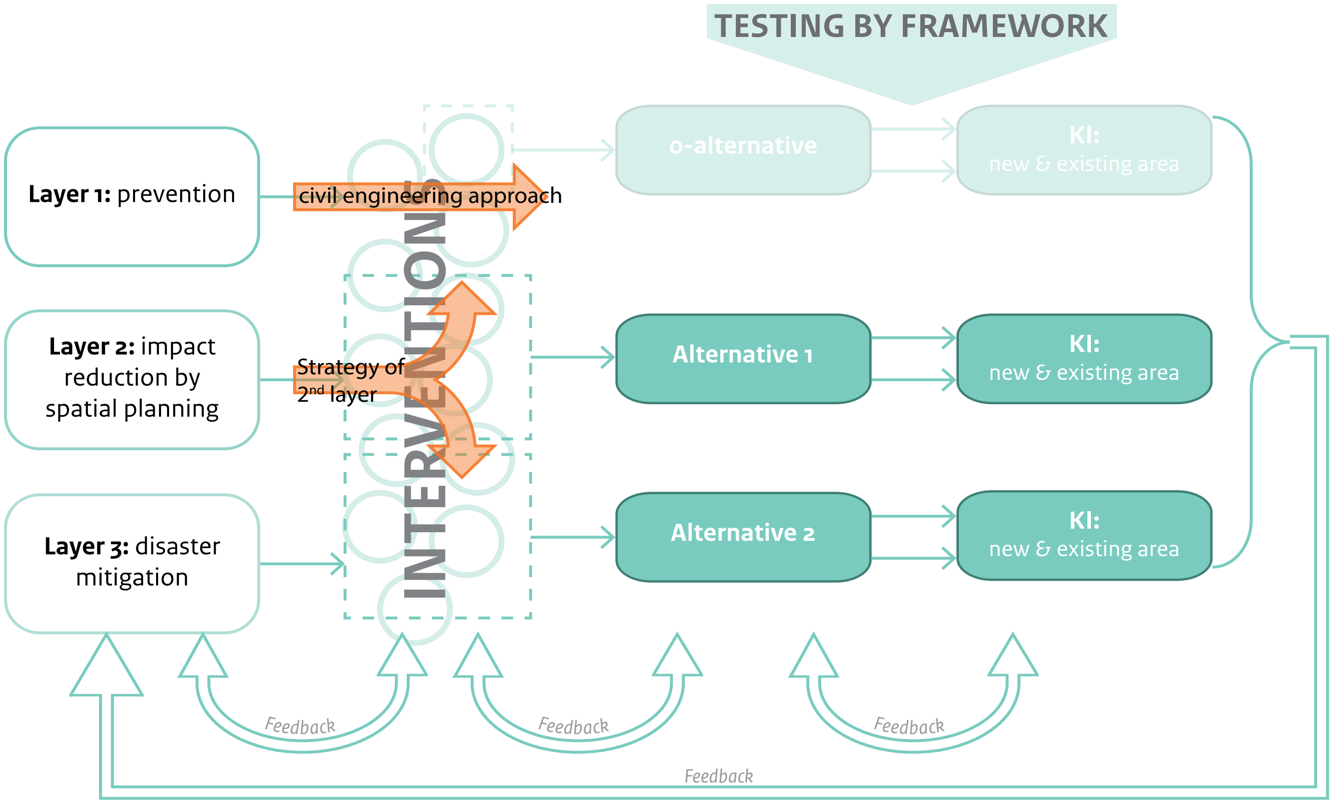
To determine which interventions can be taken to reduce flood risk, in this thesis firstly all urban and spatial factors are examined which influence physical water safety. Water safety depends on flood characteristics: frequency, arrival time, water depth, flow velocity, ascent rate, water pressure, flood duration and unexpectedness. All these characteristics are influenced by the urban and spatial structure of the flooded area. Besides that, socio-economic value, the arrangement of the polder, and the way rescue workers and inhabitants will deal with a flood play a role, or rather these elements together form the vulnerability of flood risk.

The result is an overview of possible interventions that can serve as building blocks for different alternatives for new developments and re-development areas with a high flood risk, which cope with flood risk in a different way (figure 3.1.6). This study, though applied in Almere, therefore has a generic value because of the overview of 'building blocks' and their advantages and disadvantages.

These interventions know a wide variety of scale, approach and intensity and can be classified by layer of MLS they operate on. The measures in the layer of prevention (1) can be both outside and within the polder. Impact reduction (2) and disaster mitigation (3) have the same approach: they either reduce exposure or vulnerability.

When MLS is viewed through the spatial interventions, combinations arise almost automatically and thus combinations of different layers. This is a good approach for a broader perspective than economic water safety alone, and can also be viewed as the strategy of the second layer of impact reduction by spatial planning: when taking this layer as a starting point to work from, layer 1 and layer 3 are automatically integrated because all possible interventions are considered. This in contrast to the common civil engineering approach, in which only layer 1 is considered to be necessary (orange arrows in fig. 6.1.1).

Figure 6.1.1: The process followed: interventions derived from the three layers of MLS, combined into alternatives or strategies and key interventions, which are tested by the framework for comparative assessment. Working out every step leads to insights regarding previous steps, and evenatually regarding the best balance between the three layers.



What is possible at this testing location?

In spite of the wide range of alternative interventions available, they almost never are implemented in plans. The fact that some interventions do not take the step from theory to practice, is because of administrative, economic, aesthetic, but also practical reasons. Some interventions are just not suitable for a certain location. The applicability of an intervention also differs for existing built areas compared to new developments. Other interventions are rejected after a political and economic consideration. The interests of stakeholders play an essential role.

In the current discourse there is still very much a division between 'believers' and 'non-believers' of MLS. The traditional approach of prevention by constructing and reinforcing dikes is still very present. Raising dikes will most likely always be the most cost-effective way from an almost solely economic perspective purely focused on prevention of floods, but it is the challenge to look for measures in the other layers that also reduce flood risk in terms of victims, and seek an interesting link with other climate issues such as heat stress and water nuisance as a result of more intense precipitation. Other interventions can also provide an interesting living environment, increasing spatial quality (e.g. more contact with the water, instead of dikes acting as a barrier between water and man).

The research done for this thesis shows that for a deep, inner dike urbanized polder such as the Southern Flevopolder, three strategies are possible, which emerged from combinations of spatial interventions, and resemble the two ways of moving through the scheme of figure 6.1.1 mentioned in the previous section. First, the 0-alternative continues current practice of a pure preventive strategy. Only the decisions already made, regarding for instance the Schaalsprong Almere 2.0, are taken into account. The first alternative strategy combines measures from MLS layers 1 and 2 into an alternative of a multifunctional unbreachable dike, compartmentalization and water storage. The second alternative strategy focuses on full evacuation of inhabitants, and on flood proofing vulnerable and vital functions and infrastructure – interventions in layer 2 and 3 of MLS.

An example of placing mounds in a clever way, transferring an ordinary dike into a (multifunctional) unbreachable levee in alternative 1, shows the added value of working through the layers of MLS compared to layer 1 versus layer 2 and 3. Alternatives which only work in a single layer have less added value than alternatives where interventions in several layers are joined together, as is the case in the alternatives developed in this study (layer 1+2, layer 2+3). **In general it can be concluded that when operationalizing the spatial interventions into strategies, to make**

these strategies as optimal as possible, looking for synergy between the measures is essential. Multi-layer safety offers a way to order and organize the measures and have them connected better to a clear overall plan, like is done in this thesis.

What is desirable?

A proper comparative assessment

When it comes to making a proper comparative assessment, the method used for this thesis – a combination between a scenario approach with different alternatives and a framework for comparative assessment on multiple criteria – proved to work well.

To determine the most desirable alternative for the Schaalsprong Almere 2.0, and thus *the best balance between the three layers of MLS that enhance the quality of the built environment and physical water safety,* the three alternatives have been evaluated by the framework for comparative assessment that has been created in the purpose of this study. Based on a multi-criteria analysis each alternative is given a score on aspects like cost-efficiency (from an economic perspective), flexibility, spatial quality, governmental feasibility and possibilities to link to other (climate) challenges. The result of the comparative assessment, based on expert judgement, is shown in figure 6.1.2. **Choosing the most suitable alternative will always be a human consideration of these aspects, based on case specific circumstances. It depends on how much weight is assigned to the different criteria, which is different for policymakers, scientists, designers and inhabitants; there is no rule of thumb.**

Alternative 1, a combination of a multifunctional unbreachable dike, compartmentalization and water storage, **might cost a bit more, but is incredibly attractive, effective regarding both economic and social damage, and also sustainable. It means an upgrade of the concept Almere: a much more pleasant and safer living environment.**

Alternative 2, a combination of accommodating full evacuation of inhabitants and flood proofing vulnerable and vital functions, **is less expensive, also potentially provides opportunities for enhancing spatial quality and flexibility, but is difficult to implement in terms of governmental feasibility and not without risks;** this alternative for instance always requires human action, which brings along a huge uncertainty. It reduces the number of victims significantly, but economic damage will rise to maximum (same as 0-alternative, except for vulnerable and vital functions).

Alternative 1, considering all the different criteria and not only looking at cost effectiveness in terms of water safety, therefore in my opinion provides *the best balance between interventions in the built environment that enhance physical water safety in the Southern Flevopolder.*

Realization costs for interventions in safety layer 2, such as the multifunctionality of the unbreachable dike and measures to make buildings floodproof, are higher than the (mostly administrative) interventions in layer 3. However, in the case of unbreachable dikes, especially when combined with a compartmentalization strategy, the risk of damage is reduced significantly, whereas in alternative 2 the economic damage may rise to maximum. These additional costs of alternative 1 can also eventually be (partially) recovered from future residents that will live on the multifunctional dike. Both alternative 1 and alternative 2 have a low sensitivity to uncertainties regarding climate change and regarding probabilities of failure – a great advantage compared to the 0-alternative. Alternative 1 is also not sensitive to uncertainties regarding socio-economic changes and human behaviour. However, interventions in the third layer of MLS (alternative 2) strongly depend on self-reliance, which can be efficient, but always requires human action, and thus involves a great uncertainty. Alternative 2 is also more dependent on the realization of the Schaalsprong, and for example on not lowering the A6, whereas in alternative 1, regarding water safety is does not matter if the A6 will be lowered and cohesion between Almere Stad and Almere Haven can take place, because in the compartment protected by the unbreachable dike, the area can be filled in however one pleases.

Governmental feasibility seems low for alternative 1 and 2, because in every case current practice has to be altered, more people and parties are involved, and there might be a shift of responsibilities. However, when nothing is done in current practice, and water management and spatial planning policy will remain separated, no awareness for climate change problems of citizens and administrators will be raised, and problems will always be shifted to another location or another party (now or in the future). The alternative measures in alternative 1 and 2 make sure that the parties involved have to go talk to each other, increasing awareness and adaptability of cities in the future.

For all three strategies, a structural vision and an elaboration of a key intervention is made, as part of the graduation design project. Those key interventions are two locations, one in an existing area, and one as part of a new development in the polder. The key

Alternative		Costs of realization	Risk reduction		Quality of the living environment	Uncertain future: future-proof	Governmental feasibility	Link to other (climate) challenges
			Economic damage	Social damage (victims)				
0-alternative: prevention		0	0	0	0	0	0	0
Alternative 1: unbreachable dike, compartmentalization & water storage	1a: comp. dike 1 m	0/-	0	0/+	+	++	-	++
	1b: full compartmentalization	-	++	++	+	++	-	++
Alternative 2: flood proofing and full evacuation	2a: floodproof zone new development	+/-	0	+	+/-	0/+	-	0/+
	2b: floodproof zone extended	+/-	0	+	+/-	0/+	-	0/+

Figure 6.1.2: Final assessment of the three alternatives.

interventions are twice an exploration to determine preconditions from MLS and the alternatives. Lessons derived from this are that when applying multi-layer safety interventions in a new area, with a 'tabula rasa', it is easier, because you can realise whatever you want. Interventions in the existing fabric are more difficult, and also more expensive. Regarding preconditions derived from the alternative strategies, is can be concluded that inside the compartment protected by the multifunctional unbreachable dike of alternative 1, no real constraints are attached to the elaboration of the key interventions regarding water safety. Spatial planning can be 'business as usual. Alternative 2 however delivers odd preconditions and many design tasks to design with; this alternative really means "doing something different".

Recommendations

When dealing with urbanization in flood prone areas, it is recommended to go through the scheme of 6.1.1 starting at layer 2, and to always assess solutions from a broader, more integral perspective, not only from a cost-benefit analysis. This thesis shows that combining interventions can create synergy and added value for spatial quality, flexibility in relation to future uncertainties, and positive links with other assignments.

Not only heightening or reinforcing dikes, but also experimenting with other ways of urbanization, emergency plans and investing in risk communication are possible solutions. Flood proof buildings in urban areas reduce the damage of flooding, and can at the same time serve as shelters. A link with sustainability thinking could work as a catalyst, because also for this purpose buildings can be made self-sufficient. Early flood warnings and improved risk communication make people better prepared to deal with floods. The current possibilities for evacuation in the Netherlands are limited. This would be different if in the future there were better calamity plans, more shelters and refuges. Not only the evacuation before or during a flood itself is important, also the accommodation of refugees after. To give an example: the flood duration of the Southern Flevopolder will be over a year, so eventually all people have to be evacuated out of the area. Rebuilding the whole city might take some time as well, so what to do with the people that are banned from the area for years? Should there for instance be building plans to bring these 350.000 people to high and dry grounds?

The alternatives proposed in this study are of course not exhaustive. Compartmentalization combined with an inlet near Oostvaardersplassen might also be a good strategy. The rural area will then get wet more frequently by water that occasionally comes over the dike, but it will never fill like a bathtub as is the case in the 0-alternative

Given the present national standards on flood safety, in the Netherlands the legal conditions for implementing multi-layer safety are not yet optimal. Because of the focus on an economic cost-benefit perspective, and because safety standards are set based on the probability of exceedance, and not on the actual flood risk, little space is left for choosing any alternative (not additional) measures. Therefore, the contribution to the reduction of the risk must be able to be quantified, and the exact responsibilities of different parties involved in taking measures in layers 2 and 3 has to be established.

A lot of knowledge is already available to different authorities responsible for policy on spatial planning and water management, but this knowledge is hardly shared. Difficulty is that responsibilities and money are often divided between different actors, but **a clear communication of knowledge and interest can lead to interesting new solutions that link these interests, and to innovative ideas that integrate spatial planning and water management in the future.**

As pictures at the beginning of this chapter show: it is going to be a bumpy ride, but it is worth it.


Sluice between Lange Wetering/Hoge Vaart and Almere-Haven

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View from Eemmeerdijk on a foggy winter morning

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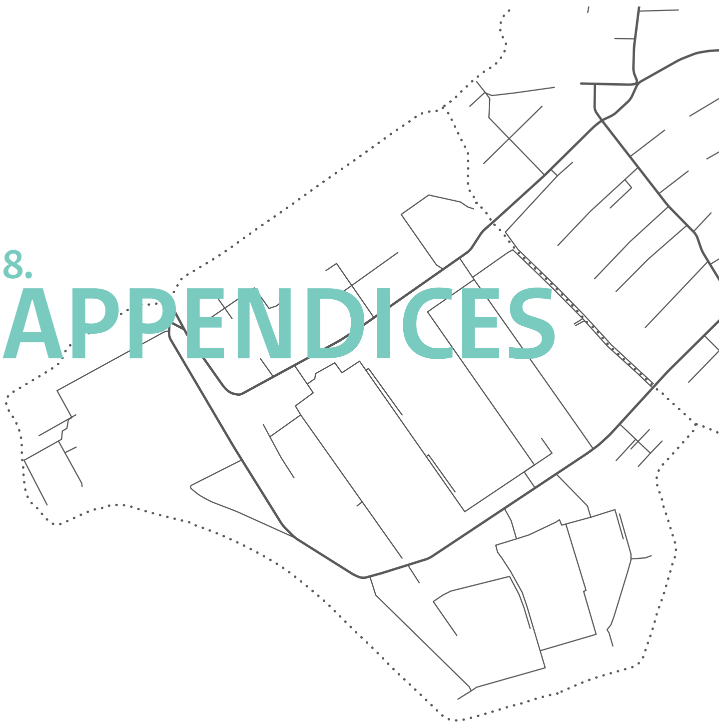
Park “De Wetering” in Zeewolde

8.
APPENDICES



“Sea Level”, by the American a

rtist Richard Serra, indicates the water level as it would have been without the dikes; situated in park "De Wetering" in Zeewolde.

8.1 List of people consulted

Figure 8.1.1: List of conducted interviews and discussions between October 2012 and May 2013

	Institution	Name	Function	Date
General	Deltares	Karin de Bruijn	Hydrologist	24-01-2013 12-03-2013
		Frans Klijn	Senior specialist river basin management	12-03-2013
	RHDHV	Marijke Ruitenbeek	Senior advisor water management - Rivers, Deltas & Coasts	27-11-2012 14-03-2013
	PBL	Like Bijlsma	Researcher urban area	19-02-2013 16-05-2013
		Arjan Harbers	Researcher urbanism	16-05-2013
		Kersten Nabielek	Researcher Urban Developments	16-05-2013
		Nico Pieterse	Senior researcher	18-02-2013 02-04-2013
		Joost Tennekes	Political scientist	06-05-2013
	TU Delft	Frans van de Ven	Associate professor Urban Water Management	23-05-2013
Flevopolder	Deltares	Nathalie Asselman	Senior advisor	03-11-2012 28-03-2013
	PBL	Bas van Bemmel	Researcher Spatial analysis and Modelling	17-04-2013 14-05-2013
		Arno Bouwman	Policy researcher/GIS expert	
		Gusta Renes	MKBA RRAAM	31-01-2013
		Bart Rijken	Policy researcher	17-04-2013 14-05-2013
	Province of Flevoland	Jeroen Doornekamp	Policy maker water safety	04-12-2012
		Martin Nieuwjaar	Former policy advisor Province of Flevoland, current: Waternet	21-03-2013
	Water board Zuiderzeeland	Joan Meijerink	Policy advisor	28-11-2012
	Security region Flevoland	Mr. M. Hupsel	Team leader Multidisciplinary Preparation	05-02-2013
		Mr. R. Walters	Head crisis management and safety bureau	05-02-2013
	Municipality of Almere	Peter Otten	Senior advisor environment and water	22-10-2012 09-01-2013
IJburg	Municipality of Amsterdam	Ilse de Jong	Engineer at Dienst Ruimtelijke Ordening Amsterdam	27-11-2012
Zuidplaspolder	HHSK	Hilde Westera	Project manager HHSK Zuidplaspolder	

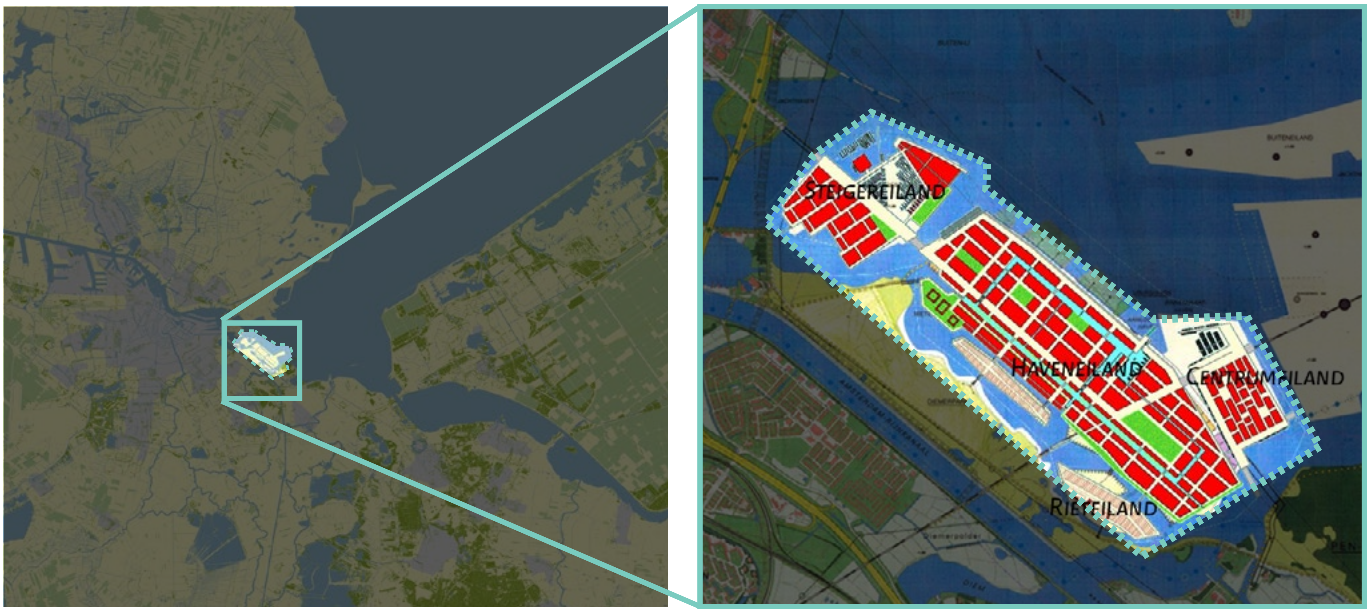
8.2 Demarcation of the project area

Figure 8.2.1: Map showing the demarcation of the Southern Flevopolder and important names of cities, embankments and waters in the area.


Construction of land for IJburg by sand nourishment, source: De Jong, 2012

8.3
CASE STUDIES

Zuidplaspolder near Moordrecht



8.3.1 Amsterdam | IJburg Haveneiland - Steigereiland

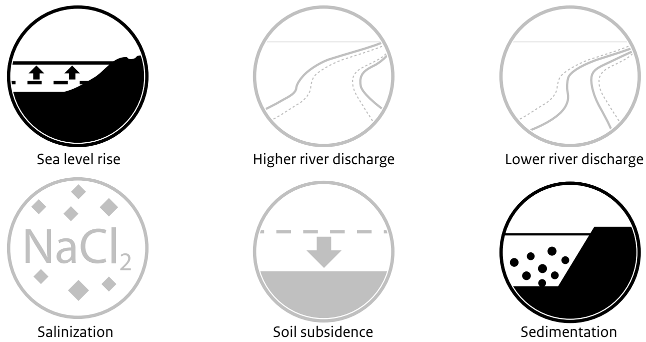
IJburg is a relatively new part of Amsterdam. The first plan for this eastern expansion towards Almere arose around 1980, but the final decision was made in 1996 by the Municipality of Amsterdam. The plans have led to a lot of protest by environmental parties, that did not want the ecology of the IJmeer/Markermeer to be ruined, but eventually the construction has started.

The creation of IJburg takes place in two phases. The first three islands, Steigereiland, Rieteiland and Haveneiland, received their first inhabitants in 2002, and nowadays have 15.500 inhabitants. The second phase consists of the construction of Centrumeiland, Middeneiland, Strandeiland and Buiteneiland, which will take more than ten years (Projectbureau IJburg, s.d.). Eventually, there will be 18,000 dwellings for 45,000 inhabitants, with densities between 30 and 70 dwellings per hectare. This means an urban to highly urban area (Projectbureau IJburg, 2000; Gemeente Amsterdam, 2004).

The islands were created by sand from the shipping channel, which also takes away excessive sedimentation in this channel. The open water of the IJmeer/Markermeer plays a special role, because IJburg is an outer dike artificial island. Situated dangerous open water, waves can rise a few meters in times of north-eastern wind. Therefore, a robust edge on the north side of IJburg was created (De Jong, 2012).

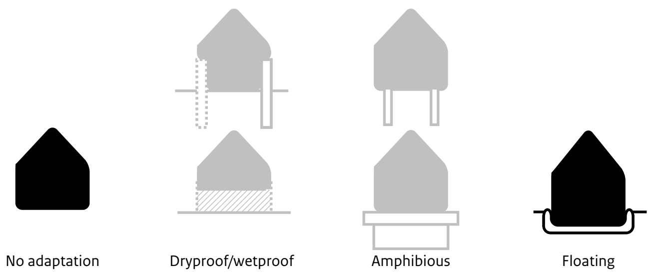
There are two types of adaptive measure taken for the built environment. First the buildings on the island. All the preventive measures were taken on the scale of the neighbourhood, by heightening the whole island to around +1.5 m NAP, taking into account the future rise of the water level of the IJmeer/Markermeer. On the north side a small extra dike (+2.2 m NAP) against waves was created. The second type is the floating houses of Steigereiland. They are situated in a basin, so that they do not lie directly in the open water.

Climate change response



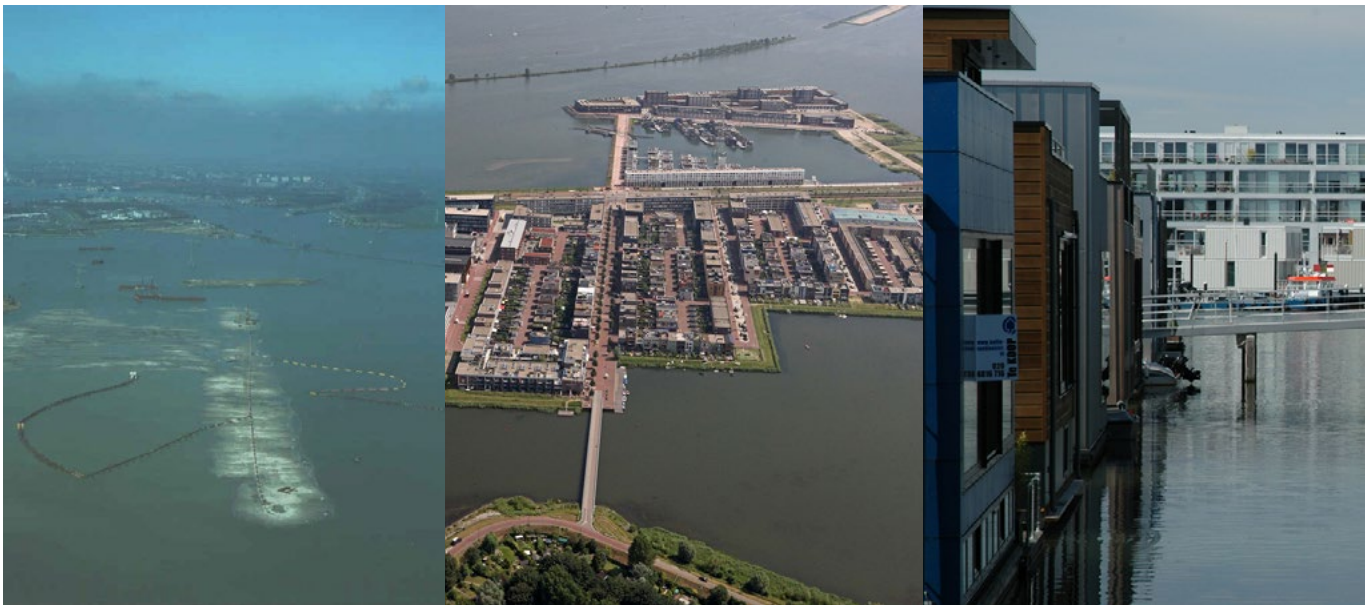
Aim

Adaptation



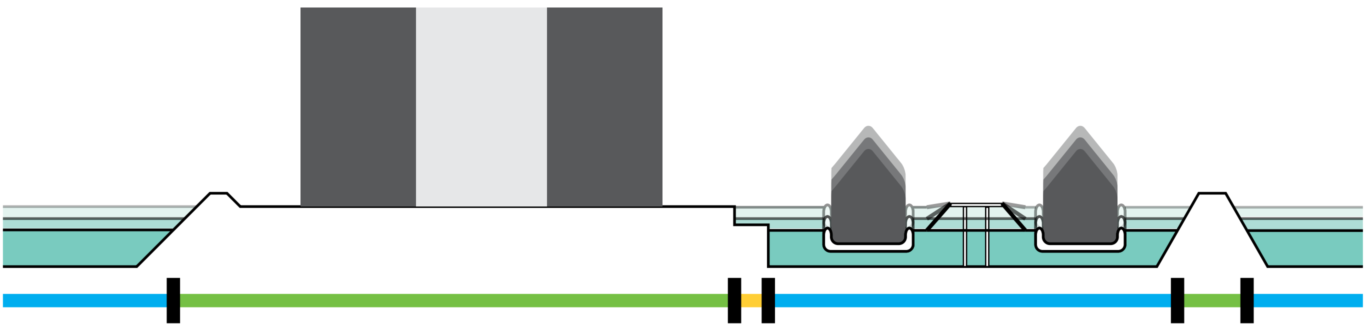
Flooding frequency

1	1/10	1/100	**1/10,000**
every year	every decade	every century	almost never



source: De Jong, 2012

Section



Characteristics Delta

Rhine delta

River length: 1230 km
River catchment area: 185,000 km²
Number of countries: 9
Average discharge: 2,200 m³/s (Lobith)

Source: Water atlas of the Netherlands, 2012: 56

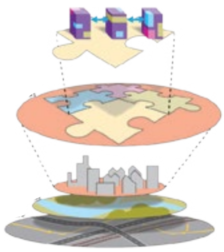
Stakeholders

Gemeente Amsterdam
 Dienst Ruimtelijke Ordening Amsterdam
Stadsdeel Zeeburg
Waternet
Veiligheidsregio Amsterdam-Amstelland
 Brandweer Amsterdam-Amstelland
Environmental parties
Several architects and urban designers
Future residents of floating houses Steigereiland (private initiative)

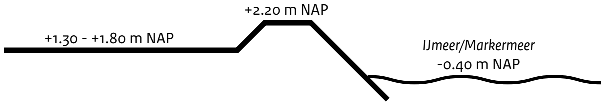
Urban context

Scale

Programme



Characteristics outer dike area



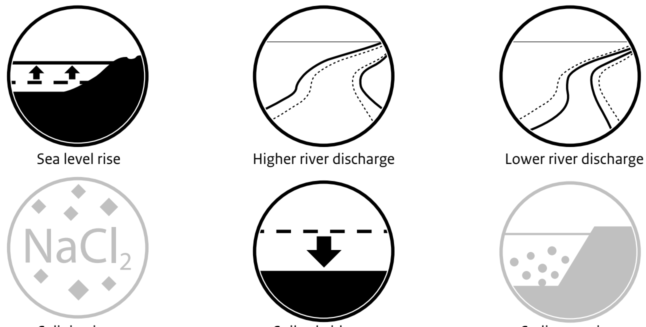
8.3.2 Zuidplaspolder | Gouda Westergouwe

The Zuidplaspolder is the lowest polder of the Netherlands, situated inside the triangle between Rotterdam, Zoetermeer and Gouda. The polder was reclaimed in the 19th century, and is surrounded by waters like the Ringvaart, the Gouwe and the tidal river arm Hollandsche IJssel. It has been designated as area for urban development in the Spatial Act 2006. To make this possible, the demarcation of the Green Heart has been adjusted (VenW et al., 2006: 33). Because of the deep position of the polder – the deepest point lies at -6.7 m NAP – there is a high flood risk, and problems with rising groundwater and seepage. New neighbourhoods where the impacts of floods are addressed are the possible expansion of Moordrecht, Nieuwerkerk Noord and Westergouwe. These neighbourhoods will be addresses in this case study.

For centuries there are plans to build in Westergouwe, near Gouda. At first this concerned a new penitentiary institution. When the building fell through, the landowners still wanted to develop the land, to prevent losses (Projecbureau Westergouwe, 2012). However, because of the economic crisis, it is also hard to develop housing here. Therefore now the development will take place in phases of 500 to 1000 houses at a time, until around 3850 houses are built (KuiperCompagnons, s.d.).

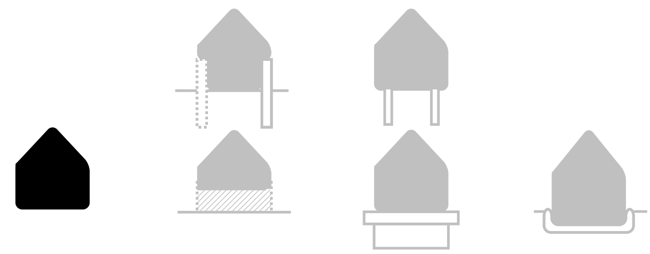
The safety standard of dike enclosure 14, of which the polder is a part, is 1:10,000. The Zuidplaspolder can flood fast and deep. The predicted inundation depth of the polder after a dike breach of the Hollandse IJssel is 1.20 m, when the storm surge barrier is closed (Pols et al., 2007: 58-62). Therefore, the water board has suggested to raise the ground level of this part of the polder (HHSK, 2007). The groundwater levels per subarea in Westergouwe differ in such a way that a cascade of mounds is chosen.

Climate change response



Aim

Adaptation

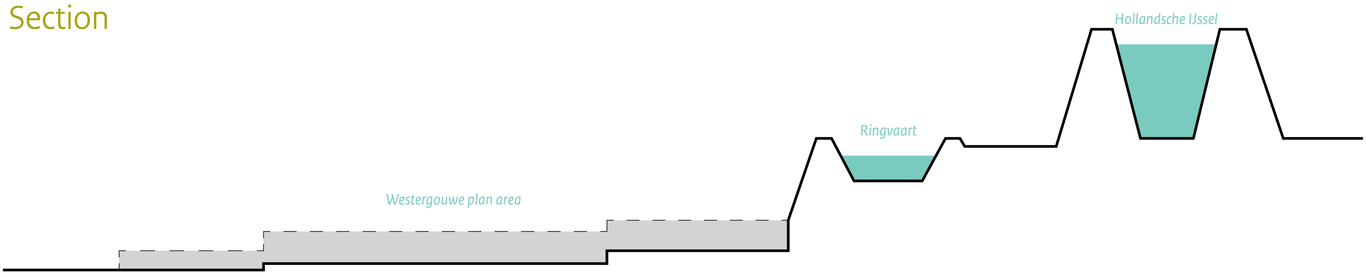


Flooding frequency

1	1/10	1/100	**1/10,000**
every year	every decade	every century	almost never


source: KuiperCompagnons, s.d.

Section



Characteristics Delta

Rhine delta

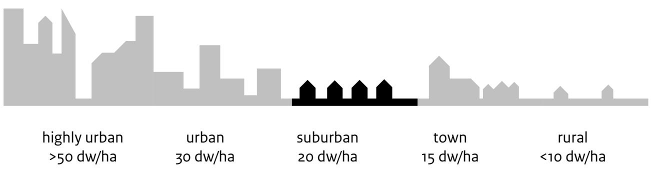
River length: 1230 km
River catchment area: 185,000 km²
Number of countries: 9
Average discharge: 2,200 m³/s (Lobith)

Source: Water atlas of the Netherlands, 2012: 56

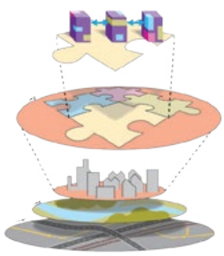
Stakeholders

Provincie Zuid-Holland
Gemeente Moordrecht
Hoogheemraadschap Schieland en de Krimpenerwaard.
Several architects and urban designers
KuiperCompagnons, responsible for phase 1: Bolwerk & Tuinen, 1000 dwellings

Urban context



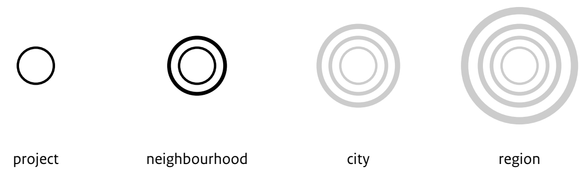
Programme



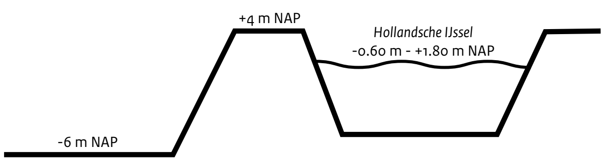
Facilities such as supermarket, playgrounds
Primary school

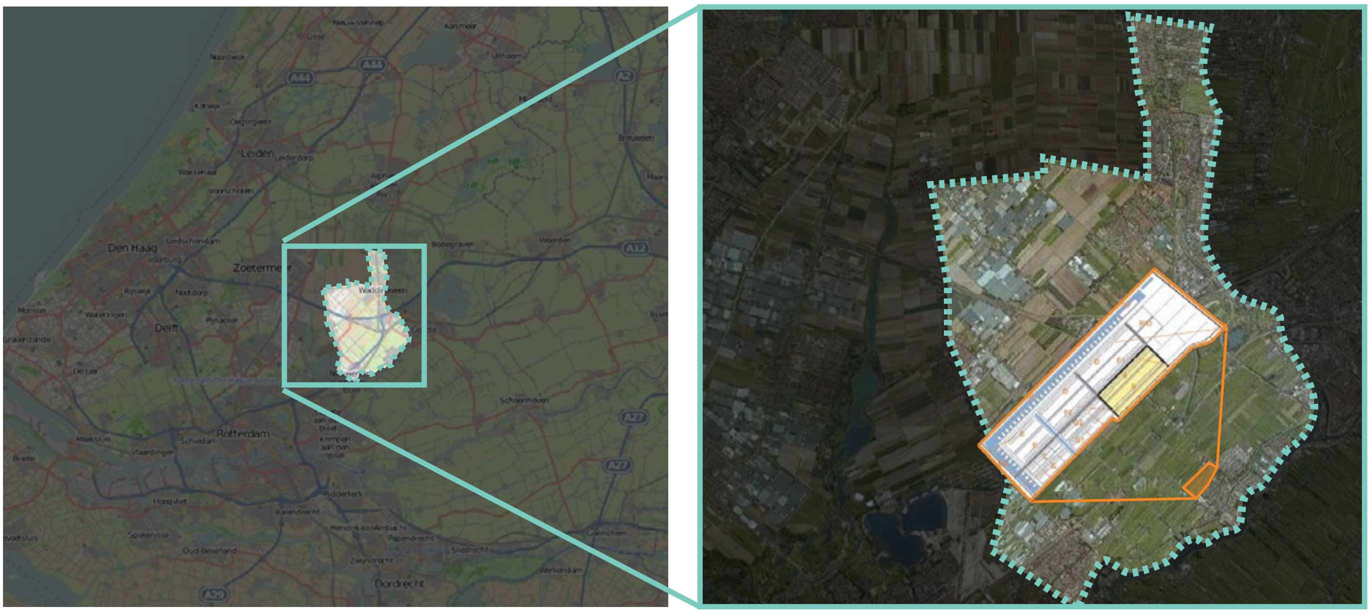
ca. 4,000 dwellings, in phases of 500-1000 houses at a time
density around 25 dw/ha

Scale



Characteristics deep polder





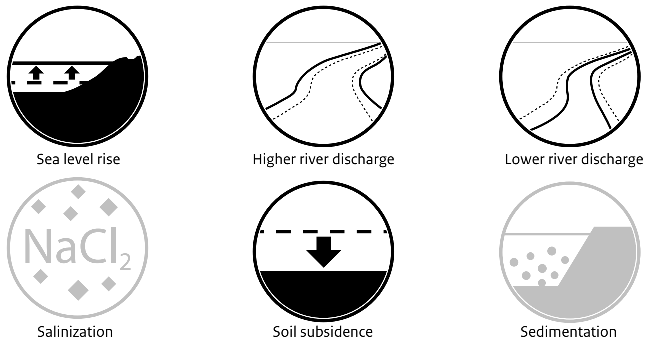
8.3.3 Zuidplaspolder | Pilot study Moordrecht

Because of its deep position, flood risk in the Zuidplaspolder is high, and other problems occur like rising groundwater and seepage. Therefore, prior to the development of the area the question is asked whether it is justified, and if so in what way, to build a water-friendly and sustainable residential area in this place with all its features. To explore the possibilities for increasing climate proofing of plans for the Zuidplaspolder, in 2007 the Hotspot project Zuidplaspolder was started, executed by Xplorelab of the province of Zuid-Holland. New building areas cannot make the flood risk increase unacceptably, future developments have to be taken into account (sea level rise, climate change leading to less or more river discharge) and there should be no passing on problems to others. The cultivation of deep polders without taking measures increases the impact of flooding in the form of damage or victims, and thus increases the risk.

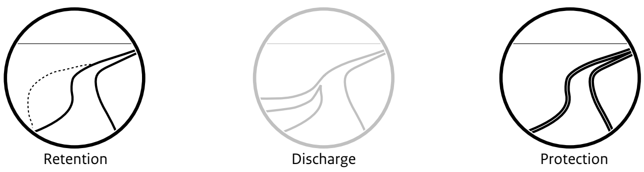
The zoning plan for Westergouwe, where measures were taken to reduce impact, was already established when the Hotspot Zuidplaspolder started. For the other locations in the Zuidplaspolder Xplorelab, in cooperation with other parties, has drawn up various background studies, pilot projects and a bundle of ideas.

One pilot project related to water safety is the 1.3 meter plan for the expansion of Moordrecht (Xplorelab, 2008b). In case of a flood 1.3 meter (1.6 meter including a small correction for waves) will be the maximum water depth in Moordrecht, due to compartmentalization by the surrounding levees and the ability to close the Hollandsche IJssel in case of disasters. Here, flood risk reducing measures are mainly on the building level. Amphibious houses, floating houses, houses on poles, houses in a mini-polder, wetproof and dryproof houses and houses on mounds are examples of the measures that are proposed.

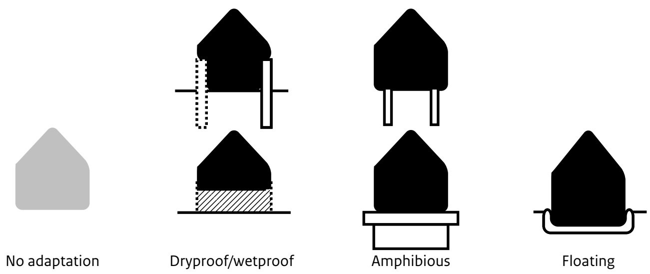
Climate change response



Aim

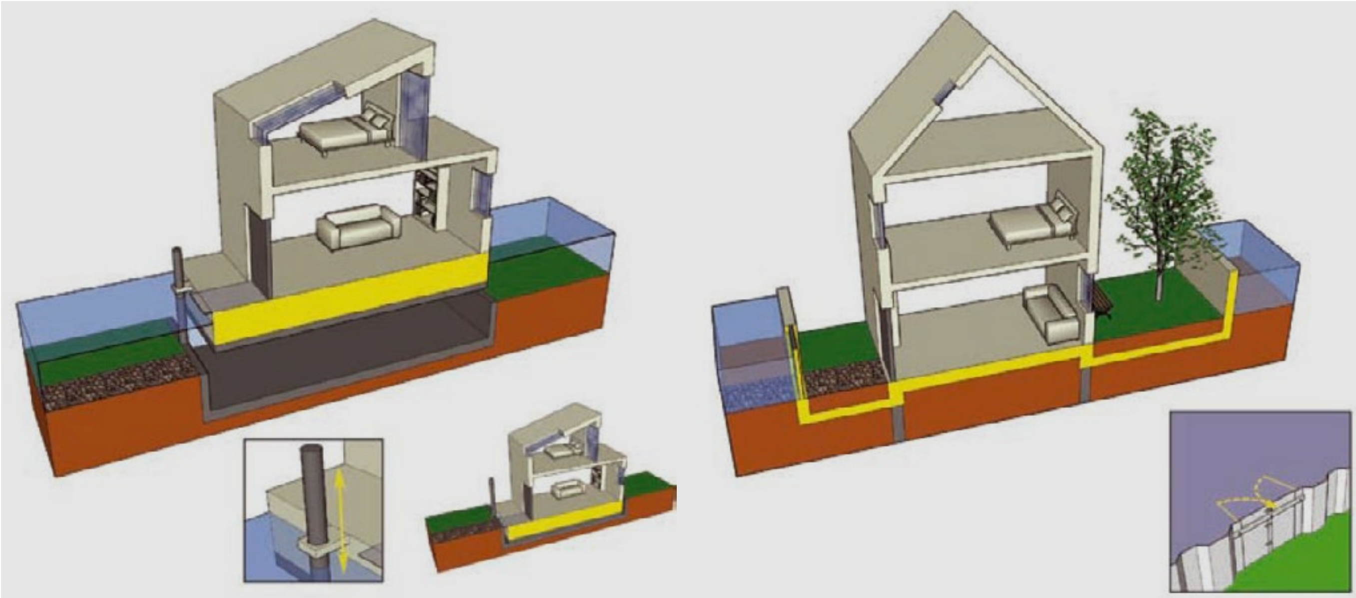


Adaptation



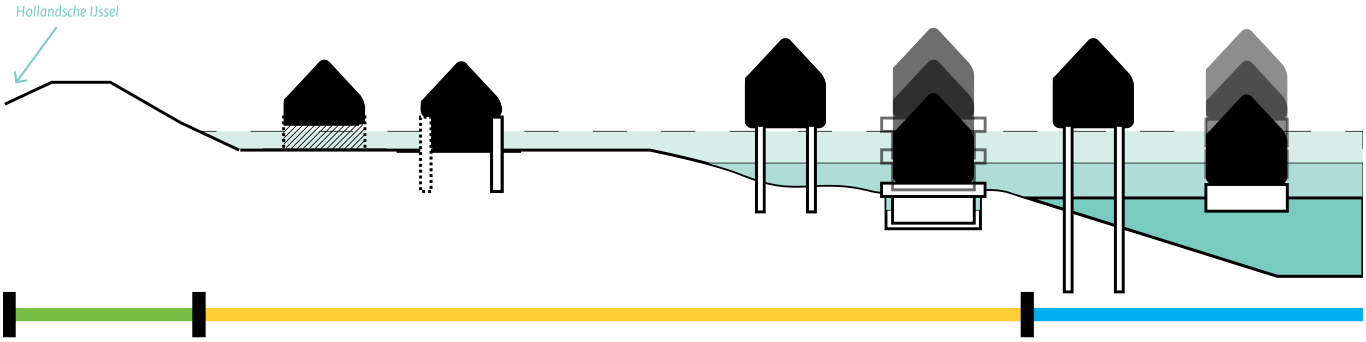
Flooding frequency

1	1/10	1/100	1/10,000
every year	every decade	every century	almost never



source: Xplorelab, 2008b

Section



Characteristics Delta

Rhine delta

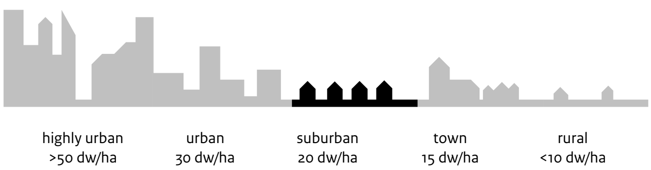
River length: 1230 km
River catchment area: 185,000 km²
Number of countries: 9
Average discharge: 2,200 m³/s (Lobith)

Source: Water atlas of the Netherlands, 2012: 56

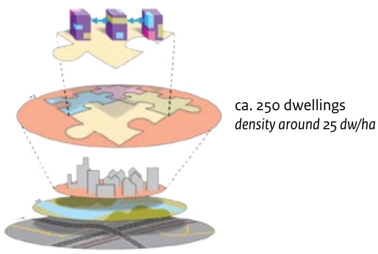
Stakeholders

Provincie Zuid-Holland
Gemeente Moordrecht
Hoogheemraadschap Schieland en de Krimpenerwaard.
Knowledge institutes, such as TU Delft, TNO, Universiteit Utrecht
Several architects and urban designers

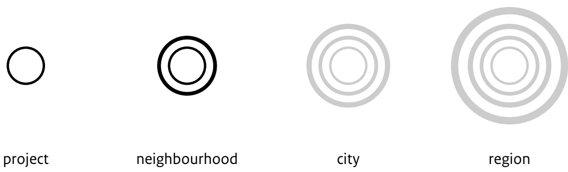
Urban context



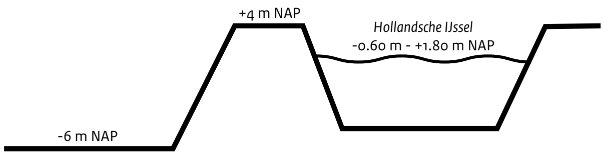
Programme



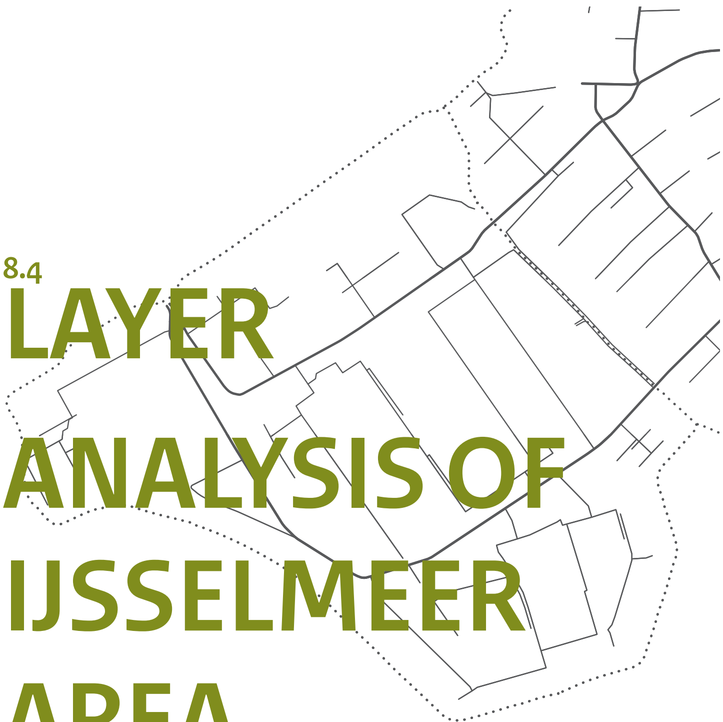
Scale



Characteristics deep polder




Houtribdijk, source: Flickr.com

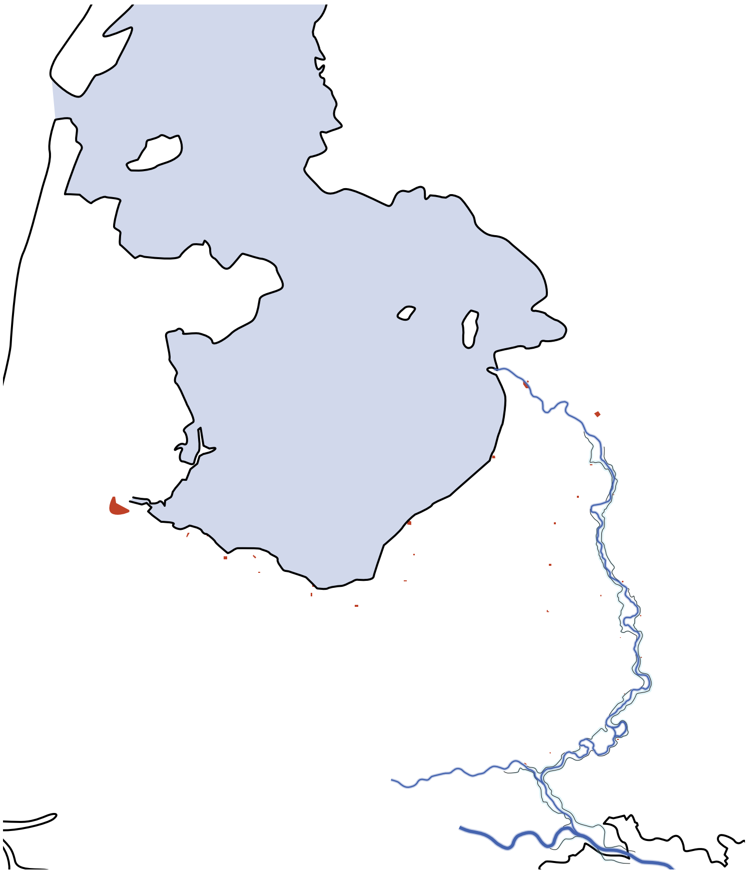


8.4
LAYER ANALYSIS OF IJSSELMEER AREA

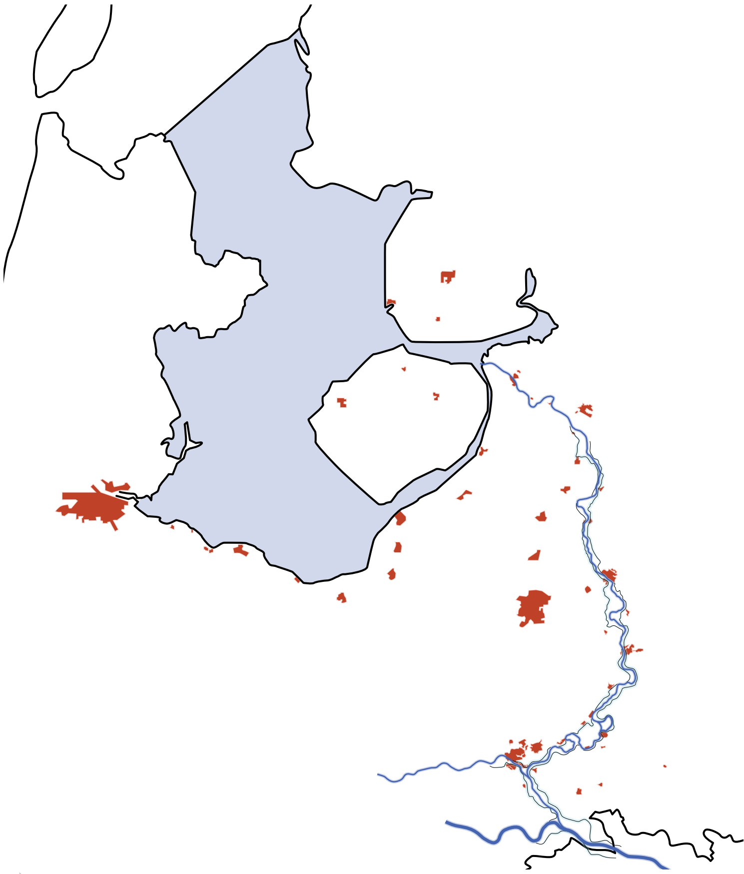
*made in the context of the studio Delta Interventions, with co-authorship of **Sylvana van Baren**

Never finished castle; a ruin before it has ever been used, source: Flickr.com

Layer 1: **OCCUPATION** ANALYSIS



1700



1960

Due to the large supply of sediment from the sea the salt marshes along the coast arised. This happened around 800 A.D. The tidal channels partially closed off because of the sand. This process led to the urbanization of the marshes. In the 12th and 13th century marsh areas along the whole coast were well populated. Though the salt marshes accreted, the coastline itself retreated. Since Roman times parts of the coast eroded and so it moved a few kilometers to the east.

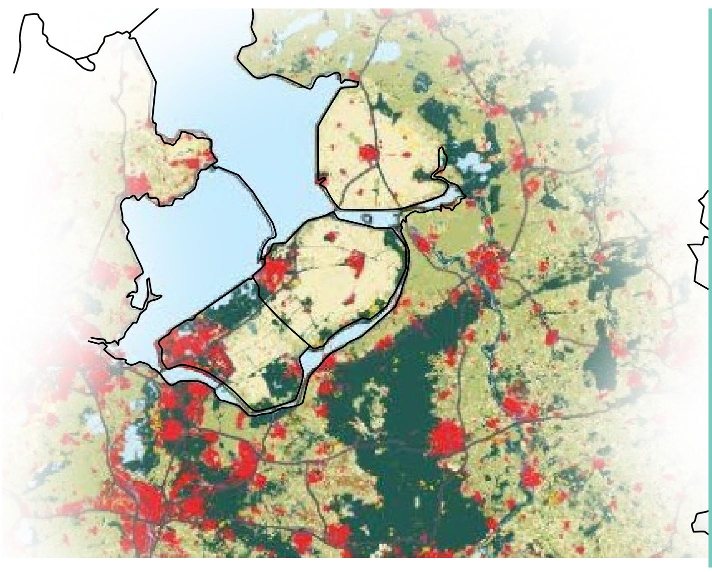
In the river areas, all large rivers were secured with dikes. Smaller rivers were dammed. The first polders are dated from this period: land entirely surrounded by dikes. By 1500, man had already developed into a main geological factor for the landcape. The landscape was almost everywhere party the result of human intervention, sometimes also unintended. The primeval forest was almost gone and the effects of peat mining and water management were clearly visible.

A map of 1850 would show that the human grip on the landscape after the Middle Ages was significantly increased.

The Zuiderzee dikes breached in 1916 under the violence of a very heavy and powerful winter storm. The Zuiderzee area was flooded. This flood was the reason to start the Zuiderzee works. The enclosure dam was constructed and large parts of the former salty sea were reclaimed. The Zuiderzee was now the IJsselmeer, a sweet water lake with a totally different ecology.

The first polder was the North East polder, constructed in 1942. The towns were arranged after the ideals of the Garden city movement, with the biggest city Emmeloord as a central point. Together these towns form the largest municipality of the Netherlands. The city Emmeloord currently counts 25.600 inhabitants. The other larger city in this polder, which lies along the IJsselmeer lake, is called Urk. This city is not part of the municipality of the North East polder, but has its own municipality with currently 19.000 inhabitants.

The largest city of the polder Eastern Flevoland is Lelystad, also the capiral of the Province of Flevoland. Biddinghuizen, Dronten en Swifterbant are the other cities of this polder.

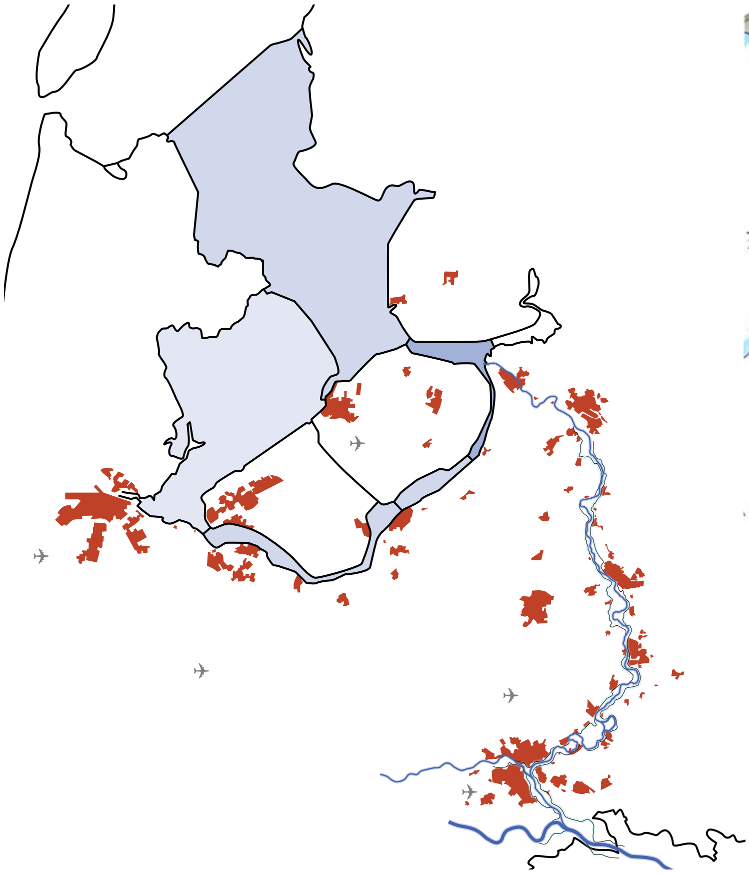


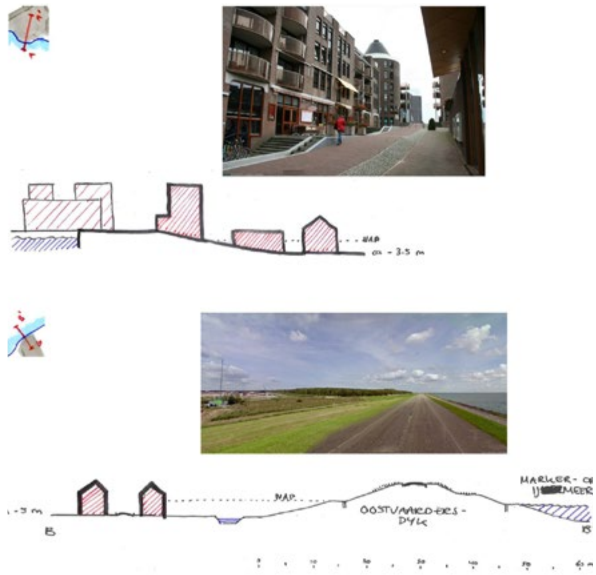
2040

The Netherlands Environmental Assessment Agency (PBL) has made several future scenarios concerning use, occupation of land and additional subjects. Trendscenario and High space-pressure scenario are presented in a publication. The prediction for the high pressure scenario concerning occupation is shown in the layer analyse above. Until the year of 2040, the total of urbanised area will increase with 190.000 hectares. The urbanisation is strongest in South Holland, North Brabant and North Holland. This will mean a strong decrease in agricultral farms, about 260.000 hectares.

The housing and office space demand will mostly increase in regions like Flevoland, Gelderland and North Brabant. But the demand will be highest in the Randstad. Big residential areas will occur in Almere, Haarlemmermeer, Purmer, between Delft and Zoetermeer and IJsselmonde, south of Rotterdam.

The pressure on the main infrastructure will increase a lot in the Trendscenario made by PBL. In the period 2000-2040 it will increse 75% for the Trendscenario and even 95% in the High space-pressure scenario. What will this mean for the accessibility?





sections

There are two kinds of relations that the occupation in the southern Flevopolder has with the surrounding water. The first is shown in section AA' above, in Almere Haven. Here the buildings move gradually up to the water, where a quay with mixed-use provides a lively interaction with the water (actually this is a precursor of the super levee).

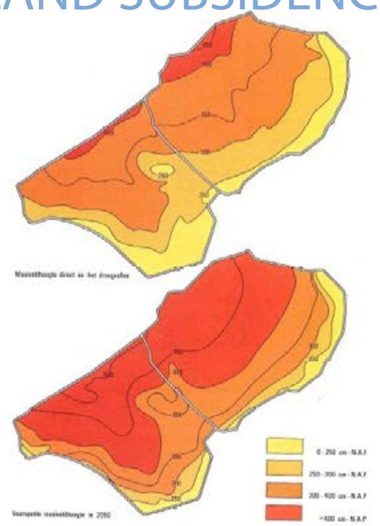
The second is shown in section BB'. This way of building north to Almere Stad shows no interaction at al, just expansion behind a high dike.

2012

In the 1970ies, the city of Almere was constructed in the last polder of the Zuiderzeewerken, the southern Flevopolder. It is a relatively new town, with a polynuclear structure. The city has known an explosive growth over the past few decades, serving as a relief for the demand of housing in Amsterdam.

During the period between 2002 and 2005, more than 40 % of new housing was built within existing urban areas in most provinces. This development fits in with policy aims to prevent urban sprawl and to improve urban facilities. Between 1990 and 2004, both urban land and nature reserves have increased in size, while agricultural land areas have decreased. This is also seen in the rest of Europe. (http://www.compendiumvoordeleefomgeving.nl/indicatoren/nl2012-Woningbouw-binnen-bebouwd-gebied.html?i=30-151).

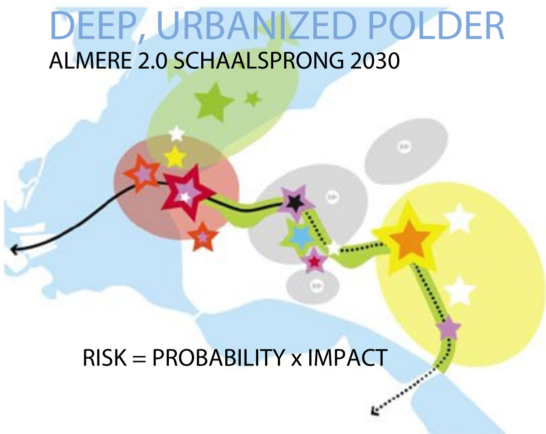
LAND SUBSIDENCE



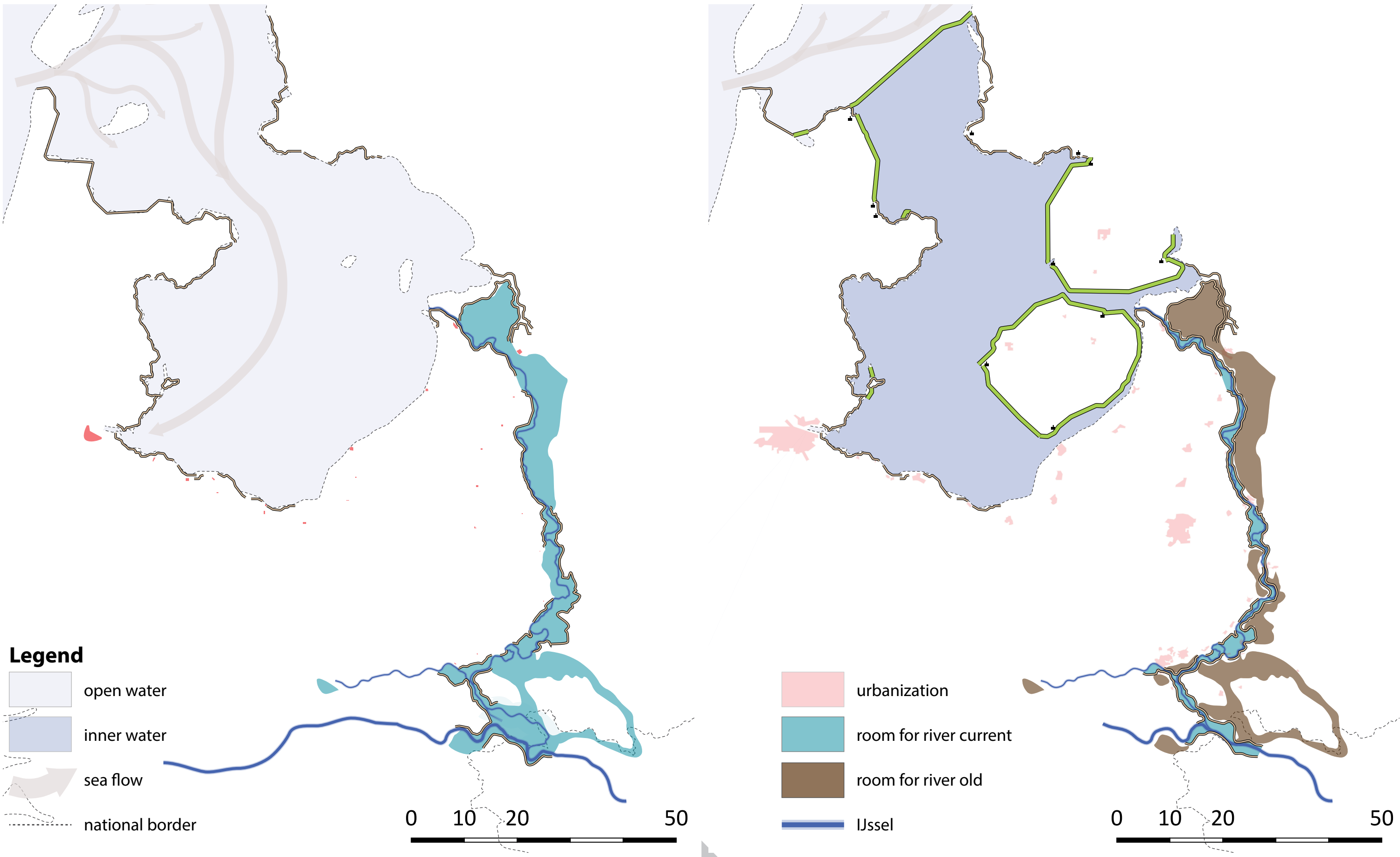
A problem of the Flevopolder is that the land is quite fast subsiding. The first image to the right shows the ground level after the polder was completed. The second image is the expected ground level in 2050.

According to the Trendscenario of (PBL), the largest part of new urbanisation till 2040, will be build in flood prone areas, in the lower parts of the Netherlands and especially in the Randstad. This is also the case for Almere, where an enormous increase of dwellings, inhabitants and business area is planned for 2030, in a deep polder surrounded by waters.

2040



Layer 2: **INFRASTRUCTURE** ANALYSIS



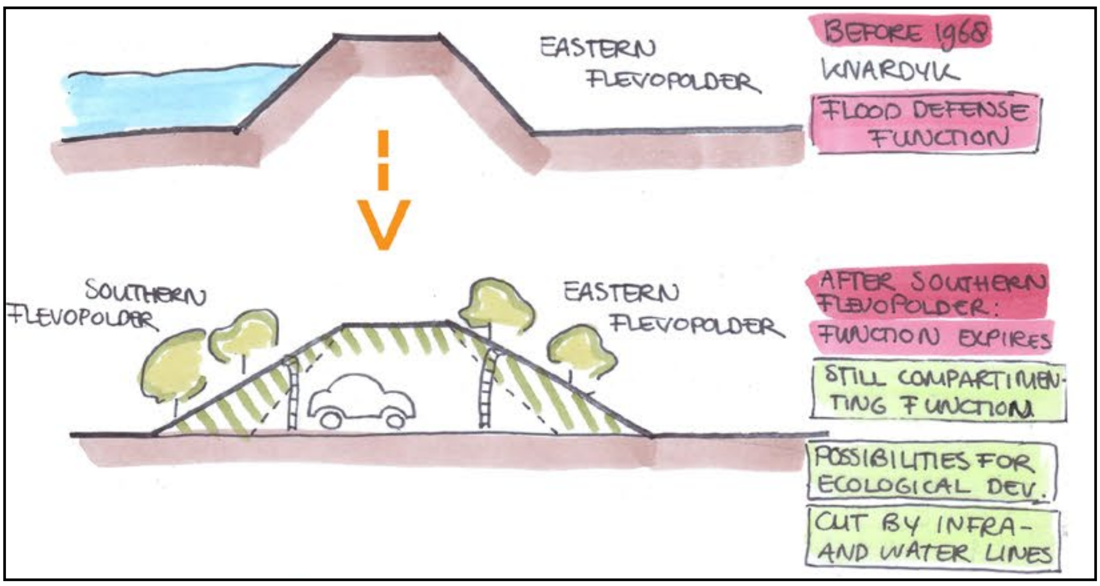
1700 | 1960

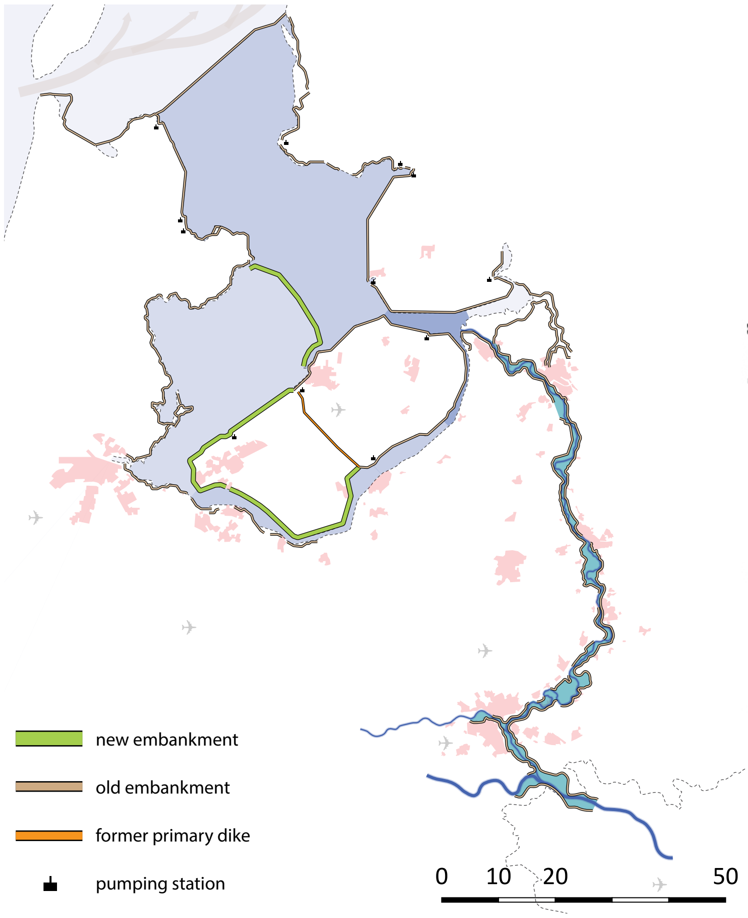
The first embankments of rivers started in the 13th century, when the first cities emerged. Still, the 18th century is characterized by relatively much room for water. The river IJssel is not rigidly embanked, so has relatively much space to flow and alter its course.

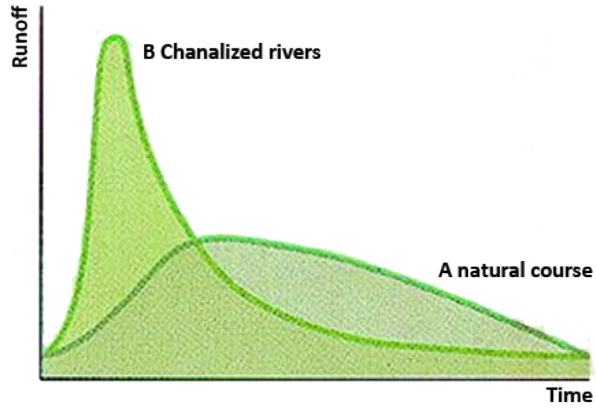
Also, the coastline of the Netherlands is much larger, because of the Zuiderzee in the middle of the country. The sea water has room to flow up untill the IJ near Amsterdam.

After 1700, a lot of infrastructural interventions related to water were made. Between 1701 and 1709 the Pannerdens canal was dug, because of the many floods that occurred in this area. This automatically decreased the room for the river. Further embankments along the IJssel have left little space for this river.

After the construction of the Afsluitdijk in 1932, the sea could no longer flow into the IJsselmeer (former Zuiderzee). This enabled the construction of the Zuiderzeewerken, large reclaimed polders. The first test was made near Andijk. Then was started with the Wieringermeer. This polder was attached directly to the main land. However, this turned out to be not the best way, so the Flevopolders have been constructed detached from the main land, as an island totally surrounded by new dikes and water.





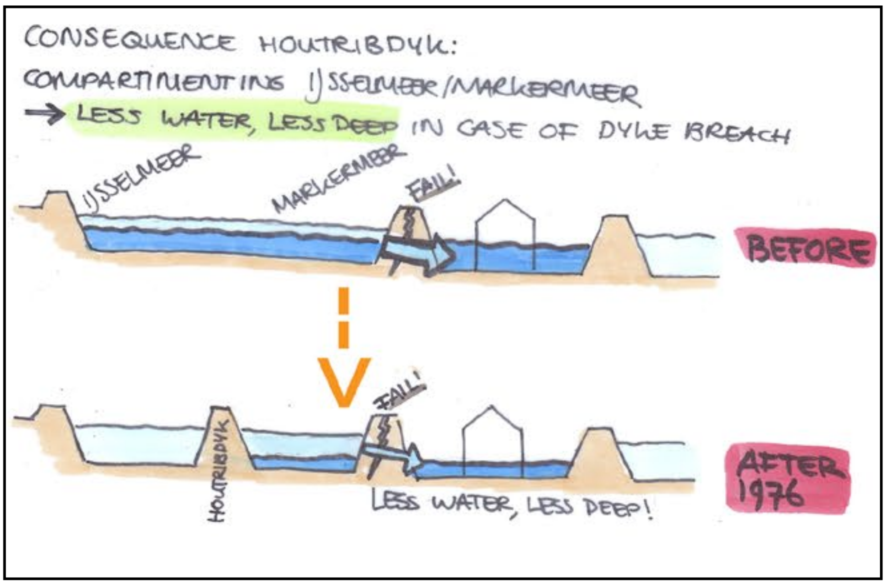


Due to the chanalization of rivers, the river has little space left to follow its natural course. One effect of this is that much less area is subject to flooding, which leaves room for urbanization. Downside to this is that the peak discharge of rivers will come earlier, runoff sooner and will have a higher peak in terms of maximum water level.

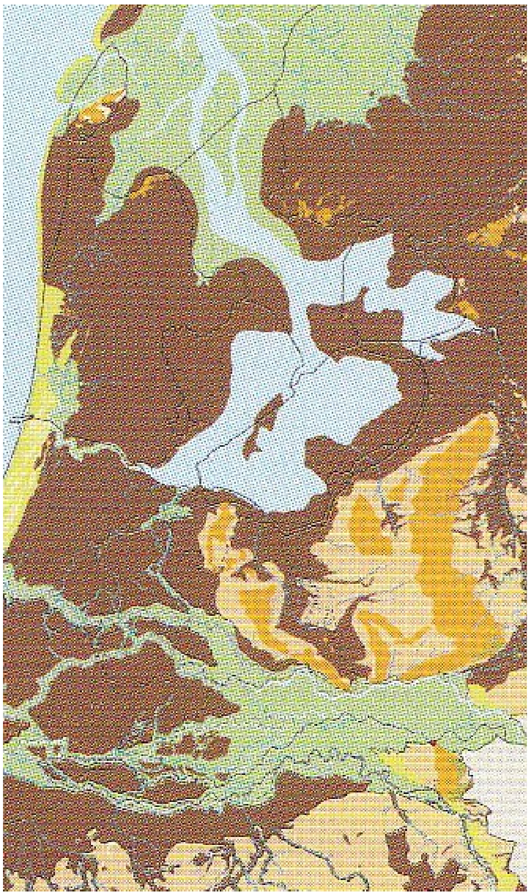
2012

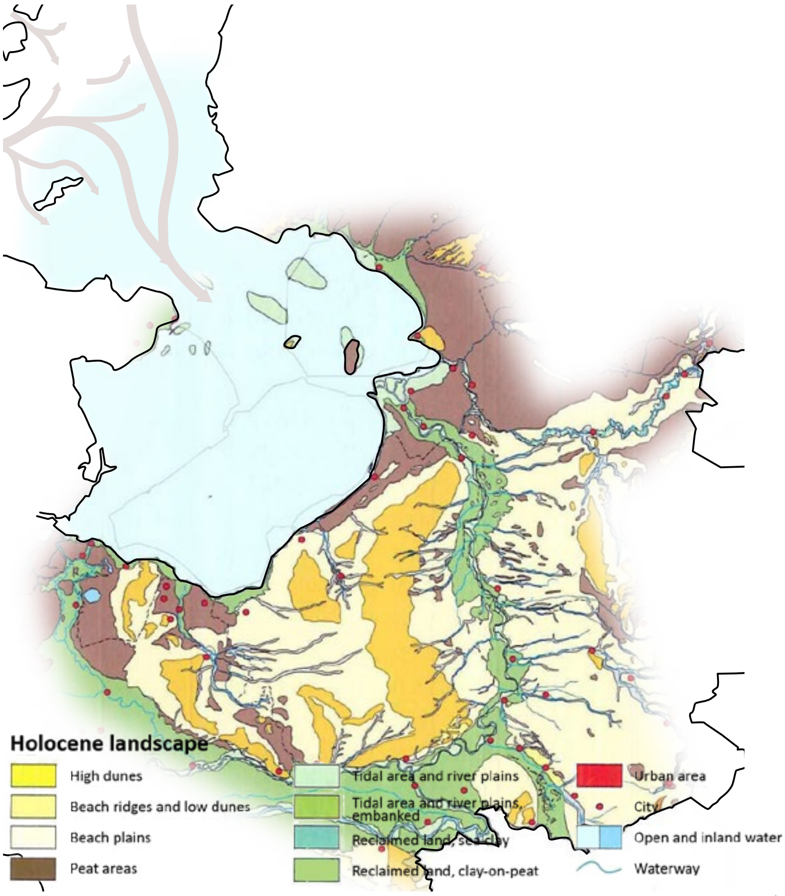
The Flevopolder was constructed in two parts: the eastern and the southern Flevopolder. First in 1957 the eastern Flevopolder falls dry. In 1968 southern Flevoland was reclaimed. An interesting thing regarding the flood protection infrastructure is the changing role of the Knardijk. This is the dike southwestern of eastern Flevoland. It first served as a primary water defence. However, after the southern Flevopolder fell dry, it lost this function. Nowadays, it serves as a regional compartmentalization dike. Many alterations to the profile and cuts through the dike by roads and waterways have been made (see below).

In 1976 the Houtribdijk was constructed, originally to facilitate the last polder of Markerwaard. This polder however was never realised, but the Houtribdijk was. This dike makes a compartmentalization between the IJsselmeer and Markermeer. Consequence of this is that, in case of a dike breach, less water volume can flow into the polder (see below).



References:
De Bosatlas van Nederland waterland. (2010) Groningen: Noordhoff Atlasproducties.
Delta Programme IJsselmeergebied (2010). *Atlas van het IJsselmeergebied*. Lelystad: Delta Programme IJsselmeergebied.
Van Duin, R. H. A. (1984). *Het Zuiderzeeprojekt in zakformaat*. Zwolle: Rijksdienst voor IJsselmeerpolders.





100

1500

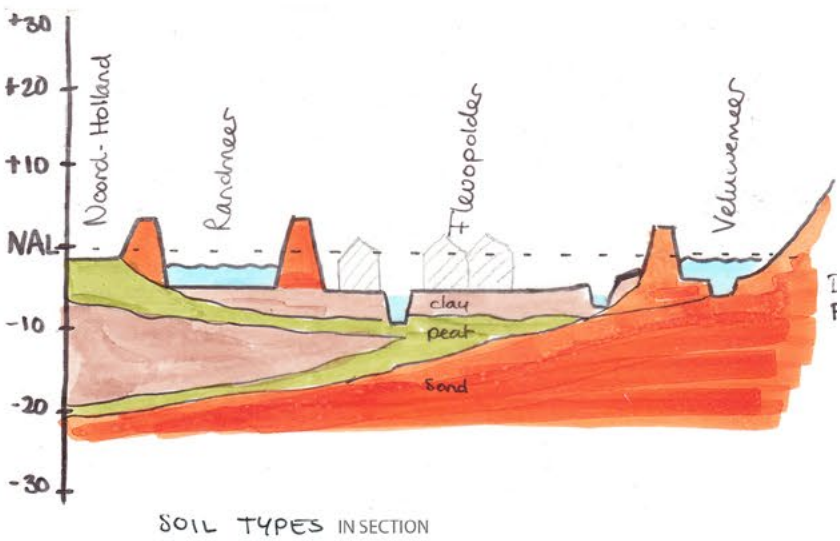
The map above shows that before the area that we now call Flevopolder was Zuiderzee, is was partly land. Recently, a skull was found near a building site in Almere. The skull is dated first or second century AD, and proves that part of the polder was once land used by the Romans. It turns out that Almere is not a town with a short history, but with a history that goes back to the Roman period.

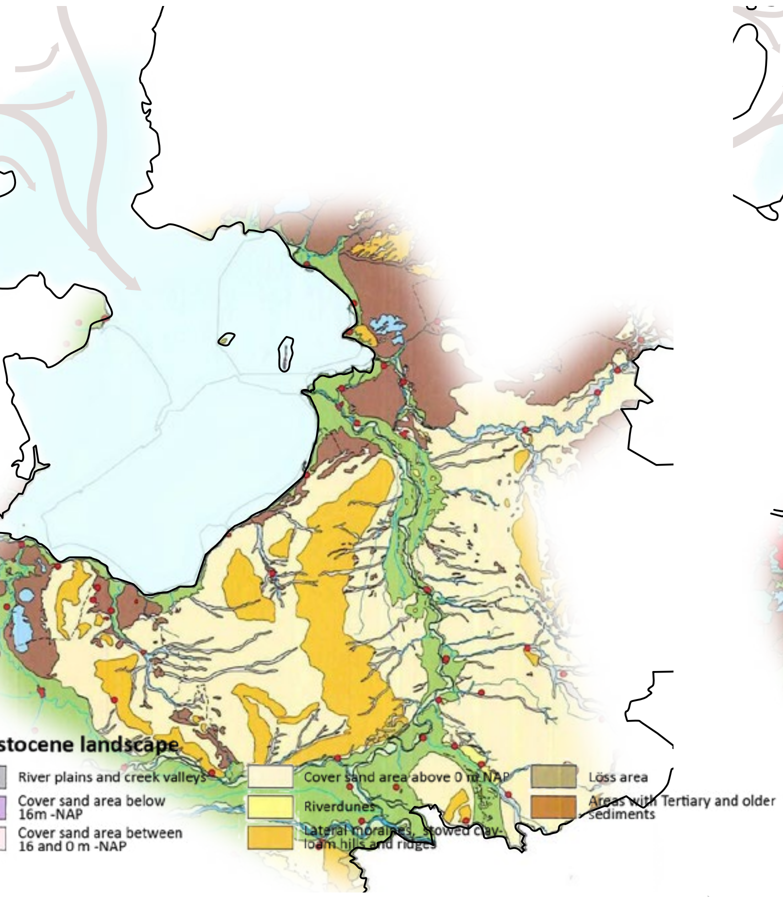
Parts of the big rivers are already embanked, but at other parts the water still gets the free hand. This leads to a dynamic coast line (compare for instance with the map op 1850), and the deposition of sediment near the mouths of the rivers IJssel and Vecht. Also some islands occur in the Zuiderzee.

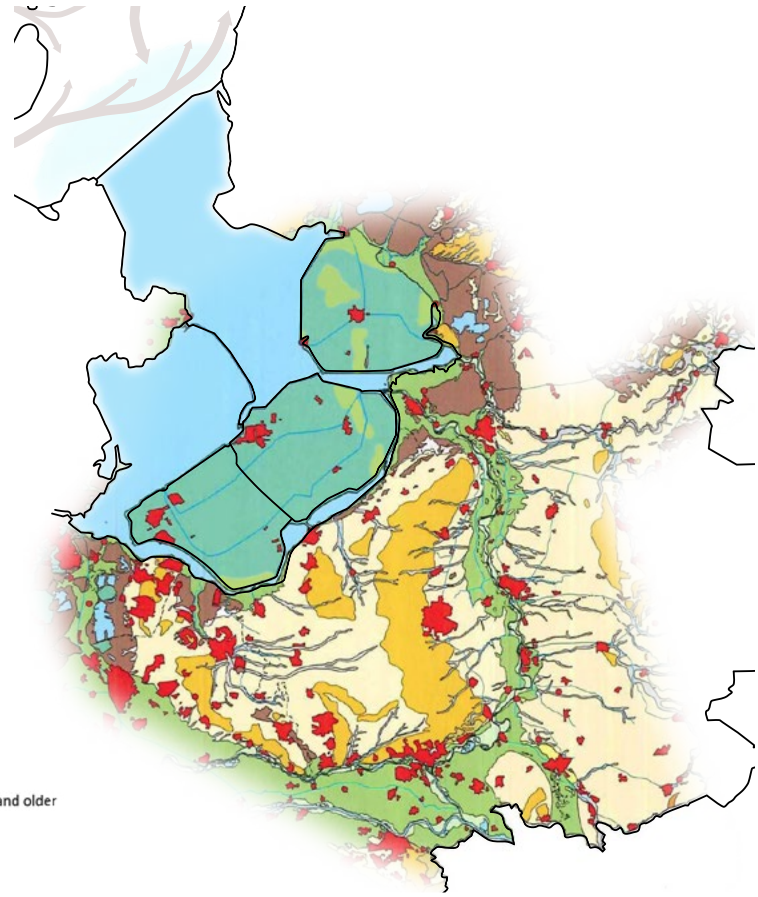
The soil types along the IJssel river mainly consist of river clay and sand.

“Ancient skull found in Almere”

Souce: nos.nl (2012) *Oude schedel gevonden in Almere*, [online] retrieved 1 November 2012 from <http://nos.nl/artikel/427809-oude-schedel-gevonden-in-almere.html>







1850

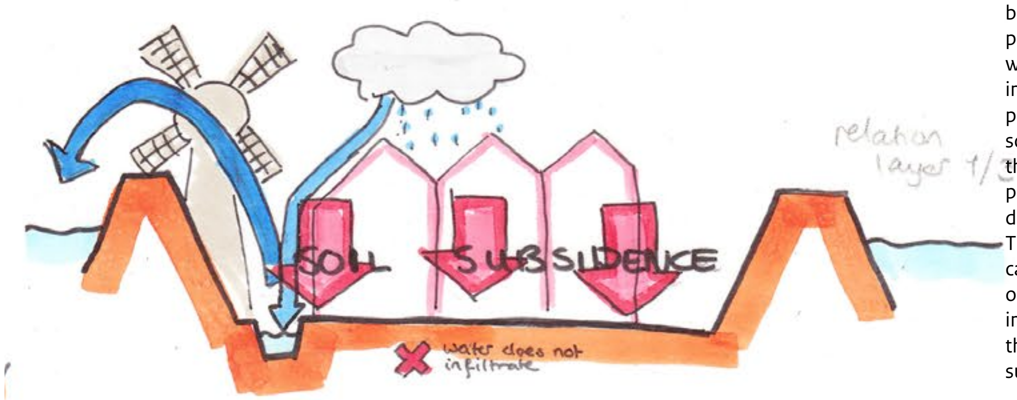
2012

Compared to the map of 1500 we can see that a bigger area along the IJssel is embanked, especially around Deventer and Zutphen, and Kampen where it flows into the Zuiderzee.

Another difference is the various changes of the coast line and Wadden islands. Also the two islands in the Zuiderzee, and the island of Wieringen have decreased in surface.

After the construction of the Afsluitdijk in 1932, the wild Zuiderzee is tamed. The water level of the IJsselmeer can be artificially controlled. This enables the construction of the Zuiderzeewerken. Large polders are reclaimed, adding a lot of extra surface area for cultivation. Again, the contours of the Netherlands change a lot.

The soil of the Flevopolders consist of sea clay, and bits of sand. At some spots, the sea clay is only a small layer that covers peat. This makes these polders subject to soil subsidence, which in certain parts can cause trouble, because the Flevopolder is already a low polder (average -4 meter below NAL).



relationship layer occupation and natural layer: land subsidence

DEEP, URBANIZED POLDER:
- DRAIN TO KEEP DRY FEET
- PAVED SURFACE
→ WATER DOES NOT INFIL-TRATE SOIL → SOIL DRIES OUT → LAND SUBSIDENCE

The Flevopolder is already a deep, urbanized polder. Further urbanization as planned in the Schaalsprong Almere 2.0 will only make it more vulnerable and increase the flood risk. Furthermore, the polder is subject to land subsidence. The soil consists of a thin layer of sea clay that covers a layer of peat. Because the polder is urbanized, it will have to be drained for the people to keep dry feet. This dries out the soil. Moreover, because in an urbanized area a large part of the surface is paved, water does not infiltrate into the ground, which dries the soil out even harder. This causes land subsidence.

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HYDRAULIC MEASUREMENTS ANALYSIS

The construction of Eastern Flevoland began in 1950 with the 'plot P', the island Lelystad Haven. Soon the dike and wider embankments became inhabited. The 90 km long dyke around Eastern Flevoland was closed in 1956 and drainage could start. Eastern Flevoland was as well a part of the Zuiderzee Works and was fully drained in 1957. It covers an area of 54.000 hectare.
The Wieringermeer was attached directly to the main land. However, this turned out to be not the best way, so the Flevopolders have been constructed detached from the main land, as an island totally surrounded by new dikes and water.

Southern Flevoland was constructed between 1959 and 1968 and the fourth and so far last polder was realised as part of the Zuiderzee Works. It is now part of the Dutch province of Flevoland and covers an area of 43.000 hectare. Almere is the largest residential area. There is also Zeewolde. The rest of the polder farmland. The main road through the polder is the A6, which connects Amsterdam with Emmeloord via Almere and Lelystad.

The Houtribdijk
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intention to re
plan has never
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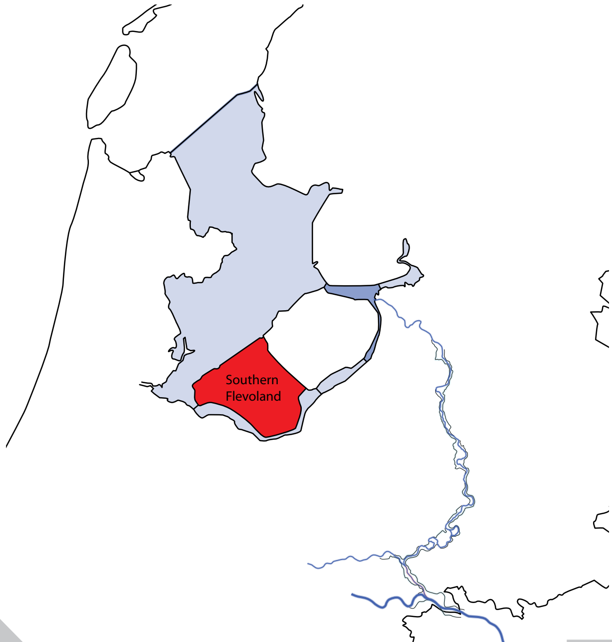
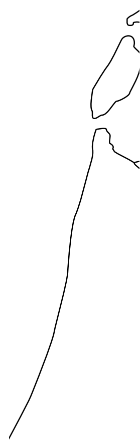
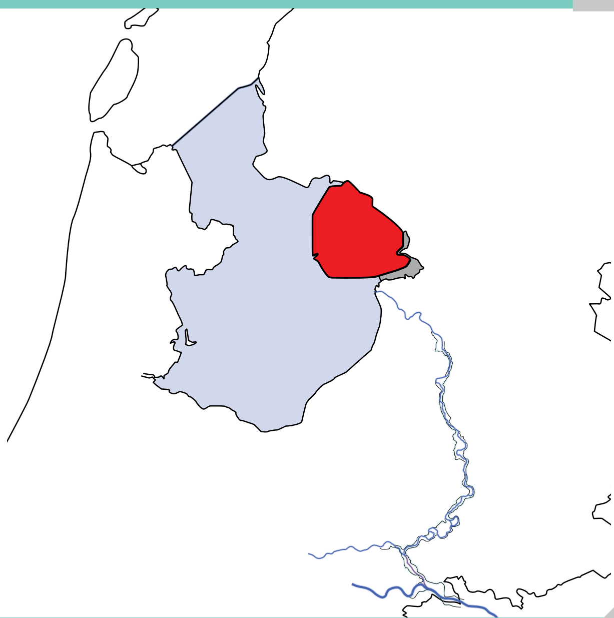
1957

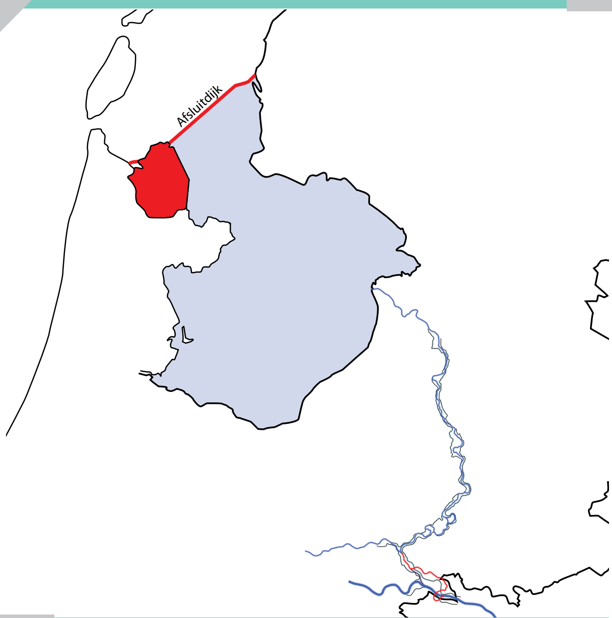


1968





1942



1920 - 1932

The first ideas about damming and draining of the Zuiderzee come of the hydraulic engineer Hendrick Stevin and date from 1667. The Zuiderzee Association was founded in1886 to start with the draining. Cornelis Lely made many plans for this association.

The Amsteldiepdike was the first measurement of the Zuiderzee Works that was build. For the first time, boulder clay was used to make a dike. The dike was compeleted in 1924 and made a connection from the mainland to the island that was first a small part of the Wieringerpolder. It was also called Shorter Afsluitdijk and stood as an expample for the actual Afsluitdijk.

In 1930 the Wieringer lake was reclaimed into a polder. The works started in 1927 and it became occupied in 1934. Since 1 July 1941, the Wieringermeer had been an independent municipality. During the Second World War, on 17 April 1945, a German command ordered the dike of the Wieringermeer to be blown up. No one was killed as the polder slowly submerged again, but the high water and a subsequent storm destroyed most of the infrastructure built in the previous decade. The floodwater was fresh water, so the land did not have to be desalinated again. Reconstruction followed quickly. It was drained again by the end of 1945. The rebuilding of roads and bridges, houses and farms, was greatly facilitated by the experience of building them the first time.

The Afsluitdijk was designed by Cornelis Lely and constructed between

k is a dike in the Netherlands, built between 1963 and
ates the IJssel lake from the Marker lake. It was the
claim the Marker lake into the Markerwaard, but this
been executed and is now unlikely to be constructed
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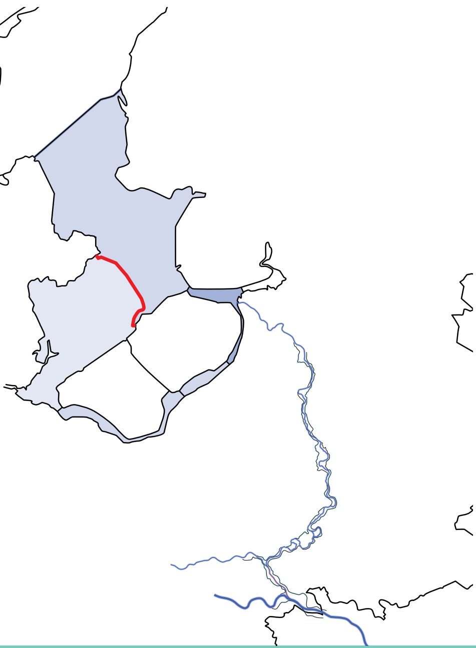

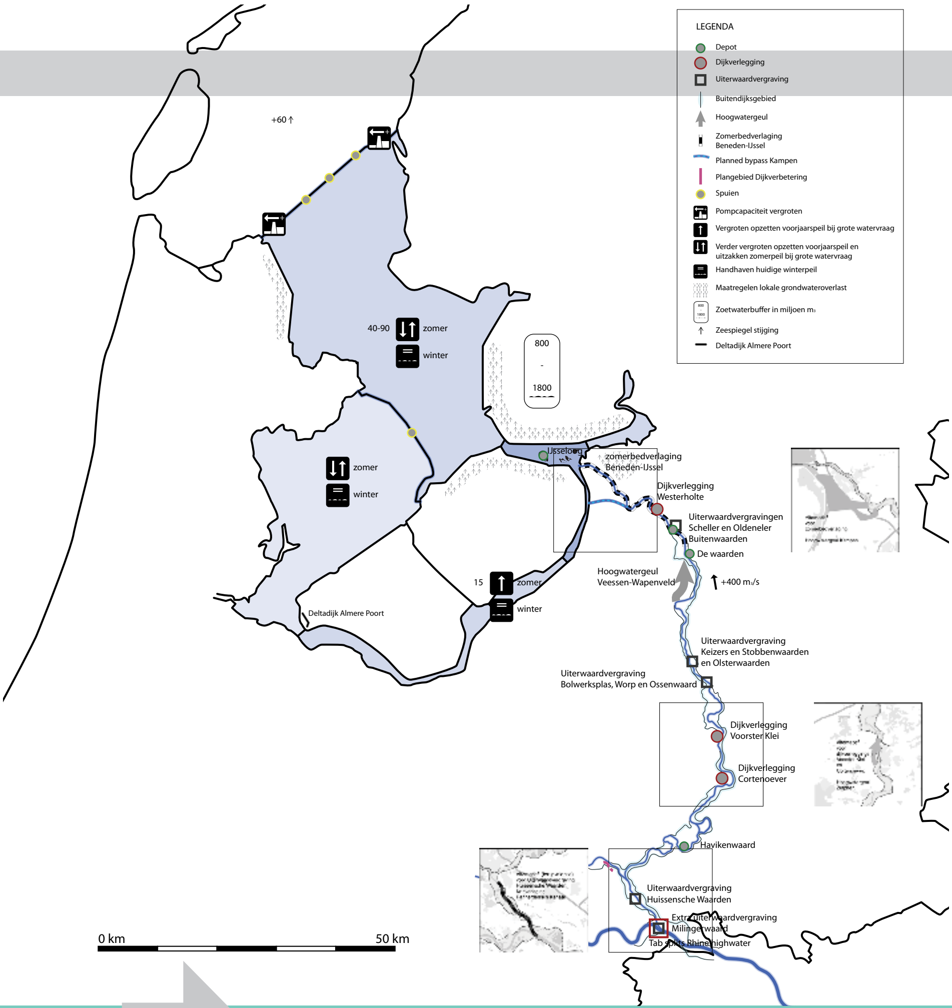

1976 → 2012

To prevent the Netherlands from flooding, two important documents give guidance to future perspectives. The first one is called: Room for the river, the second one: Delta Programme 2013.

The Room for the river, 2007 notes:
Extremely high river discharges will occur more frequently in the future and for this reason it was decided to ensure that the rivers could discharge the forecast greater volumes of water without flooding.

The Delta Programme IJsselmeer region focus on safety and fresh water.

Safety tasks involve:

- maintaining the current flood protection agains flooding
- updating the current flood protection against flooding
- anticipate the consequences of climate change

The freshwater challenge involves:
- enabling inventory of fresh water
- anticipate the consequences of climate change

1927 and 1933 and running from Den Oever in North Holland province to Zurich in Friesland province, over a length of 32 km and a width of 90 m, at an average height of 7.25 m above sea-level. It was built as part of the Zuiderzee Works, damming off the Zuiderzee, a salt water inlet of the North Sea and turning it into the fresh water lake of the IJsselmeer.

In 1949 the Northeast Polder was constructed. It was made for agriculture. The demand of agricultural land was very high. But not all the land turned out to be suitable for agriculture. The largest settlement in the municipality is Emmeloord. Most tourists will visit Schokland, a former abandoned island that has been declared an UNESCO World Heritage Site.

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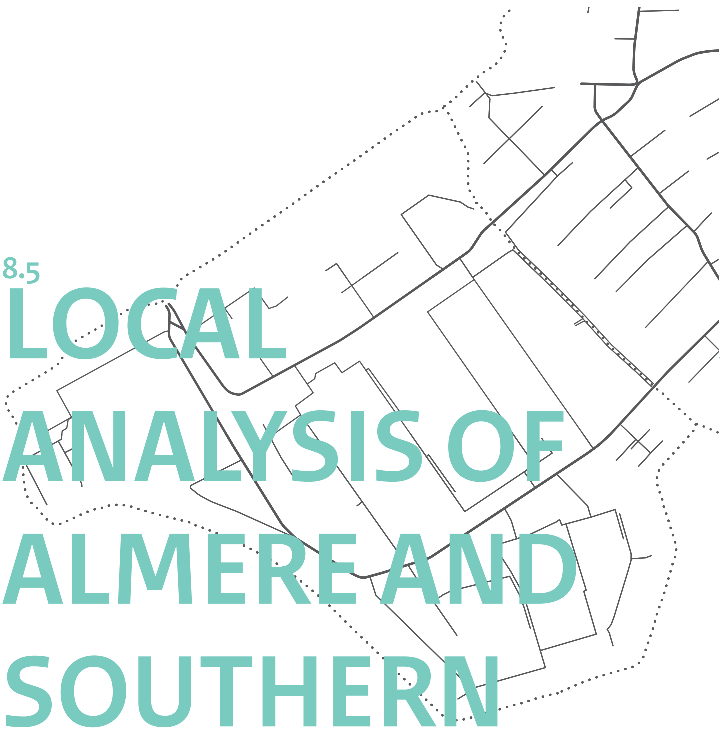
Totally seperated traffic modes: bus lane along Weerwater



8.5
LOCAL ANALYSIS OF ALMERE AND SOUTHERN FLEVOPOLDER

Train on the railway embankment between the Hollandse Brug and the new station Almere Poort, source: Flickr.com

8.5.1 Analysis | Water system

The water system of the Flevopolder is artificially kept operating by several pumping stations, sluices, dikes, and two main canals. The polder is surrounded by primary water defences category A and C, and divided by the Knardijk, a regional water defence. The Knardijk is cut by the two canals, Lage Vaart and Hoge Vaart. Other infrastructure, such as roads, crosses this dike on top. The primary dikes are robust, with a width of around 60 meter (Rijksdienst voor de IJsselmeerpolders, 1971: 18). The body of the dikes is filled with sand, and directly founded on the Holocene sand. One drawback is that, in case of a dike breach, the sand body will be washed away, and the hole can grow rapidly up to several hundred meters.

According to the VNK study by Bossenbroek (2012) there are currently some dikes subject to failure by piping, overflowing or overtopping, including parts of the Oostvaardersdijk and Nijkerkerdijk.

Whereas building IJburg in the IJmeer/Markermeer was relatively easy and cheap for the Municipality of Amsterdam, this will most likely not be the same for plans for outer dike expansion in front of Almere Pampus. The water depths here vary between 3 and 4+ meters, as opposed to the 1 to 2 meters near IJburg (RWS-RIZA, 1995). Expansion in the Markermeer near Almere will therefore cost a lot more sand, and thus will be substantially more expensive. Another thing the map of water depths shows is the deep waterways that have to be kept free of building (see also 8.5.2 Infrastructure).

The maps of the current ground level and that in 2040 show a very deep polder, which will become only deeper due to soil subsidence. The deepest part is that of the area in Almere Oost, where also a large part of the expansion is planned. This area, and the area in Almere Pampus in the west, will have to deal with water nuisance in 2040 (Waterschap Zuiderzeeland, 2010). Combined with the planned program in this area, this will cause some problems in the future, which will have to be resolved.

Figure 8.5.1:

Figure 8.5.2:

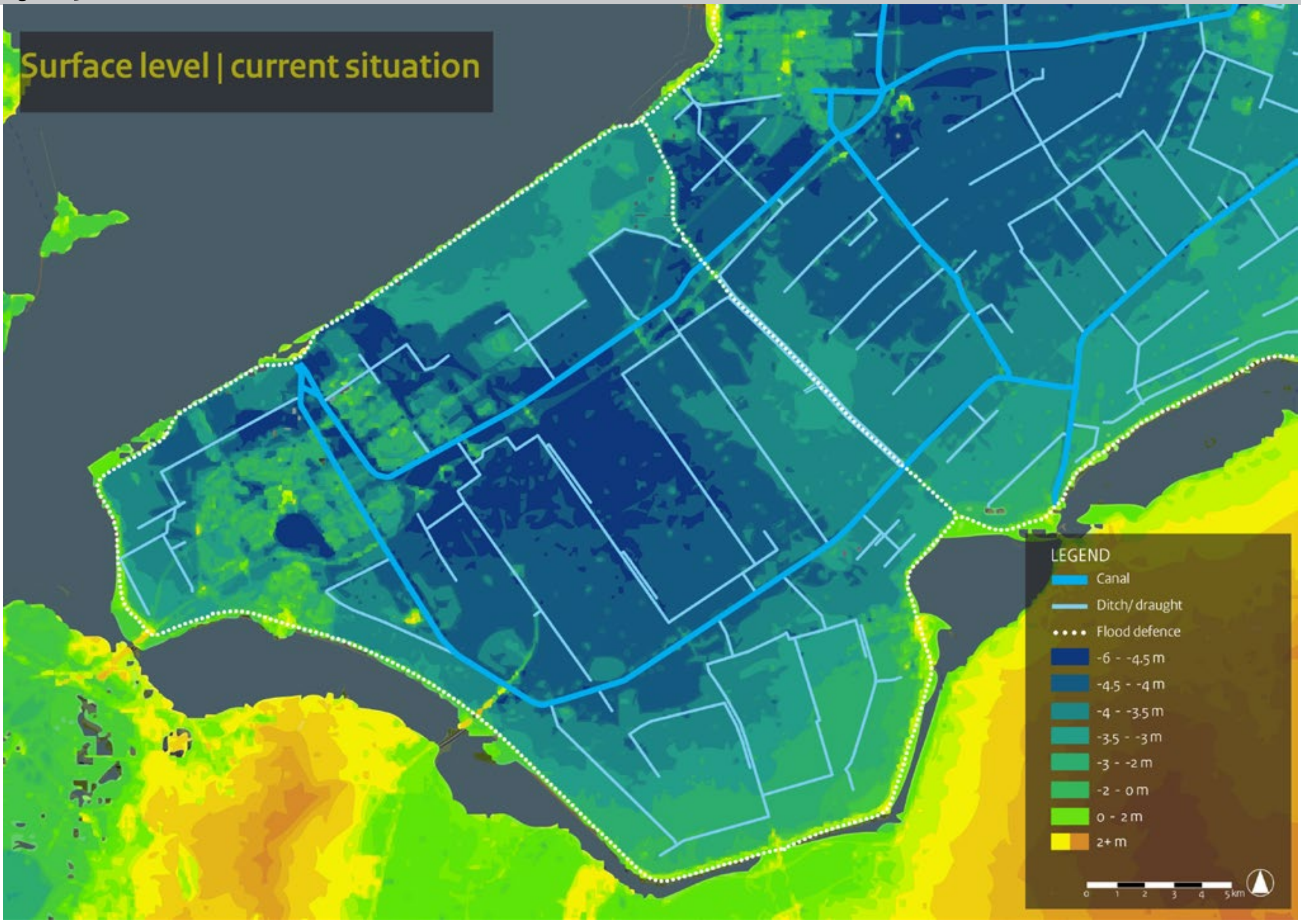


Figure 8.5.3:

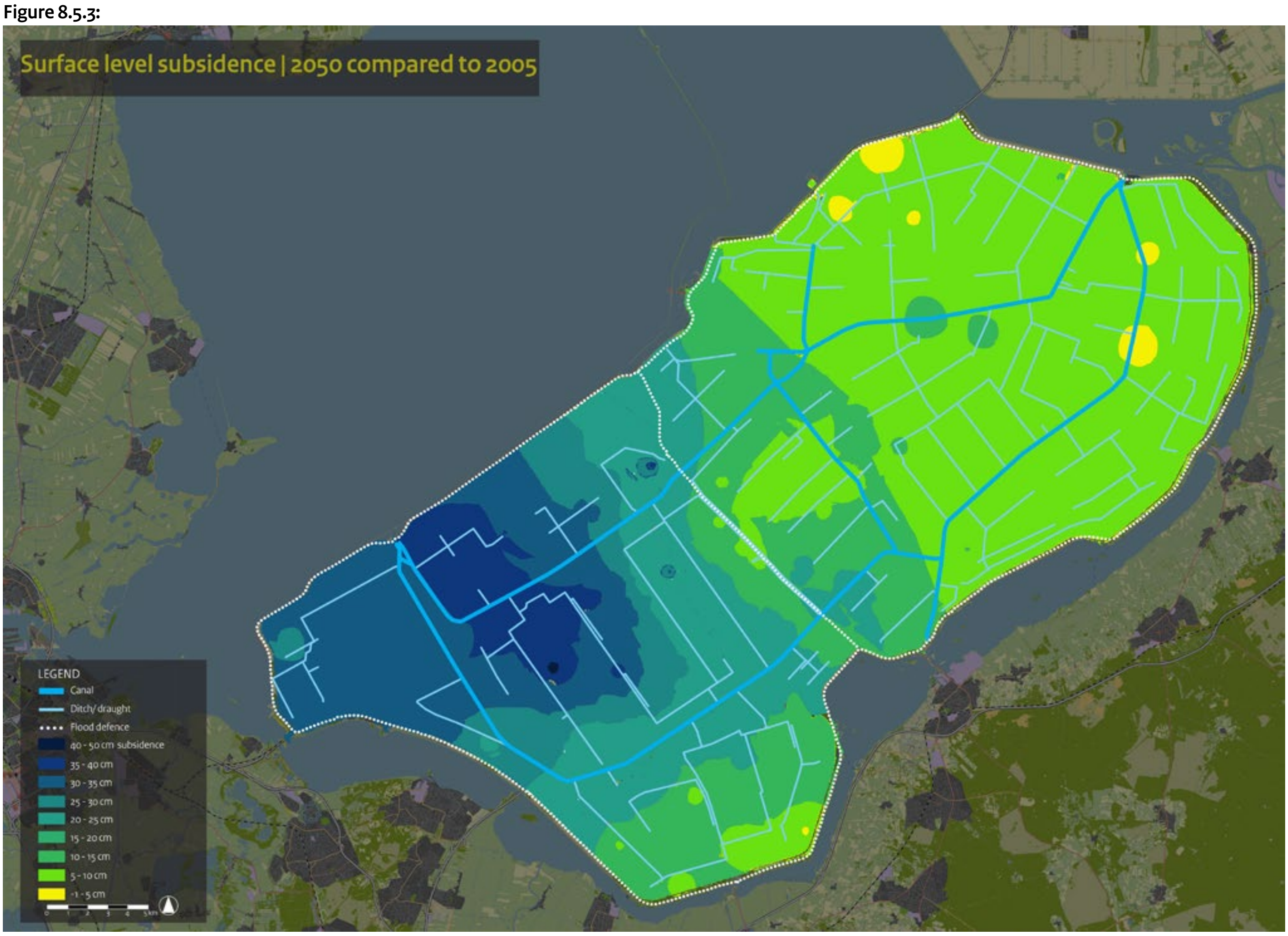


Figure 8.5.4:

Figure 8.5.5: Section of the dikes along the Markermeer and IJsselmeer.

Figure 8.5.6:

Source: based on Bossenbroek (2012)and FLOODsite (s.d.)

Figure 8.5.7:

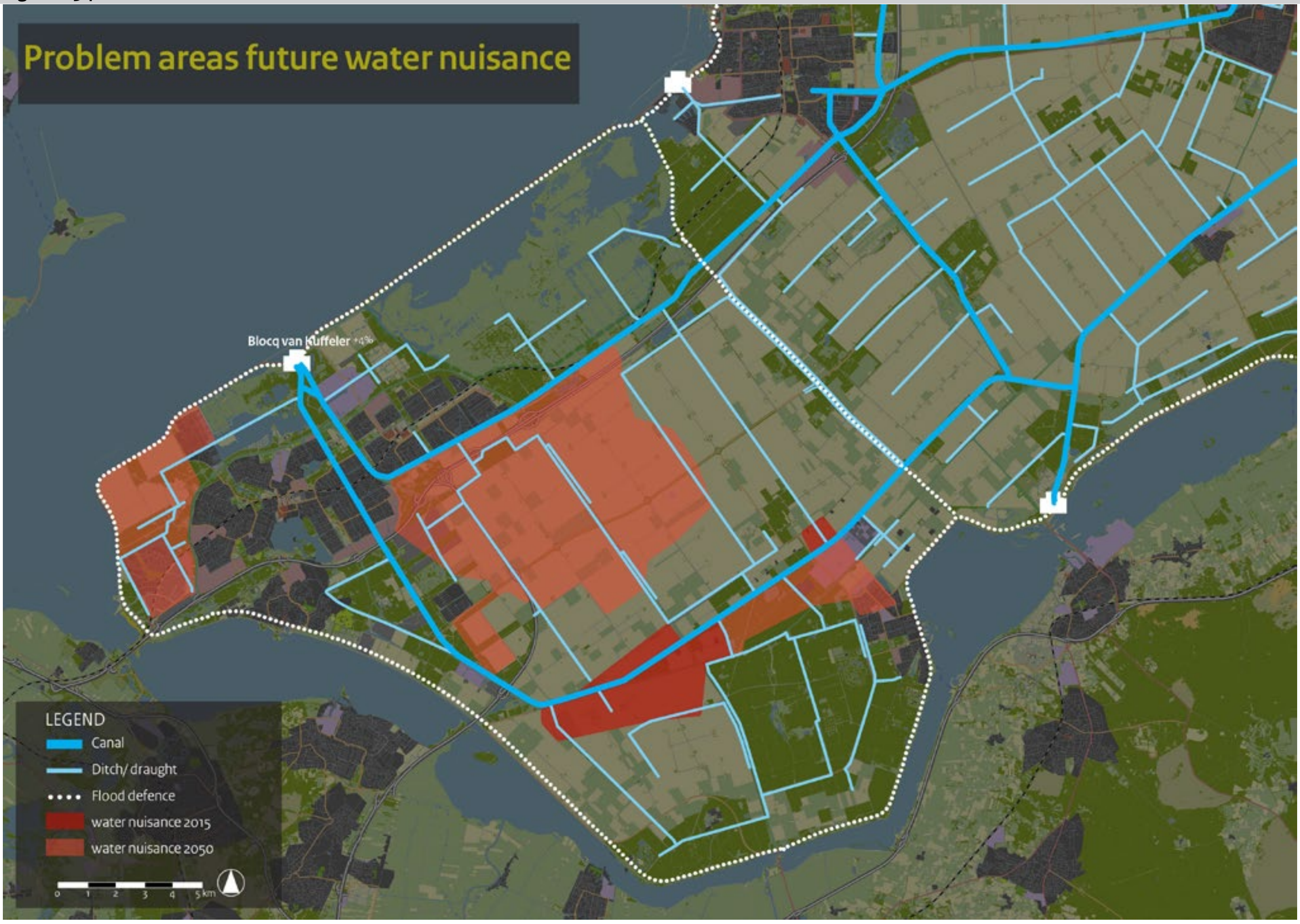
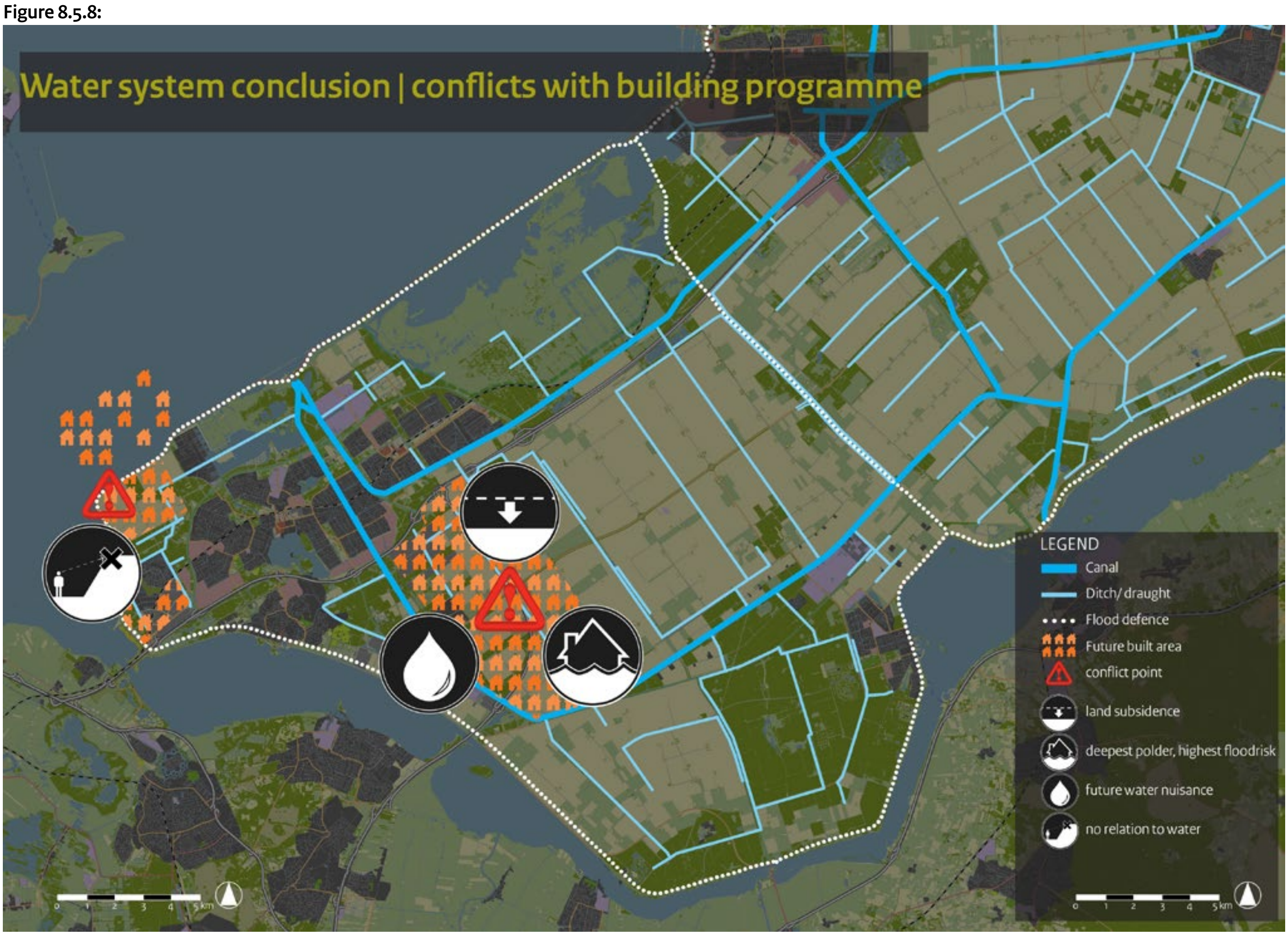


Figure 8.5.8:



8.5.2 Analysis | Infrastructure

As mentioned before, a lot of important shipping routes run along the polder. To enable shipping and recreational boats, a number of sluices have been constructed. The Nijkerkersluis, Roggebotsluis and Houtribsluizen also function as structures that compartment the water, when they are closed. The Lage and Hoge Knarsluis have to be closed for the Knardijk to serve as compartmentalization dike (fig. 8.5.9).

Due to the ideology from the 1970ies according to which Almere is designed, many transport systems are separated. Two highways run through the city; the A6 towards Amsterdam and Lelystad, and the A27 towards Hilversum, which form a separation between the cores Poort, Pampus, Stad and Buiten on the one hand, and Haven, Hout and Overgooi on the other. There is a provincial road towards Zeewolde and an orbital road around Almere. The different areas are accessed by avenues with separate lanes. The bus lane, an important part of the public transport network is also constructed separately. Through the northern part of the city runs a railroad, with the stops Muziekwijk, Central Station, Parkwijk, Buiten and Oostvaarders (fig. 8.5.14). Until recently, this railroad stopped at Lelystad, but now it is extended towards Zwolle. The frequency and capacity of this train connection will be increased. A new train station is planned near Almere-Poort (Rijksoverheid, 2012b). The map of the local public transport clearly shows that Almere-Haven is the only neighbourhood that is not as well connected as the others, because of the lack of train (fig. 8.5.15). To improve the public transport system and stimulate development on the west side, the IJmeerlijn is planned, running from Amsterdam IJburg to Almere Central Station, with possibilities to extend through Almere Oost and beyond along the A27 towards Utrecht in the form of a bus as a high quality public transport line (WAA, 2012; Werkmaatschappij Almere Oosterwold, 2012: 87).

As an alternative for the IJmeerlijn, several alternatives have been elaborated (RRAAM, 2012). When only upgrading the frequency and quality of the existing Hollandse Brug alternative, Pampus and Poort will be connected to the city of Almere with a high quality public transport line (tram or bus) from Weerwater to Almere-Poort station, Almere-Pampus, Almere-

Figure 8.5.9:

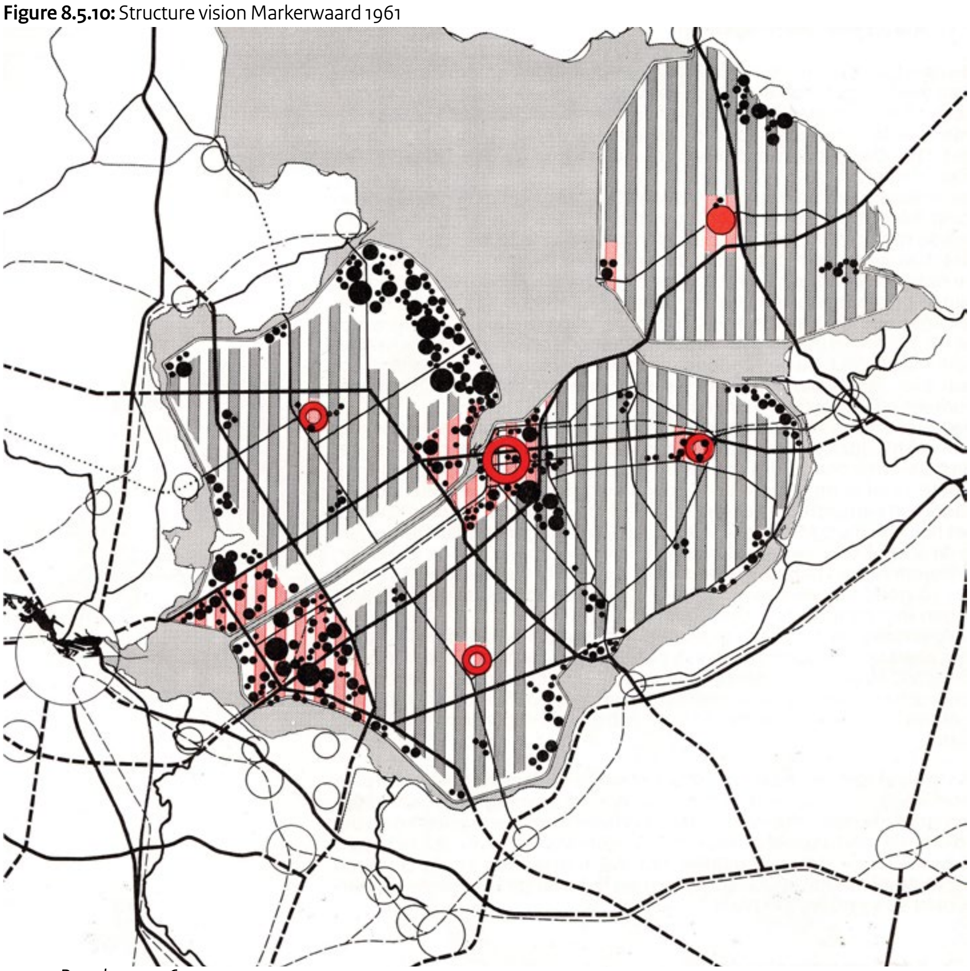
City station, and running onwards to Oosterwold and beyond. Connecting the new developments to the existing upgraded train system makes an expensive IJmeerlijn across the IJmeer unnecessary (Posad, 2012).

Plans are to upgrade the existing road system by widening the lanes, and putting a small part of the A6 along the Weerwater underground (Rijkswaterstaat, 2010; Rijksoverheid, 2012a). However, no extra bridges will be added, so the amount of exits from the 'island' will remain limited to four. Lowering the A6 will also have negative consequences for evacuation in times of flooding, because the main evacuation route will also flood. The complex structures of the cauliflower neighbourhoods increase evacuation time drastically (see also next section 8.5.3 Built Environment).

The original plans for the Zuiderzeewerken contained an extra polder: the Markerwaard. When in the early 70s of the last century the construction of the first homes in Almere began, this was still based on the construction of the Markerwaard as the third IJsselmeer polder. The city of Almere was designed based on this idea (see fig. 8.5.10). In 2007 however, the definite decision was made not to realize this polder.

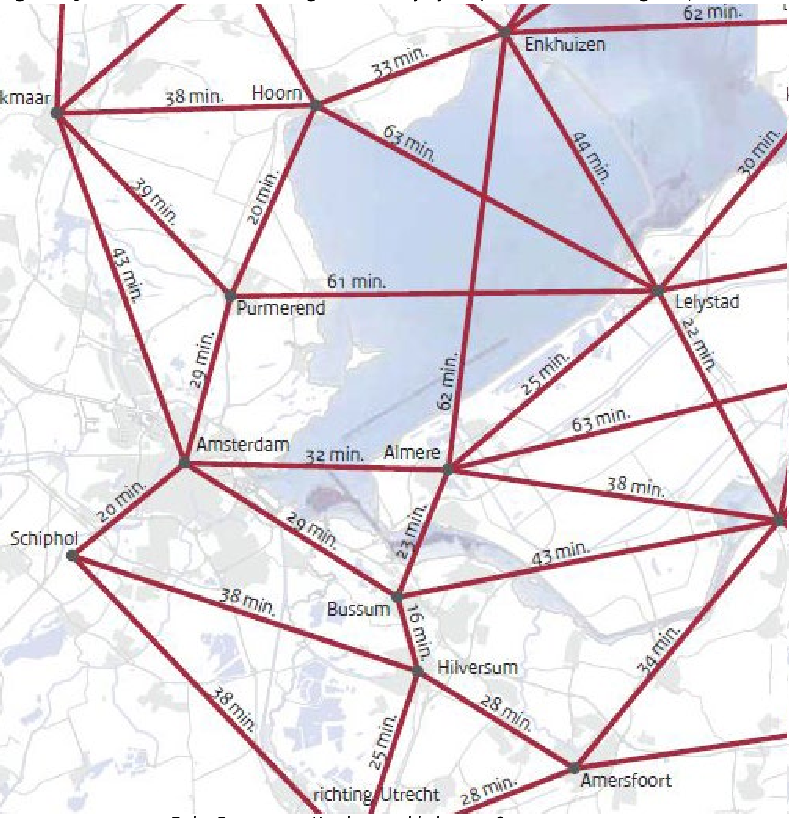
Because of the absence of the construction of the Markerwaard and thus the lack of additional infrastructural connections with 'the mainland', Almere is developing more and more along one axis. This axis is connected to the Amsterdam Metropolitan Area through the Hollandse Brug. Plans for the IJmeerlijn as an additional connection with the mainland are made to take the pressure of this one axis.

Figure 8.5.10: Structure vision Markerwaard 1961



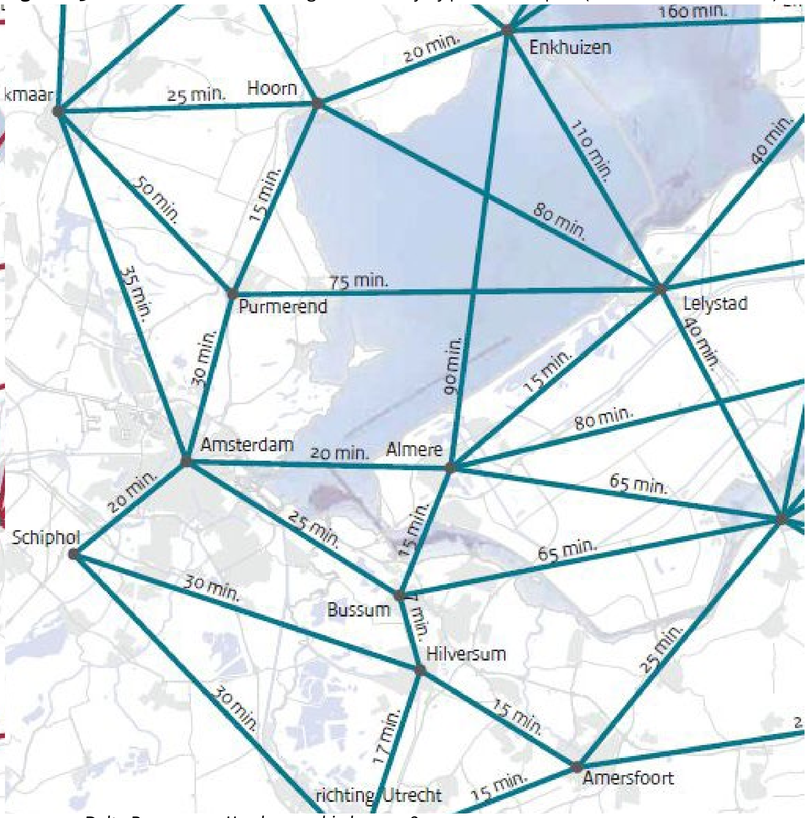
source: Posad, 2012: 16.

Figure 8.5.11: Travel times between big cities nearby by car (shortest route along land).



source: Delta Programme IJsselmeergebied, 2010: 84.

Figure 8.5.12: Travel time between big cities nearby by public transport (from station to station).



source: Delta Programme IJsselmeergebied, 2010: 85.

Figure 8.5.13:

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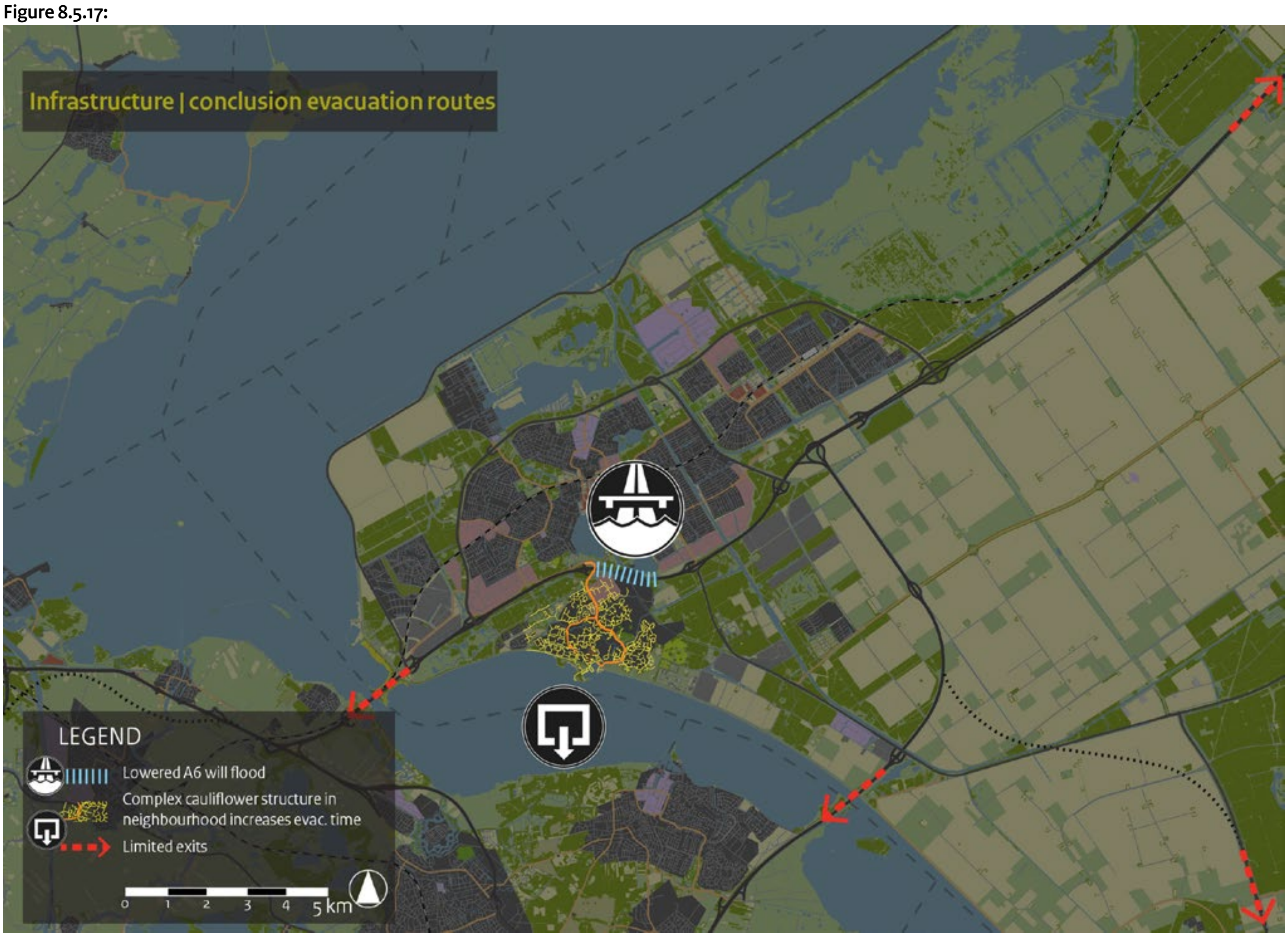


8.5.3 Analysis | Built environment

High rise is mainly found in Almere Stad and Almere Buiten. Almere Haven consists mainly of low-rise. Villa districts can be found in Almere Overgooi and Hout. Still under development are Almere Poort and Almere Pampus in the west, and Almere Oost.

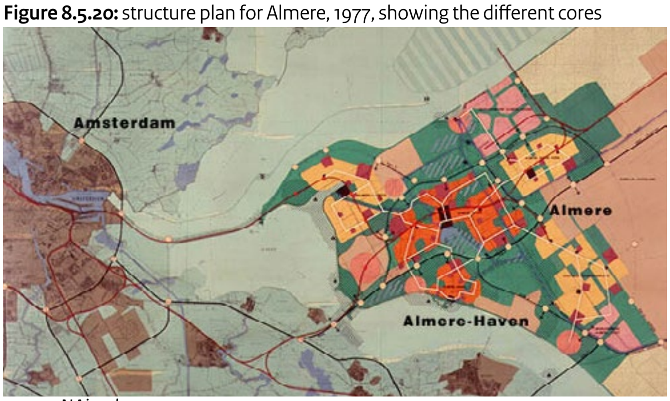
The spatial structure of Almere is characterized by the makeability. Almere is developed from the idea that a city would be makeable. However, this approach can be seen as a technocratic thinking where the inhabitants and users of the city are kept in the background. However, some argue that sociocratic thinking is very important in the development of the city; the user should be placed central. The urban design should meet the needs and interests of man. In Almere the neighbourhoods stand on their own, as was the idea of the structure vision by Teun Koolhaas according to which Almere was built (fig. 8.5.20 & 8.5.21) (Van der Most, 2011). In addition, Almere is characterized by functional separation. This means that functions are spatially separated, which has a large influence on the time and space. The inhabitants of Almere have a strong urge to move to use several functions, leading to an increased mobility.

Figure 8.5.18:

source: adapted from EduGIS, s.d.; CBS Statline, 2013

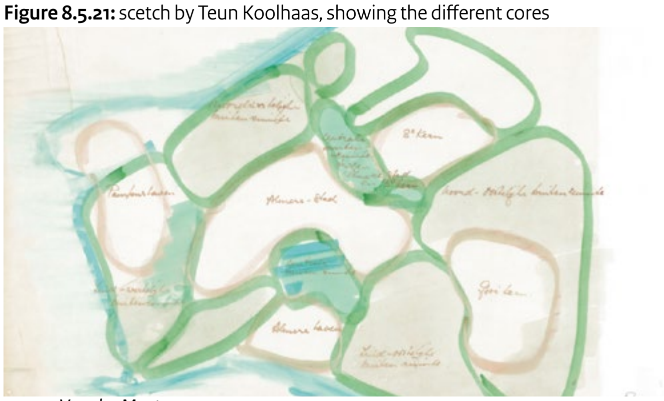
Figure 8.5.19: urban growth of Almere since the 1970ies until expectations for 2040

Figure 8.5.20: structure plan for Almere, 1977, showing the different cores



source: NAi, s.d.

Figure 8.5.21: scetch by Teun Koolhaas, showing the different cores



source: Van der Most, 2011

Figure 8.5.22: urban structure of building blocks Almere-Stad

Figure 8.5.23: urban structure of cauliflower neighbourhood Almere-Haven

Roughly five types can be distinguished in the built environment: building blocks, cauliflower neighbourhoods, town houses, villas and farm houses. Each has their own character. The building blocks can mostly be found in the centres. The centre of Almere Stad has recently been renewed, in an attempt to make the city more lively. It has become a trendy shopping centre with a lot of stores and users. The contact with the water of the Weerwater at the end of the shopping street has also been made. Here also the theatre is situated.

Because of the complex cauliflower structure in some areas such as Almere Haven, and access to neighbourhoods by roundabouts, the evacuation of the neighbourhoods in Almere takes 24 hours. In other words, if you are the last to get in your car, and join at the end of the line, you have to wait 24 hours to get on the highway. From there, it will take another 6 to 9 hours to get out of the polder. Also emergency relief and rescue operations are hereby made more difficult (Veiligheidsregio Flevoland, 2008).

Almere faces the problems of a young city. The city is often perceived as monotonous or ugly (Heijmans, 2008). This is probably because it was built in such a short time span, with cheap resources and a lot of town houses that look all the same. The recently built neighbourhoods, such as the first part of Almere Poort, also consist of town houses, but here there is more variety to the buildings, partly because of public-private partnerships where people can build on their own plot.

The types of urban structures with the lowest densities are the villa districts and farmhouses outside Almere. In Southern Flevoland the farm house and garden are usually located before a vegetation wall around the farmyard and the farm buildings. The farms were placed in groups of two or four farmhouses together, and contribute to the unique character of the vast open landscapes of the polder(Provincie Flevoland, 2011a).

Figure 8.5.24: urban structure of town houses Almere-Buiten

Figure 8.5.25: urban structure of villa's Almere-Overgooi

Figure 8.5.26: urban structure of farmhouses outside Almere

source: Google Maps, s.d.; TU Delft Maps, 2011

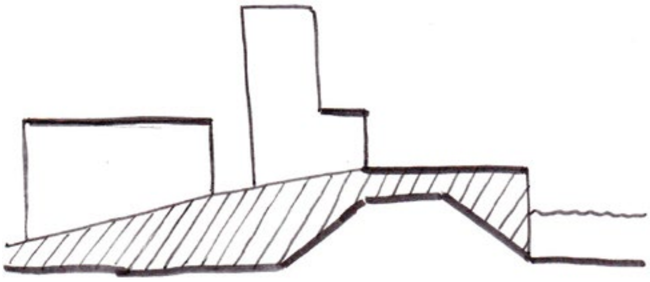


Figure 8.5.27: Early example of an unbreachable multi-functional dike (super dike) at Almere-Haven

Figure 8.5.28: Dwellings on mounds at Almere-Haven

Existing examples of impact reducing interventions: Unbreachable multi-functional dike (super dike)

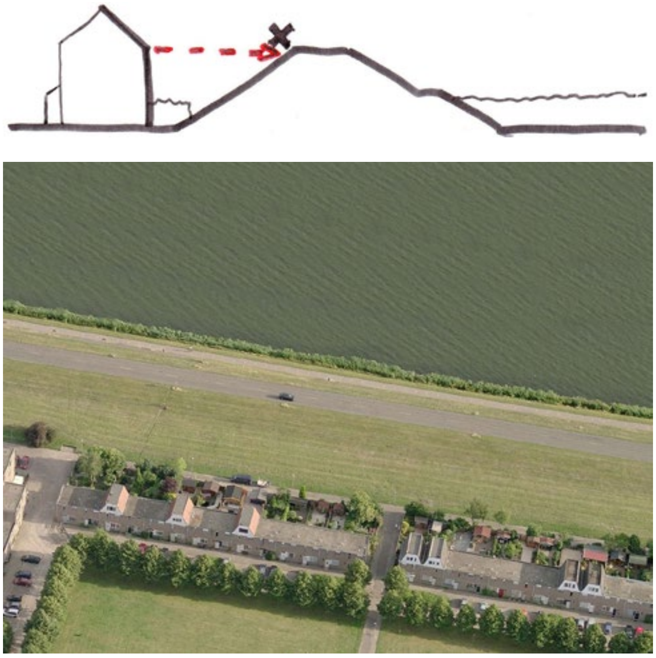
Regarding other ways of dealing with flood risk than the traditional dike reinforcement, two examples of alternative solutions can already be found in the polder. First is the unbreachable (multi-functional) dike. One that already exists is the dike around Almere-Haven. Here, the streets of Kruisstraat and Sluis gradually run up to the quay of the Sluiskade (see figure 8.5.27), with multiple functions such as facilities and dwellings placed along. Also along the quay restaurants and shops are situated. Other plans for multi-functional unbreachable dikes are the plans for DUIN in front of Almere-Poort. Here, not for safety reasons but in order to get more contact with the water, plan is to develop a large dune over the actual dike body. The municipality Almere bought land from the water board Zuiderzeeland, in order to be able to build closer to the dike; instead of the usual 45 meter from the seepage ditch, the buildings can now be placed 25 meter away, along a broad boulevard, to increase the relation with the water. Conversations with people responsible at the municipality as well as the water board learned however that the distribution of responsibilities and finances can be a tedious process.

Dwellings on mounds

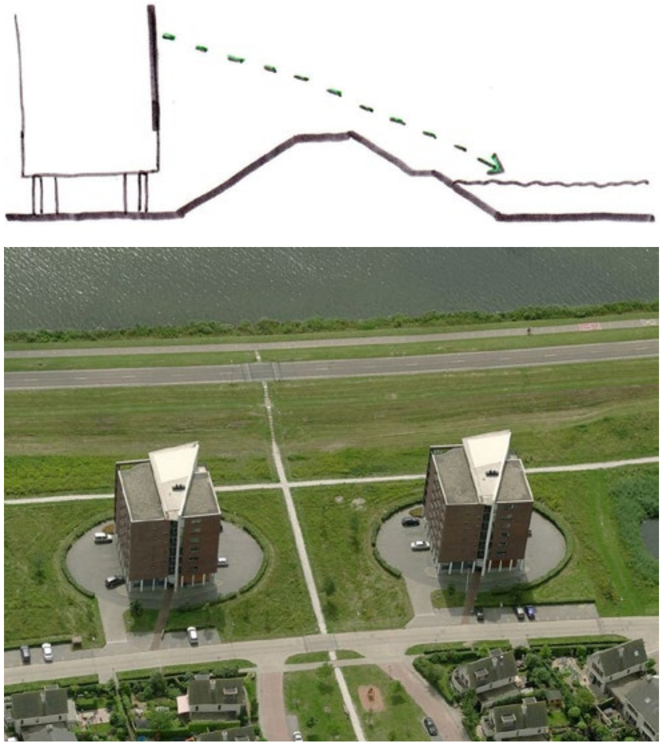
Also in Almere-Haven nine mounds are situated with residential buildings on top. Exact reason for this is not known, probably to create an exciting living environment, and not for safety reasons.

Figure 8.5.29: Plan DUIN, a very broad dune combined with other functions to be developed in front of Almere-Poort

source: Almere deze week, 2012



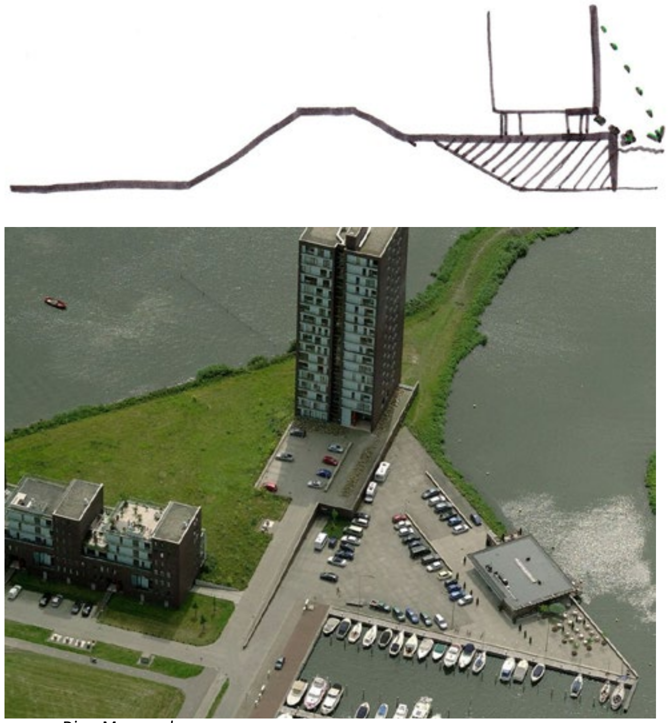
Low buildings behind the dike, without direct contact with the water



High buildings behind the dike with direct contact to the water

When driving along the water edge of Almere and the Southern Flevopolder, some good and some bad examples of the relation between buildings and water can be found. In Almere-Haven low rise is placed directly behind the dike, with their back yards towards the dike. However, next to this, a few high residential towers are built, of which the people who live on a higher floor do have visual contact with the water. In the relatively new neighbourhood Noorderplassen, there are houses with direct access to the water and a mooring for their boat. Also, a few outer dike areas, for example around Almere-Haven and the marina near Almere-Poort, can be found.

Inner dike houses with direct access from house to water



source: Bing Maps, s.d.

Outer dike houses with direct contact to the water

8.5.4 Analysis | Landscape

When Almere was built in the 1970ies, it mainly served as a place for families coming from the big city who sought peace and tranquillity in suburban residential areas. Nowadays in the Randstad still remains a task of growth and densification (De Jong & Van Duin, 2011). Moreover, a lot of valuable green areas such as the Amsterdamse Scheggen, Waterland, Green Heart, Utrechtse Heuvelrug and Naardermeer are situated in the close proximity of these cities, which cannot be built. Almere because of this faces urban pressure from both Amsterdam and Utrecht (see figure 8.5.31) (Gemeente Almere & MVRDV, 2009).

Locally, Almere possesses a few valuable green and archaeological areas as well. As mentioned before, Almere used to be land in Roman times and before. Some remainders such as settlements and shipwrecks still can be found. Also, the river Eem used to run through what is now the polder (see figure 8.5.30) (Gemeente Almere, 2012b; Provincie Flevoland, 2011b).

The IJsselmeer polders were originally constructed for food production. However, at the time the polders were ready, the demand for agricultural functions had changed in such a way that on some parts large woodlands were created, such as the Horsterwold (Barends, 2005: 90). Besides this, the Markermeer, Lepelaarsplassen and Oostvaardersplassen have been designated as Natura2000 area, and the green areas between the different cores also serve as important ecological connections between the different nature areas (fig. 8.5.32) (Arcadis, 2009; LNV, 2008; Provincie Flevoland, s.d.). These green buffers between the red cores however also function as a barrier, making Almere not one real interconnected city, but a city consisting of a lot of small, individual parts (fig. 8.5.33).

Figure 8.5.30:

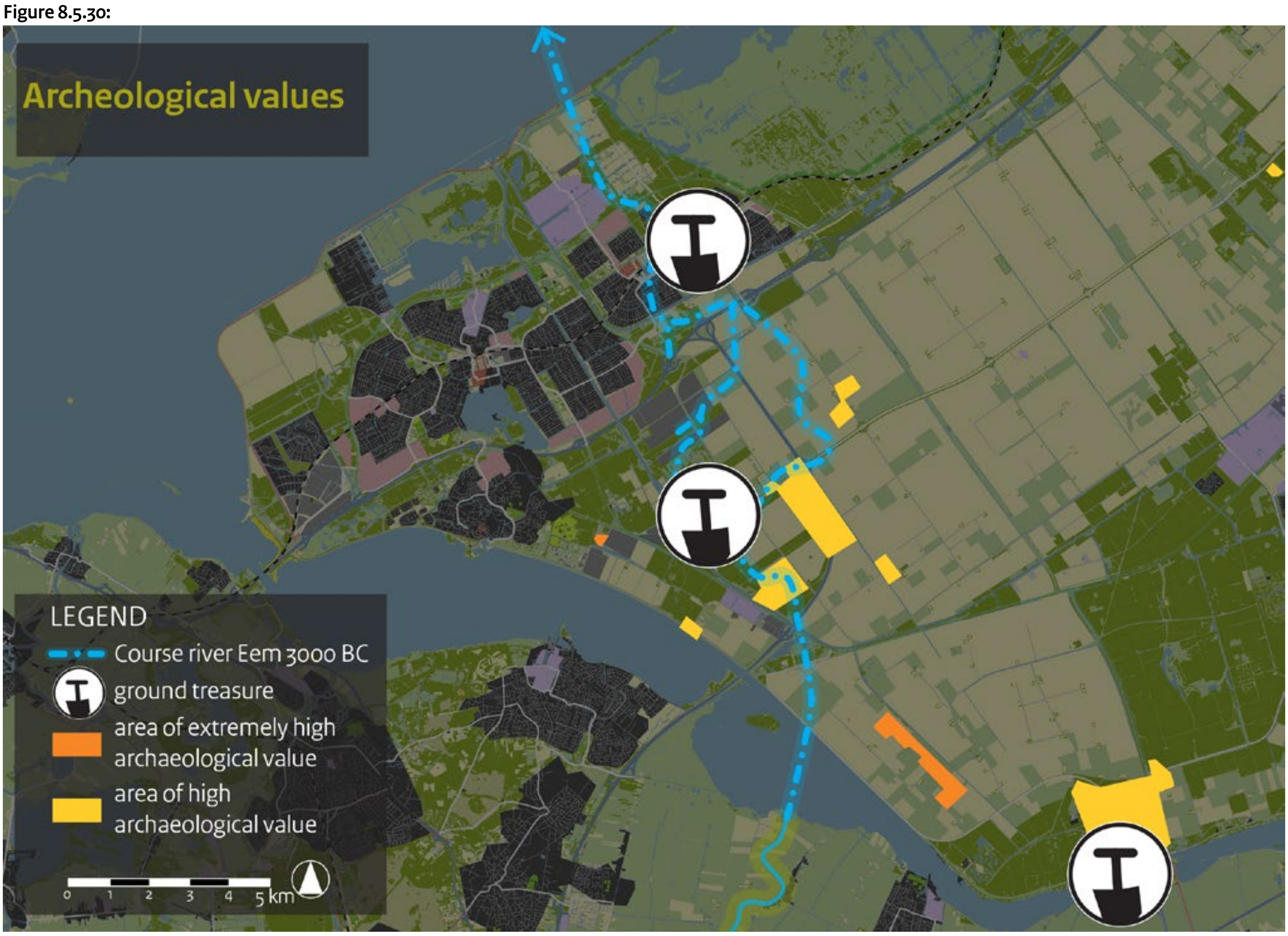


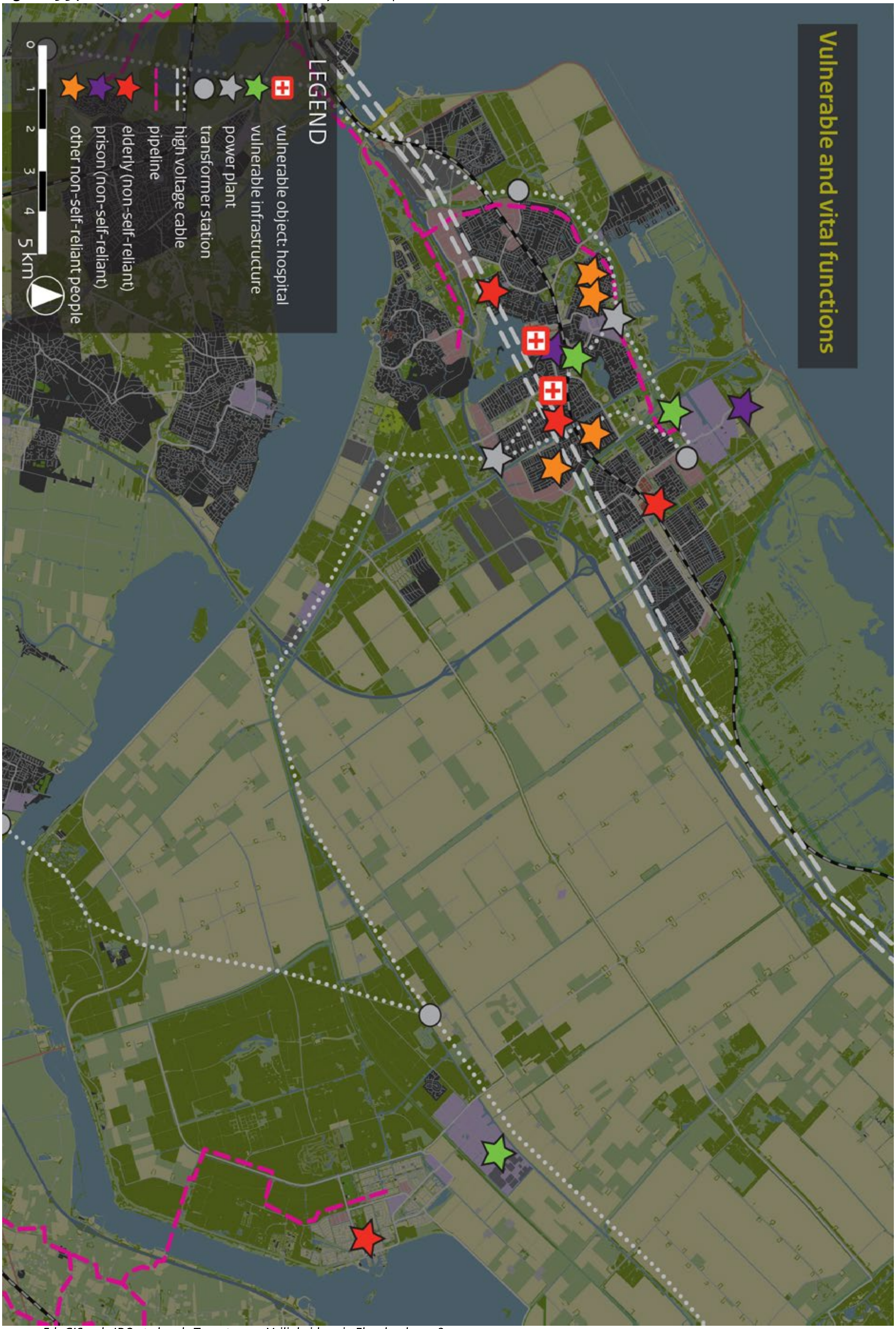
Figure 8.5.31: Valuable green areas and urban pressure from the region.

Figure 8.5.32:

Figure 8.5.33:

8.5.5 Analysis | Vulnerable and vital infrastructure and objects

Figure 8.5.34: Vulnerable and vital infrastructure and objects in the polder.



source: EduGIS, s.d.; IPO et al., s.d.; Tennet, 2011; Veiligheidsregio Flevoland, 2008

8.5.6 Analysis | Socio-economic issues

Population growth and structure

Almere is one of the fastest growing municipalities in the Netherlands. With about 190,000 inhabitants it currently belongs in the top ten largest cities of the Netherlands. With the planned growth to 350,000 inhabitants in 2030, this ranking will only rise.

The population structure in Almere is characterized by a high percentage of young people (see figure 8.5.37). Almere is one of the youngest cities in the Netherlands, so the population of Almere is also fairly young. Another reason for the high percentage of young people is the relatively large proportion of independent entrepreneurs in Almere. The city offers affordable space and easy access from and to the rest of the Randstad, making it an attractive location for young entrepreneurs.

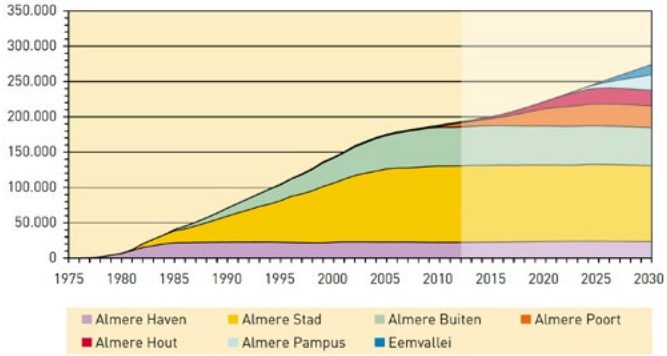
The most common type of household is a couple with one or more children, but the percentage of single-parent families and people living alone is increasing.

Figure 8.5.35: Population facts and figures

Population	
Number of inhabitants *1 January 2013*	x 10,000 = **195,138**
Number of inhabitants *2030*	x 10,000 = **350,000**
Largest group	Families with children
Immigrants	**40%** (30% non-Western)
Educational level	underrepresentation higher educated
Dwellings *1 January 2012*	x 5,000 = **76,610**
Dwellings *2030*	x 5,000 = **135,690**
Housing occupancy	**2.52**
Cars per household	**1.12**

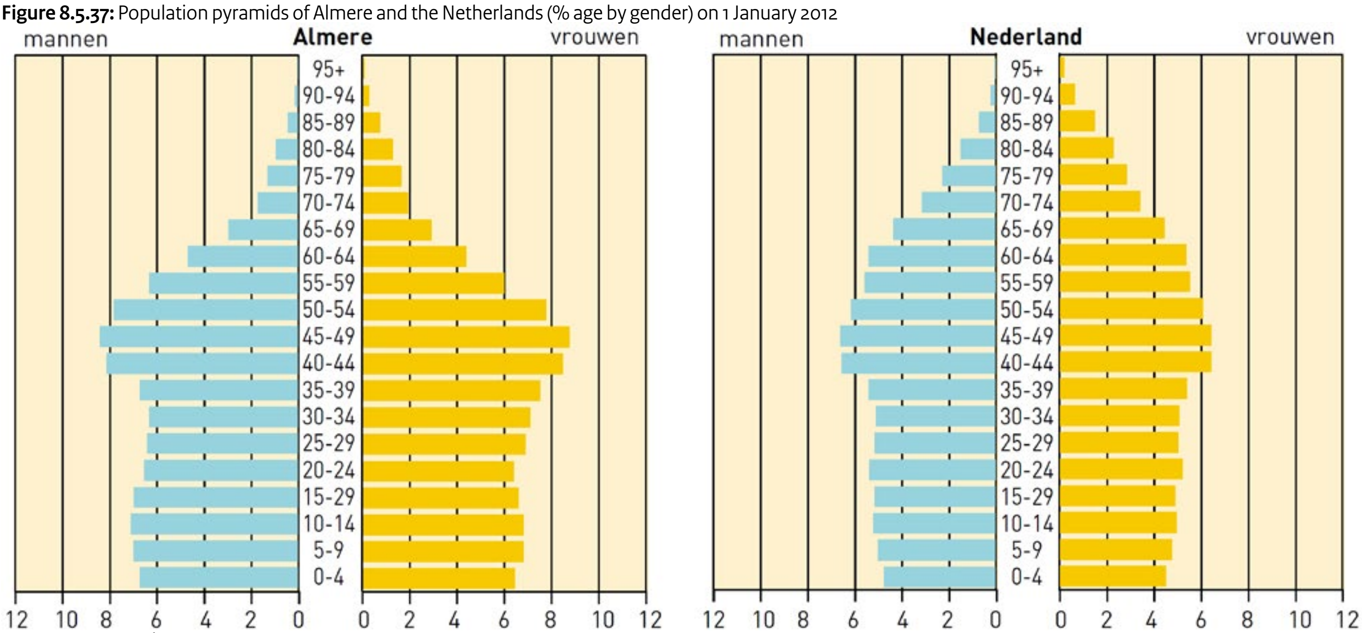
source: adapted from Gemeente Almere, 2012c

Figure 8.5.36: Development number of inhabitants per city district, 1975-2030



source: Gemeente Almere, 2012c: 12

Figure 8.5.37: Population pyramids of Almere and the Netherlands (% age by gender) on 1 January 2012



source: Gemeente Almere, 2012c: 14

Figure 8.5.38: Employment facts and figures

Employment	
Number of jobs *1 January 2011*	x 10,000 = **81,186**
Number of jobs 2030	x 10,000 = **180,000**
Working population	**97,800**
Number of jobs to 100 of working population	**84** (NL: 103)
Outgoing commuters	**43,700**
Most important employers	USG People the Netherlands B.V., Accenture Technology Solutions B.V., Mitsubishi Caterpillar Forklift, Almeerse Scholen Groep, Flevoziekenhuis, Gemeente Almere, Zorggroep Almere

source: adapted from Gemeente Almere, 2012c

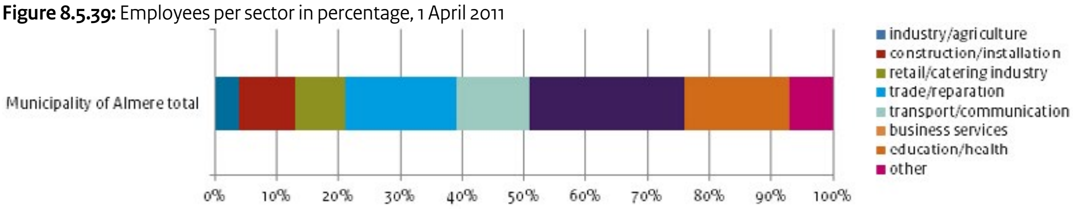
Economy

Past decade, Almere has relatively had the greatest economic growth in the region, which she owes to her pretty good business climate. The number of jobs between 2000 and 2010 grew by 65%. Until 2030, an extra growth with 100,000 jobs is planned.

The city is especially popular among start-up companies, but also offers plenty of room for businesses with options for growth. On the industrial area the Vaart a combination of industry and nature is developing. In the north-east of the city many greenhouses are situated. What is striking is that Almere knows a lot of functional separation.

Figure 8.5.39 shows that the majority of employees operating in the business sector. Moreover, the share of other services is also very large. Major employers are USG, Accenture, Mitsubishi Caterpilar, Almeerse Scholen Groep and the Flevoziekenhuis.

Figure 8.5.39: Employees per sector in percentage, 1 April 2011

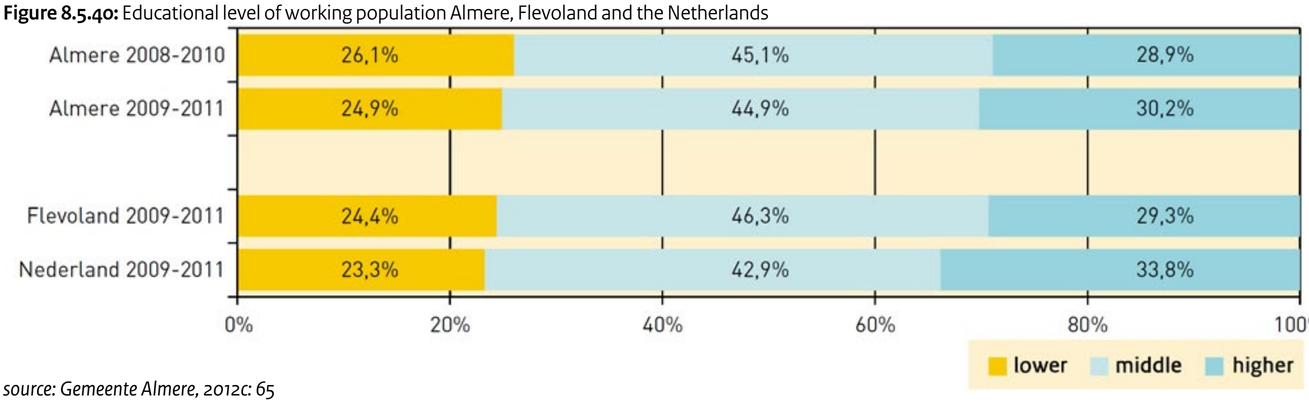


source: adapted from Gemeente Almere, 2012c: 102

Education level

The share of highly educated people in Almere is lower than in the rest of the Netherlands (fig. 8.5.40). This phenomenon is difficult to explain, but it may be that people who want to follow a higher education leave to other cities. Almere has little to offer in the area of higher education (one annex of La Salle business university, only two annexes of HBO), making these individuals forced to follow the educational program of their choice in another city. Usually, this also means that this person moves to the city concerned. Chances are that this student feels more connected with their study city than with Almere city, and that the person continues to live there for several years.

Figure 8.5.40: Educational level of working population Almere, Flevoland and the Netherlands



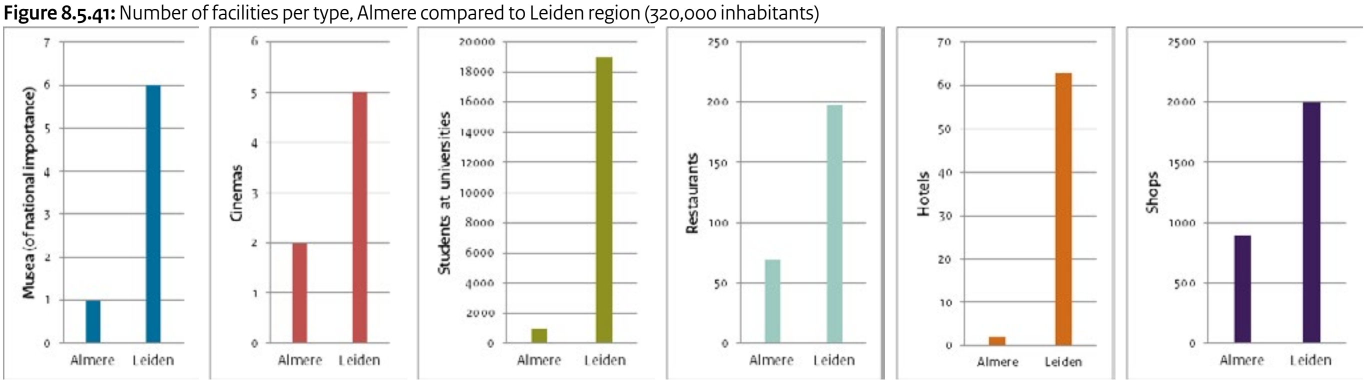
source: Gemeente Almere, 2012c: 65

Facilities and leisure activities

Almere is designed in the 1970ies in such a way that each neighbourhood was close to a beach or forest. Moreover, in Almere much space is created for an individual way of leisure activities, in the form of allotment gardens, city meadows and bees' gardens. Sports also are ubiquitous, with a large variety of sports facilities. Almere has 132 indoor and 137 outdoor sports accommodations. The sports facilities such as sports halls and swimming pools, are scattered in Almere and have a large number of visitors every year. The theatre of Almere has a great popularity, with 92,772 visitors in 2010 for different types of performances. The festivals that take place in Almere have a great attraction at regional and perhaps national level. In 2011, the amount of visitors of festivals and other events in total added together to 637,000 people (Gemeente Almere, 2012c).

However, compared with other regions with around 350,000 inhabitants such as the Leiden region, Almere has to grow a lot in terms of facilities (figure 8.5.41). The number of restaurants is ideally seen as an indicator of urban atmosphere life in combination with prosperity and wellbeing. Research by INTO (2007: 44) shows that the current facilities of Almere, particularly regarding hotels/restaurants/cafes, culture and tourist attractions, and in lesser extent in terms of shops, is regarded below standard. The amount of facilities, measured by the number of jobs in those sectors compared to the population size, is insufficient. In qualitative terms, not only historical heritage is missed, but also the small mix of own, authentic shops and cultural activities.

Figure 8.5.41: Number of facilities per type, Almere compared to Leiden region (320,000 inhabitants)



	Musea	Cinemas	Theatres	Music halls	Galleries	Students at University	Hospital	Restau-rants	Hotels	Cafes	Shops
Almere	1	2	2	4	7	1000	1	69	2	29	900
Leiden	6	5	7	1	6	19000	1	198	63	63	2000

source: INTO, 2007: 42,43

Figure 8.5.42: Facilities

source: adapted from Gemeente Almere, 2012c; INTO, 2007: 40; opentot.nl, s.d.


View from car on Oostvaardersdijk

8.6
LITERATURE REVIEW PAPER

View from airplane to Southern Flevopolder , source: Wikipedia

Fighting or embracing the water?

Towards integral alternative flood control planning strategies in the Dutch spatial planning practice

Course AR3U022, Theory of Urbanism
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31 January, 2013
11th Graduation Lab Urbanism Conference

Abstract – In the Randstad and the major cities in the Netherlands still remains a task of densification, mostly in areas with a high flood risk. Question is how planners and urban designers can spatially anticipate on flood risk in new developments and re-development areas. Nowadays, it is either fighting against water, or working with it. The traditional Dutch flood management still focuses on prevention. Over the years, a feeling of insecurity led to heightening dikes, which led to a greater sense of safety. Because of this, the land will be more intensively used, which will again lead to more flood risk, and so back to heightening dikes, and so on.

This illustrates the dominant approach towards water management, a technical one aimed at ensuring safety and protecting land by blocking out water. It also illustrates the lack of integration between water management and spatial planning: water boards construct and maintain dikes, and behind the dikes planners and urban designers develop land use plans, without worrying about flood risk. Raising dikes however not always contributes to spatial quality of an area. Furthermore, implementation of climate proofing measures in urban development today may considerably reduce costs for tomorrow. Spatial measures can be taken not only to prevent floods, but also to lower the impact. This approach, the so-called multi-layer safety approach (MLS), has been introduced in the National Water Plan (NWP). Somehow a balance must be found between measures on these different layers.

This paper will provide an overview of the spatial interventions that can improve the physical water safety on all the three layers of multi-layer safety, based on a literature review. It will organize these interventions based on different scales and layers of multi-layer safety they operate on. This is the first step to be used as a tool for developing a framework for comparative assessment to balance the different interventions. It will help communication between planners and designers, to help develop certain strategies for floodproofing new development and re-development areas, to contribute to integral spatial planning.

Key words – flood control policies, multi-layer safety, flood risk, urbanized delta, control paradox, climate proof, climate change

1 Introduction

1.1 Worldwide climate change

The climate is changing (IPCC, 2012). The sea level rises and the peak discharges of rivers increase. Moreover, intensive precipitation occurs more frequently. These are hard to absorb locally and can lead to water nuisance and damage. In addition, longer dry and hot periods can lead to unpleasant urban living conditions and lowering of the groundwater level. This leads to dehydration of the soil, causing oxidation, and thus soil subsidence (Goudie, 2006; Kundzewicz et al., 2007; Parry et al., 2007).

1.2 Flood risk in built-up deltas

Fifty-five percent of the Netherlands is sensitive to flooding (Alcamo et al., 2007: 547). A big part of the country lies below sea level, and large rivers like the Rhine, Meuse, Scheldt and Ems flow into the sea through the Netherlands. The regions where the risk of flooding is the greatest, are the most densely populated and intensively used. Moreover, these areas increasingly cope with densification and further urbanization. This makes the impact of floods increase, because more lives and property are at stake. The Netherlands is therefore a so called 'red delta'. For these regions there is a special planning task (Van Drimmelen & Oosterberg, 2005; Hidding & Van der Vlist, 2003).

Furthermore, these areas contain more paved surface, accelerating the urban runoff of water, causing compaction of the soil. This way, the land keeps getting lower relative to the water level, causing mainly the impact component of flood risk to increase.

Risk is generally defined as the product of probability × impact (VenW, 2007: 51). Regarding flood risk this means "the chance of negative consequences of floods" (Klijn et al., 2007). These consequences consist of four types of damage: damage to human health, economic damage, social disruption and political damage (Pols et al., 2007: 48).

2 Traditional and alternative flood policies

2.1 A shift in discourse

For centuries the Dutch have reclaimed land and protected themselves against water (coming from rivers and seas) traditionally by the construction of higher and stronger levees (Brouwer & Van Ek, 2004). This illustrates the dominant approach towards water management, a technical one aimed at ensuring safety and protecting land by blocking out water (Voogd & Woltjer, 2009: 189). In planning there are however more ways to deal with flood risk. Wiering and Immink (2006: 429) speak in this context of the safety discourse[1] of the 'battle against water', the existing Dutch planning doctrine of separating water and land use while relying on dikes. This may be a cost-effective approach, but perhaps not so sustainable[2] towards the future. When we look at the ecological and socio-economic advantages on the long term, there is a strong case for alternative flood control policies. First, implementation of climate proofing measures in urban development today may considerably reduce costs for tomorrow (PBL, 2011: 44). Furthermore, by artificially controlling water levels and systems, ecosystems get more vulnerable. Moreover, due to future climate change and further densification, social and economic consequences of floods increase. Nowadays, we can hardly afford floods, because every risky place is built-up. We are, as it were, caught in what is often referred to by professionals as the *control paradox* (fig. 1) (Remmelzwaal & Vroon, 2000; Wiering & Immink, 2006). Over the years, a feeling of insecurity led to heightening dikes, which led to a greater sense of safety. Because of this, the land will be more intensively used, which will again lead to more flood risk, and so back to heightening dikes, and so on. The result is that disasters such as floods occur less often, but when they occur, the impact and damage increase. To shift from traditional to alternative flood control policies, a change of discourse is needed. This way, 'fighting water' changes into 'embracing water'.

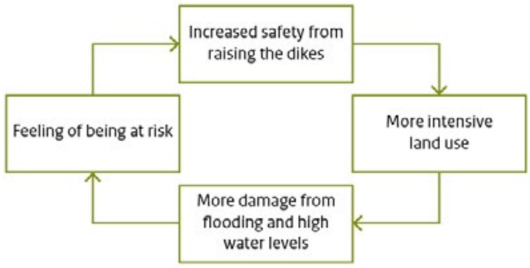

Figure 1: The control paradox
Source: Wiering and Immink (2006: 430)

2.2 Water safety in the Netherlands

On national level the climate challenges are now acknowledged and treated in the National Water Plan 2009-2015 (NWP), and the latest Delta Programme (DP2013) (VenW et al., 2009b; IenM & EL&I, 2012). With the introduction of the NWP, response was given to the call for an alternative policy, and a political choice was made for the multi-layer safety approach (MLS; fig. 2). This approach consists of three layers: '*1 Prevention as the policy cornerstone*', '*2 Sustainable spatial planning*' and '*3 Systematising and sustaining disaster mitigation*' (VenW et al., 2009b: 71). This is done to limit the *residual risk*.

The first layer, prevention, responds to the probability-component, whereas the second layer – impact reduction – addresses the other component of flood risk. The third layer is that of disaster mitigation: measures aimed at minimization of victims, damage and social disruption. The

[1] *Discourses* are images and concepts that are connected to each other and together give meaning to social and spatial phenomena (Hajer, 2006).
[2] *Sustainability* means that "current and future generations must strive to achieve a decent standard of living for all people and live within the limits of natural systems" (Berke et al., 2006: 11).

Figure 2: Multi-layer safety (MLS) in picture
Source: VenW et al. (2009a: 15)

distinction between the three layers is not absolute. Reasons for interventions in layer 2, such as adjusting evacuation routes, can come from the third layer, while strengthening a dike to prevent floods – layer 1 – needs space. Reserving this space then again belongs to layer 2.

However, integrated solutions are often difficult to achieve because our spatial planning is still organized in a very sectorial way. Primary responsibility for prevention rests with the Dutch ministry of Infrastructure and the Environment (IenM) and water boards. Provinces, municipalities and IenM are responsible for safe and sustainable spatial planning. The safety regions and the ministry of the Interior and Kingdom Relations (BZK) coordinate disaster management (VenW et al., 2009a: 16,19,28). This illustrates the lack of integration between water management and spatial planning: water boards construct and maintain dikes, and behind the dikes planners and urban designers develop land use plans, without worrying about flood risk.

Raising dikes may also be an administratively simple solution, but with a strictly preventive strategy a lot of opportunities are missed for an integral approach that adds to other values, such as spatial quality and other spatial planning assignments which are typical for every urban area in the Netherlands, e.g. realising desired program, water nuisance, as well as water shortages and heat stress. Somehow a balance must be found between measures on these different layers, taking these criteria into account. A precise research is needed on what is possible, and desirable.

3 Physical measures on different layers of MLS to reduce flood risk

3.1 Urban and spatial factors that influence flood risk

Purpose of this paper is to provide an overview of the spatial interventions that can improve the physical water safety on all the three layers of MLS, based on literature review. In order to do so, a quick understanding of urban and spatial factors that influence flood risk is needed.

Water safety depends on flood characteristics, the socio-economic value and the arrangement or organization of an area, and on how emergency services and inhabitants cope with a flood. Behind these variables is a number of urban and spatial factors, described below.

First, flood characteristics are important. The Province of Utrecht (2010: 15-21) lays out eight indicators that influence how high the water will come, where the water speeds are high, how fast an area will flood, and how long it takes until an area falls dry again. First, **frequency** is important. This depends on the probability of a dike breach. For primary water defences these probabilities are smaller than for regional and secondary water defences. For example, the safety standard of dike enclosure 8 – in which Almere is situated – is 1:4,000, whereas the standard of the Knardijk is lower. In an outer dike area, these probabilities are even higher. Besides factors that are taken into account for this standardization – among others wind direction and velocity, weak spots in the underlayer, constructions in the dikes, dike height, slope, exceedance of normative water level and wave height, and hydraulic loads (Klijn et al., 2007: 4-1) – insecurities such as climate change, terroristic attacks, the probability of failure of a mechanism of a water defence, human action et cetera play a role.

Second indicator is **time of arrival**. Whether horizontal evacuation out of the area and preparing for a flood is possible, depends on how long it takes before the water reaches an area. A flood in the river areas for example is predictable long before, so that the warning time is long. Floods from sea or the IJsselmeer however, are hard to predict, making

3

vertical evacuation (through the air and up a building) the only possibility to escape the water. Areas on flood risk maps that are indicated as 'quick' when the water arrives within nine hours after a breach (Pieterse et al., 2009: 12).

Regarding time of arrival on a smaller scale, because water flows to the lowest point, not everyone in a flooded polder has to get wet feet at the same time. For the flow of water, ground levels, water level, spatial elements in an area that block the water or push it in a different direction, the street pattern and the pattern of waterways are important. Spatial elements that retain the water, such as rows of connected buildings and compartmentalization dikes, can force water to find another route. To win time, water could for instance be guided to lower, undeveloped parts of a polder.

Thirdly, water safety depends on **water depth,** which is determined by the distance to the source of the flood, and the ground level. When the water is higher than 50 centimetres, cars can no longer drive, and people cannot leave the area with motorized vehicles. When it will become higher, people can drown. High buildings and higher areas should be used then. When for instance compartmentalization dikes are present in the area, this can mean that the area between the compartmentalization dike and the place of the breach will flow deeper and sooner; the so-called 'bath tub effect'. This effect has two consequences: on the one hand the water depths on the other side of the dike are strongly reduced or even zero. On the other hand the water depth on the side of the dike breach will be significantly higher, and thus the situation here becomes more hazardous. The choice for compartmentalization will thus be a consideration between both consequences.

High flow velocities lower the water safety, because material can be washed away, and people can be taken by the current. This term is interconnected with **water pressure**. High flow velocities mostly occur near a breach and locations where the water needs to pass a narrow gap, for example between two buildings. Street patterns therefore influence flow velocity and **ascent rate**. The size of a breach and the high tide determines how much water will flow through the breach or over the water defence, and with what velocity. This determines the way in which the water will rise. In deep polders the water will rise rapidly to a great depth. In case of the previously mentioned 'bath tub effect', ascent rates are also high. When a polder is divided into compartments, one compartment will fill up faster and deeper then when the water would be spread throughout the whole polder. Urban elements that can function as a compartmentalization, such as a railway embankment, a road emplacement, or a long row of uninterrupted buildings, influence the ascent rate. Ascent rates are important for water safety, because the time people have to evacuate depends on this.

Water pressure also influences water safety. Because of flow and ascent velocities water puts a certain pressure on the objects in the flooded area, damaging material, because it will be smashed or washed away. People are also hindered by high water pressure, because moving through the water becomes more difficult.

Seventh factor that influences flood characteristics is the **duration of the flood.** This depends of which water defence has failed and in what way – is it a regional or a primary water defence, is there a breach in the dike, or does the water only flow over the dike because of a high water level? – and how fast the flood is contested or ceased. When for instance along the Southern Flevopolder a dike along the Randmeren breaches, a relatively smaller area will flood, because these waters are compartmentalized. A limited amount of water will flow into the area. When however a flood occurs from the Markermeer or IJsselmeer without the dams in the Knardijk being closed, the water will flow into the polder until the water levels at both sides of the dike will reach the same height, or the breach has been fixed. Extra pumping capacity can be used to drain the area sooner, with the higher areas falling dry first (ground level thus, besides water depth, influences the duration of the flood as well). It will however take longer before the flooded area will be **liveable** again. When in the construction stage of buildings flood proof materials and way of building have been taken into account, these buildings will stay during a flood, and can be used again sooner after.

Final factor mentioned by the Provincie Utrecht (2010: 20) is the **unexpectedness** of a flood. According to the Province of Utrecht, high water levels of rivers can be forecasted several days ahead, while a storm on the Randmeren, with a dike breach as the result, is hard to forecast. Whether inhabitants can flee out of the area – horizontal evacuation – or don't have time for this so that vertical evacuation is the only option, depends on the warning time. Therefore, places to escape to, such as shelters, are necessary. For this, higher grounds in the area can be used, but also higher specially equipped buildings.

Besides flood characteristics, socio-economic characteristics play a role. When in a flooded area a lot of functions with high economic value are

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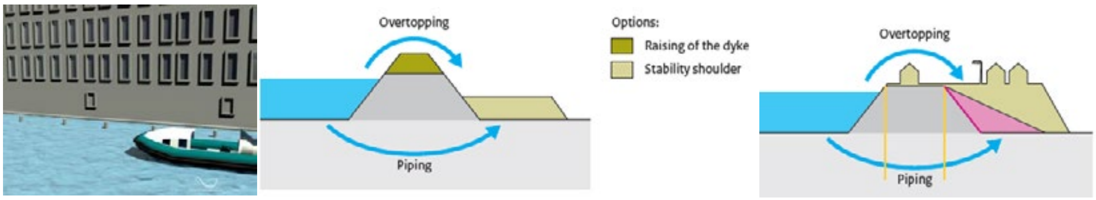

Figure 3: a building as a water defence; conventional and unconventional solutions for dyke reinforcements. Source: Provincie Utrecht (2010: 38); PBL (2011: 25).

situated, the impact will be greater than in a flooded area with little economic value. Related to this is the density of an urbanized area (in percentages of built area or number of inhabitants). This indicates how much material damage or damage to people will occur. When a densely populated area floods, the chance of a fatality is higher, because there are more people. Besides that, everyone tries to escape at the same time, which makes it more difficult in a densely populated area than in a thinly populated area.

The lay-out of an area, of which in the above already a few characteristics are mentioned, is also important for water safety. For instance, the street height determines the time people have to escape. The level of the ground floor related to the surface level determines whether the water will infiltrate the buildings at once, or whether there is a buffer. Use of materials and way of constructing can also influence the way the water damages the buildings in the flooded area.

Flood characteristics influence also the way a flood is handled – the third layer of disaster management. Whether people anticipate on floods, depends on the awareness of inhabitants and managers. Awareness of course is a psychological and not a spatial factor. Nonetheless is stopped to think about this, because an action perspective is of high importance for water safety: of course people must know what to do during a disaster, but already in the pro-action phase people can act. These actions can be spatial, for instance the water robust organization of an area with a high flood risk. People can also be made aware of the fact that they are in a flood risky area by spatial measures. This is shown in Dordrecht, where water has such a prominent role because of the tidal influence. Spatial and urban elements also can indicate the evacuation routes through and out of the area. Following sections will go further into this.

3.2 Spatial interventions per layer and type

The overview is shown in figure 5. The interventions are organized based on the different layers of MLS as described in the NWP, per approach and category of intervention (what does the intervention do to improve water safety on that layer?) and per scale they operate on. These scales – polder, neighbourhood and building/person – are derived from Xplorelab (2008c). In the first layer interventions can also take place outside of the polder. In terms of approach of these layers, in the first layer outside the polder the hazard source can be reduced. Interventions in the polder itself can reduce exposure. In the second and third layer a rough division can be made between reducing exposure (by reducing the number of people or objects in a risky area or preventing the water from reaching the objects or people) and reducing vulnerability (by reducing or preventing damage of flooded objects).

3.2.1. Layer 1: prevention

The prevention layer mostly includes interventions on a large scale, because in this paper prevention is defined as the prevention of a flood of the polder. Preventing floods on a neighbourhood or building scale (when the polder is already flooded, but a neighbourhood or building is kept free of water) is part of impact reduction.

Firstly outside the polder measures can be taken to prevent the polder from flooding. A flood wave can be kept out by strengthening levees elsewhere, so that it will not breach (for instance, in the case of Amsterdam, the Lekdijk near Amerongen). This can possibly be in combination with emergency flood plains elsewhere. In the case of the Zuidplaspolder, increasing the safety norms and reliability of the storm surge barrier (Maeslant- and Algerakering), and compartmentalization of leading big waters (rivers) is suggested (Xplorelab, 2008c: 6-7). By compartmenting these waters, for instance by partitions underneath bridges, the water volume is reduces, maybe even in such an extent that the flood wave will be kept out of the region. Also to keep a high water wave from the river area outside the region, river discharges can be redistributed. By constructing a flood channel, the water will be diverted downstream. Moreover the flow rate[3] can be redistributed over existing river arms and canals, and additional canals and rivers can be dug (Pols et al., 2007: 94). To make sure that for instance the Lekdijk

[3] The amount of m^3 water a second which passes a certain point in a river.

Figure 4: Building elevated: building elevated on poles, a non-livable ground floor, or a difference in level between street level and ground floor.
Source: Provincie Utrecht (2010: 42, 43, 60).

near Amerongen will not breach, extreme forces on water defences can be prevented, for instance by topping off the flood wave, and by other measures from the Room for the River program. Emergency flood plains, increasing and deepening summer beds, artificial and natural water buffers can add to this (Pols et al., 2007: 94-97; Xplorelab, 2008b: 14). In the plans for New Orleans after hurricane Katrina an artificial island in front of the shore was proposed, which can mitigate possible high waves as a result of – in the case of New Orleans – a hurricane (Meyer et al., 2009). Preventive measures in the polder are mainly aimed on creating more or strengthening existing water defences. There are a lot of different types of water defences: natural (dunes), dams, retaining walls, quays, et cetera. Buildings can also function as a water defence (figure 3). Water defences can be strengthened by sand nourishment (dunes), or by broadening or heightening. Example of sand nourishment is the pilot "Sand Engine". Twenty million cubic meters of sand is put in front of the coast of Delfland. Natural flow and sedimentation processes will redistribute the sand, leading to coastal accretion and development (VenW et al., 2009a: 26). In the light of future reinforcements, reserving space along embankments is required (see also section 3.2.2). A delta dike for instance is a broad dike with a very gentle slope. This is strong enough to exclude a breakthrough. Water can only flow over it, but cannot erode the dike. The dike can also be built on, making the buildings part of the dike and eliminating the barrier between water and hinterland. Nowadays, so-called '*ijkdijken*' can indicate 48 in advance by electronic monitoring if there is a chance for a breach. A cascade of dikes, placing dikes in steps, is also reinforcement. The flow of water inside the dike can also be controlled by water defences with controllable inlets and flood proof water defences. If as a result of climate change, storm surge barriers, such as the Algera barrier in the case of the Zuidplaspolder are closed longer, and a pumping stop is announced, overflow areas in the polder can be a measure to prevent water nuisance in vulnerable areas.

3.2.2 Layer 2: impact reduction by sustainable spatial planning

Impact reducing interventions can take place on different scale levels. Also the approach of the interventions can differ: measures that reduce exposure by reducing the amount of objects and people in the risky area, measures that prevent the water from reaching the objects, and measures that reduce vulnerability by preventing or reducing damage to affected objects.

The number of objects and people in risky areas can be reduced by elevating the area, or by reconsidering location choices. Elevation can be on the scale of the polder, neighbourhood or building. There are natural high areas, but also artificial high grounds, such as the outer dike harbour areas in Dordrecht and Rotterdam. These grounds can be elevated by filling them up with sediment. To reduce flood risk, this should be done up until the calculated inundation depth. In very deep polders, this can also reduce problems with rising groundwater and seepage, as is the case in the Zuidplaspolder. Here, the groundwater levels per subarea differ in such a way that a cascade of mounds is chosen. In case of a flood 1.3 meter (1.6 meter including a small correction for waves) will be the maximum water depth in Moordrecht, due to compartmentalization by the surrounding levees and the ability to close the Hollandse IJssel in case of disasters. Here, flood risk reducing measures are mainly on the building level (Xplorelab, 2008d). At the level of the building elevation can be achieved by a difference in level between street level and ground floor, building elevated on poles, or a non-livable ground floor (figure 4).

By reconsidering location choice, certain vulnerable and vital functions can be banned, and program, land use and function changes can be zoned

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by building only on (physical) convenient locations in the polder – for example, the higher parts, where the water in case of flooding will not come immediately. Certain areas can be reserved. This is also important in the case of space reservation around dikes. VenW et al. (2009a: 19, 28) advise to keep enough space along dykes free of buildings, to enable future reinforcements. In the meantime this can be filled in by multi-functional spatial use: temporary nature with recreational possibilities, or for agriculture and biomass production. The water manager maps the space requirements, municipalities consider this and translate it into the zoning plan.

While mapping this required space, the upper limits of the extreme climate scenarios should be maintained. Mapping risky places makes people involved aware of the risk, so they might already choose another location themselves. To prevent undesired developments in risky areas, improved obligatory "*watertoets*" is required. Should governments still choose to develop in vulnerable areas, VenW et al. (2009a: 29) advise further design measures. "Of developers involved (public and private) and future residents and users in that case is expected that they themselves bear the costs for this".

By compartmentalization and controlling flow inside the dike, water can be prevented from reaching objects. Compartmenting at polder level can be done by the double wall strategy – placing a second water defence behind the primary one – or by partitioning. This last strategy divides the polder into compartments, which fill up one by one. When constructing new infrastructure, the way they affect the flood course should be investigated, because compartmentalization is not always wanted (see section 3.1). The surrounding waters can also be compartmentalized, to reduce the volume of inflowing water. Compartmentalization can also take place on a smaller scale, for instance by constructing a dyke around a neighbourhood or building. This way, valuable functions can be protected. These dykes can be used to redirect the water to lower, less valuable areas. Influencing the flow of water is also possible by placing steps between buildings, or by flowing through the public space. Street profiles and watershores are then arranged in such a way that flowing with the water becomes possible. For this it is necessary to remove all obstacles. Buildings can be flooded to protect other parts of the area. These buildings then have to be designed wetproof. Facilities to store water can also be of use. This however will be more in case of water nuisance than in case of a real flood.

Wetproof design is part of reducing vulnerability by preventing damage to objects and people. Flood proofing on the scale of the polder can be done by increasing pumping capacity, and by deriving water to emergency overflow areas, that can also be used during closed storm surge barriers and pumping stops. On the scale of the neighbourhood vulnerable and vital parts of roads and water infrastructure can be protected, to prevent economic damage and for the benefit of evacuation possibilities. Neighbourhoods can also be constructed in a flexible way, for instance on floating platforms. Flexible construction can also be done only at building level: floating, amphibious, on boats, pontoons, in demountable and temporary buildings. In addition, waterproof buildings can be constructed. In case of a dryproof building the water does not intrude the building. In a wetproof building the intruding water causes no damage. Also the choice and treatment of materials can reduce damage. If the chosen building material is waterproof, ventilation grills and electrical outlets are installed elevated, and plasterboards for example installed horizontally, so that after a flood not all plates have to be replaced, this saves a lot of damage. Also thinking about the design of buildings (e.g. no power supply and expensive equipment in the basement, building without crawl spaces, building with waterproof baffles, and heavy foundations) are measures on the building level that minimize damage to objects.

3.2.3 Layer 3: disaster mitigation

A sustainable spatial plan in layer 2 and the interventions to mitigate disasters in layer 3 know the same approach, i.e. reducing exposure and reducing vulnerability. The measures of layer 2 however are of a permanent nature, where the measures of layer 3 are more temporary. Depending on the size of a flood, measures outside the polder play a role in disaster mitigation as well.

The number of objects in a flooded area can be reduced preventive or during a disaster by evacuation. This concerns mobile objects such as valuable artwork, animals and humans. This evacuation can be partly or whole, horizontal out of the area, or vertical in the area itself. Important vital functions, such as energy, food and drinking water supply, telecom/ICT and vital infrastructure, are crucial to reduce social disruption, but can fail due to a flood. To enable communication between the teams of security regions, water managers and inhabitants,

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a water robust communication network is needed. Therefore, essential equipment shall be installed elevated. Water robust infrastructure is also important. Elevated escape routes ensure people they have time to leave the area. Most neighbourhoods in VINEX-locations are accessible by roundabouts. Here it is more difficult for people to get away, because of the so-called funnel effect. The complex cauliflower-structure of several neighbourhoods in Almere also lead to a large evacuation time. According to estimates made within the context of *Veiligheid Nederland in Kaart* it will take 24 hours to get out of the neighbourhood in Almere-Haven (Bossenbroek, 2012). Several exits from a neighbourhood are useful in such cases.

When routes are flooded, marking by poles, buoys and reflectors on buildings can help. This way, routes stay recognisable and usable for evacuees, rescue services and military vehicles (Xplorelab, 2008a: 39). More generally, evacuation plans can be included in the masterplan. "When constructing new roads, it is wise to do an evacuation check right away: do roads stay above the water and usable during a flood? And if so, do they have sufficient capacity, possibly with temporary adjustments (such as *reverse laning*[4])?" (Xplorelab, 2008c: 17). VenW et al. (2009a: 36) also advise to pay attention to the spatial impact of disaster management in new structural visions and zoning plans. Besides this, local escape mounds can be arranged. Schools and sports halls often are designated as shelter. When these buildings have to be used also during floods, they have to be built or furnished water proof. On the building level, for the purpose of evacuation of the dwelling, access to the house above the expected inundation level will be required.

People can also be made aware of the fact that they are in a flood risky area through risk communication, for instance by means of a water artwork or NAP-stickers on lampposts. Another useful tool for communication is the risk map, which is available nationwide, and indicates the result of a flood in a particular area (IPO et al., s.d.).This way, inhabitants get an idea of what it means to live in a deep polder or an outer dike area.

To prevent water from reaching objects temporarily, temporary water defences can be used. One can think of sandbags and a waterproof cover on the broken dam, temporary dikes in the neighbourhood (standing, inflatable, fillable and cellular defences), highway barrier blocks, and partitions in front of doors or windows. Again information and awareness play a role. When human action is required for a temporary water defence, for instance for placing stop logs, the ones responsible for this task need to be well informed. When these logs don't have to be removed from the shed for years, possibility is they will be forgotten and thrown out. To prevent this, regular disaster drills are needed.

Regarding reducing vulnerability, during a disaster self-reliance of citizens is important. "Self-reliant people are able to keep themselves safe without assistance from other people. [...] There is a strong emphasis on self-reliance of citizens. There is no capacity for evacuation after the evacuation decision to offer assistance to other groups than the non-self-reliant citizens" (Veiligheidsregio Flevoland, 2008: 32, 36). Possible shelters – most of the time the higher parts of the area – have to be accessible and known to people who try to get themselves into safety. Also the limited access of neighbourhoods, for instance by roundabouts or the cauliflower structure, plays a role. If people want to survive in a flooded area, buildings should be equipped with floodproof self-sufficient energy and drinking water supply – for example in the form of generators, water tanks or clean water cellars. Examples include also the storage of an emergency package of provisions.

Finally, vulnerability can be reduced by emergency relief and rescue operations. Rescue workers assist the evacuation, and evacuate non-self-reliant including disabled people, young children, elderly and animals. For operations like technical assistance to restore the breach and pump the land dry and humanitarian aid, accessibility of the area and evacuees is very important.

4 Conclusions and recommendations

4.1 The interventions matrix

To determine which interventions can be taken to reduce flood risk, in this paper firstly the urban and spatial factors are examined which influence physical water safety. Water safety depends on flood characteristics: frequency, arrival time, water depth, flow velocity, ascent rate, water pressure, flood duration and unexpectedness. All these characteristics are influenced by the urban and spatial structure of the flooded area. Besides that, socio-economic value, the arrangement of the polder,

[4] In order to facilitate traffic during evacuation, official travel directions sometimes are reversed.

and the way rescue workers and inhabitants deal with a flood play a role.

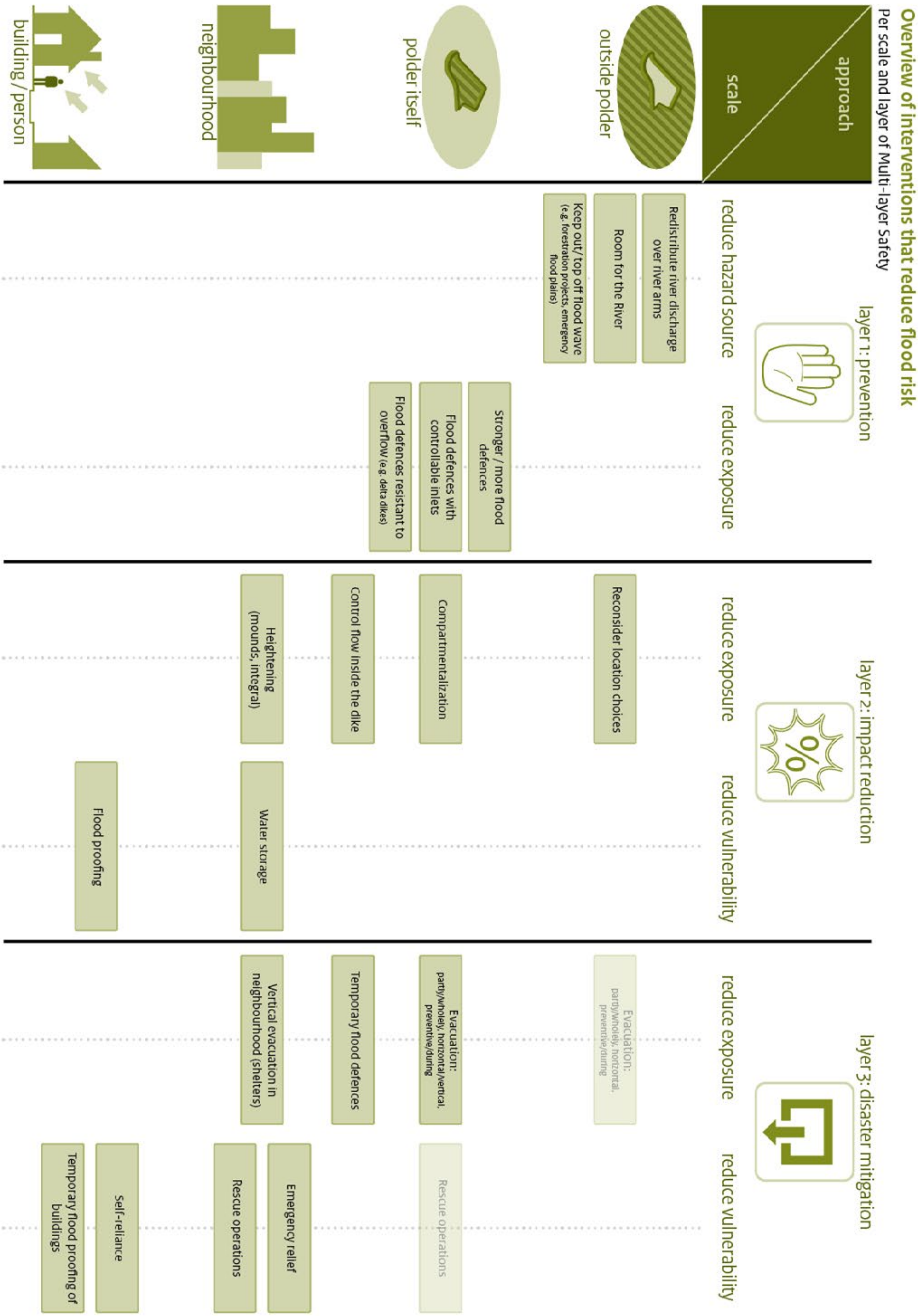
An overview is provided of possible interventions in these factors which reduce flood risk (figure 5). These interventions know a wide variety of scale, approach and intensity. The different interventions that increase water safety can firstly be classified by layer of MLS they operate on. The measures in the layer of prevention can be both outside and within the polder. Impact reduction and disaster mitigation know the same approach: they either reduce exposure or vulnerability. Not only heightening dikes, but also experimenting with other ways of urbanization, emergency plans and investing in risk communication are solutions. Floodproof buildings in urban areas reduce the damage of flooding, and can at the same time serve as shelters. A link with sustainability thinking could work as a catalyst, because also for this purpose buildings can be made self-sufficient. Early flood warnings and improved risk communication make people better prepared to deal with floods. The current possibilities for (large) evacuation in the Netherlands are limited. This would be different if in the future there were more shelters and refuges.

4.2 From theory to practice

In the current practice there is still very much a division between 'believers' and 'non-believers' of MLS. The traditional approach of prevention by constructing and reinforcing dikes is still very present. This paper provides an overview of interventions that can serve as building blocks for different alternatives for new developments and re-development areas with a high flood risk, which cope with flood risk in a different way. Raising dikes will most likely always be the most cost-effective way, but it is the challenge to look for measures in the other layers that seek an interesting link with other climate issues such as heat stress and water nuisance as a result of more intense precipitation. Other interventions can also provide an interesting living environment, increasing spatial quality (e.g. more contact with the water, instead of dikes serving as a barrier between water and man). A link with sustainability thinking could work as a catalyst.

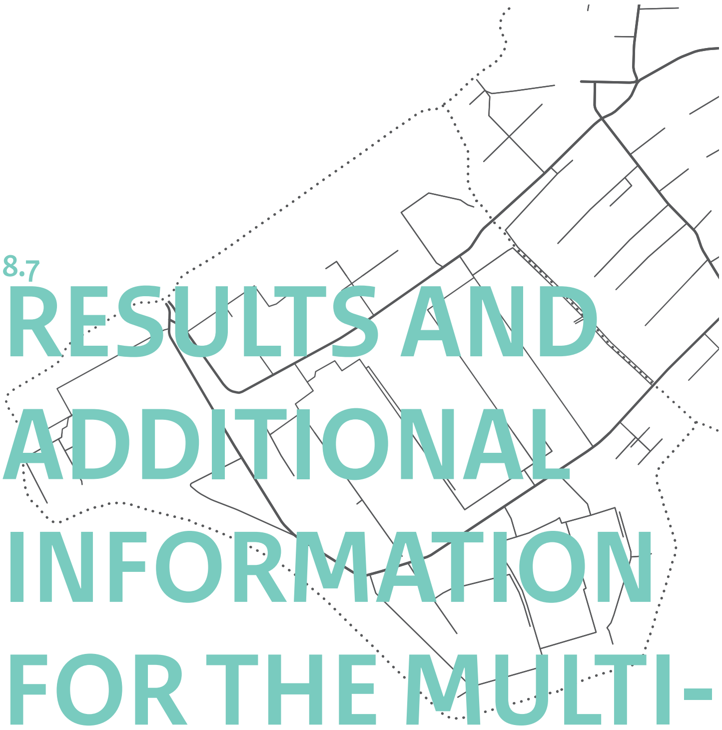
A lot of knowledge is already available to different authorities responsible for policy on spatial planning and water management, but this knowledge is hardly shared. Difficulty is that responsibilities and money are often divided between different actors, but a clear communication of knowledge and interest can lead to interesting new solutions that link these interests, and to innovative ideas that integrate spatial planning and water management in the future.

Figure 5: Overview of interventions that reduce flood risk, per scale and layer of MLS



Source: derived from Meyer et al., 2009; Pieterse et al., 2009: 15, 39-45, 61-62; Pols et al., 2007: 90-101; Provincie Utrecht, 2010: 27; Van de Ven et al., 2009: 33-39, 95-123; Xplorelab, 2008a; Xplorelab, 2008b: 43-45; Xplorelab, 2008c; Xplorelab, 2008d: 19-23.


Almere Poort before construction, source: Flickr.com



8.7

RESULTS AND ADDITIONAL INFORMATION FOR THE MULTI-CRITERIA ANALYSIS

Almere Poort during construction, source: Flickr.com

8.7.1 Flood simulations in SOBEK

In order to determine the cost-effectiveness of the alternatives, flood simulations have been made. This is done with help from Nathalie Asselman from Deltares, using the computer program SOBEK.

In each alternative the maximum water depths, ascent rates, time of getting wet, and time of reaching maximum water depth has been determined.

This has been done for three different breach locations: Almere, Oostvaardersplassen and Zeewolde. In alternative 1 Almere as a breach location has been excluded in the flood scenario, because here an unbreachable dike will be realised.

This has resulted in 13 scenarios, as is shown below in the table and the pictures of the outcome for maximum water depth per scenario.

Some conclusions for the SOBEK simulations are that a compartmenting sluice underneath the Hollandse Brug only makes a difference for a breach near Zeewolde (compare fig. 8.7.10 and 8.7.22); in case of a breakthrough at the Oostvaardersplassen it would not make much difference (most of the water is after all coming from the Markermeer and not from of the border lakes).

A compartmentalization through a bicycle path on a dike of 1 meter height does not have the intended effect: the path is too low. The water courses are not closed in this scenario, because it would become a too expensive measure with little effect. When the breach would take place near Zeewolde, closing off the water courses could have an effect though.

In all scenarios of a breach near Zeewolde, after 112 hours the water still flows in (without compartmentalization of the water). When the dike along the Markermeer breaches, after about ten days an equilibrium is reached between the water depth inner dike and outer dike.

location of breach / *Alternative*	1. Almere	2. Oostvaardersplassen	3. Zeewolde
0-alternative	Y	Y	Y
Alternative 1 a: compartmentalization by 1m high bicycle path	N	Yes, with compartmentalization of the water underneath Hollandse Brug/A6	Yes, with compartmentalization of the water underneath Hollandse Brug/A6
Alternative 1 b: full compartmentalization	N	Yes, with compartmentalization of the water underneath Hollandse Brug/A6	Yes, with compartmentalization of the water underneath Hollandse Brug/A6
Alternative 2: a: floodproof zone in new development area	Y	Y	Y
Alternative 2: b: floodproof zone extended towards existing city	Y	Y	Y

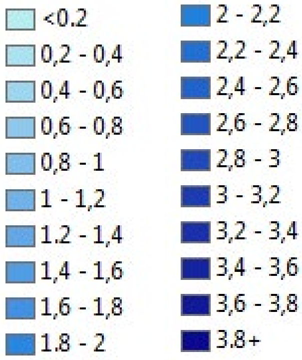


Figure 8.7.1: Legend for maximum water depth (in meters).

Figure 8.7.4: Max. water depth after a breach near Almere, 0-alternative

Figure 8.7.2: Legend for time of getting wet (in hours).

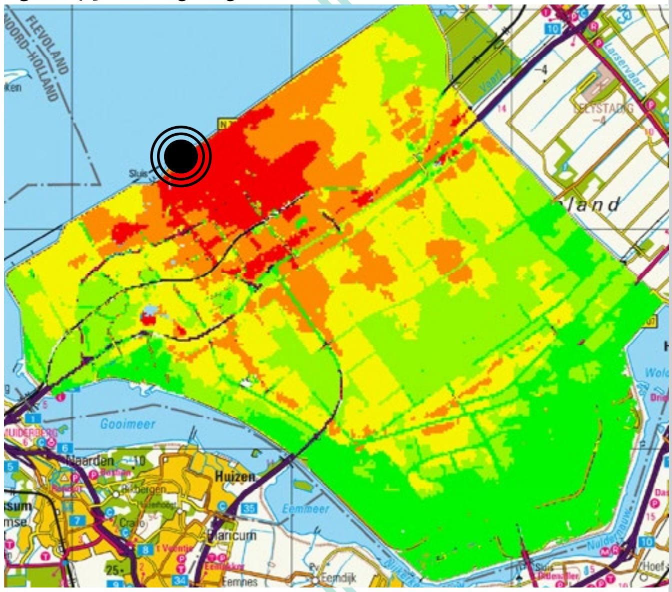


Figure 8.7.5: Time of getting wet, breach Almere, 0-alternative.

Figure 8.7.3: Legend for economic damage (in billion euros).

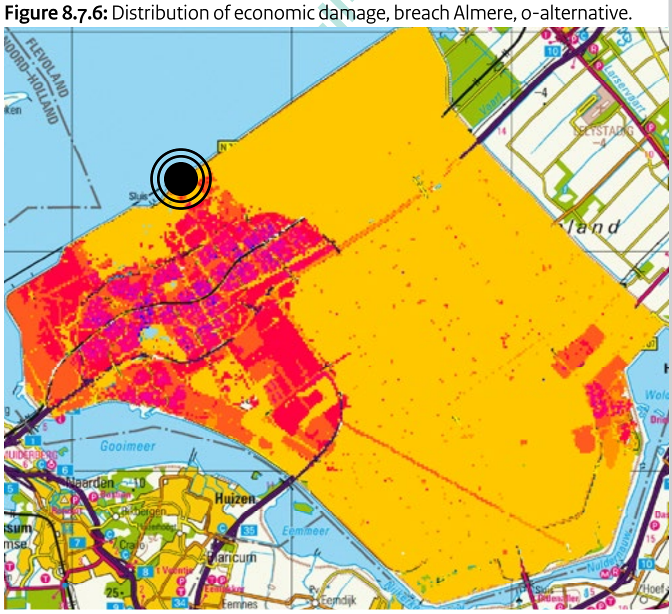
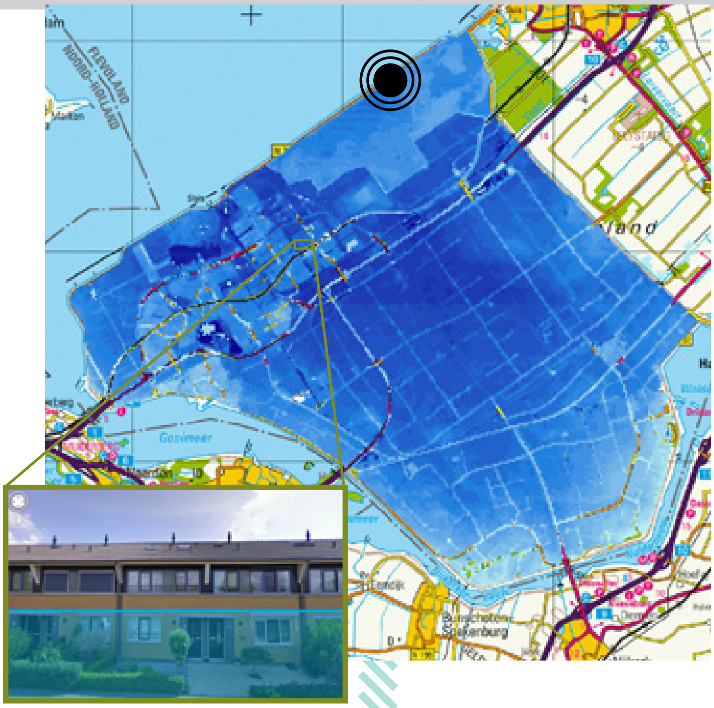


Figure 8.7.6: Distribution of economic damage, breach Almere, 0-alternative.

Figure 8.7.7: Max. water depth after a breach near Oostvaardersplassen, o-alternative



ca. 2.4 m

Figure 8.7.8: Time of getting wet, breach Oostvaardersplassen, o-alternative.

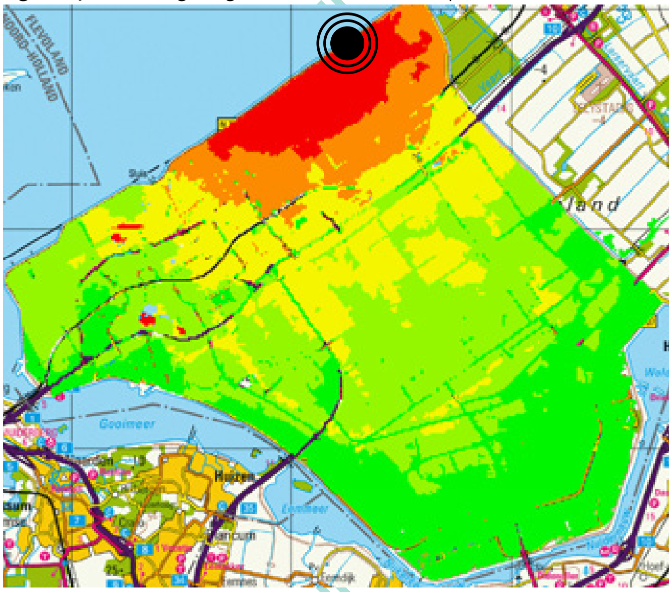


Figure 8.7.9: Distribution of economic damage, breach Oostv., o-alternative.

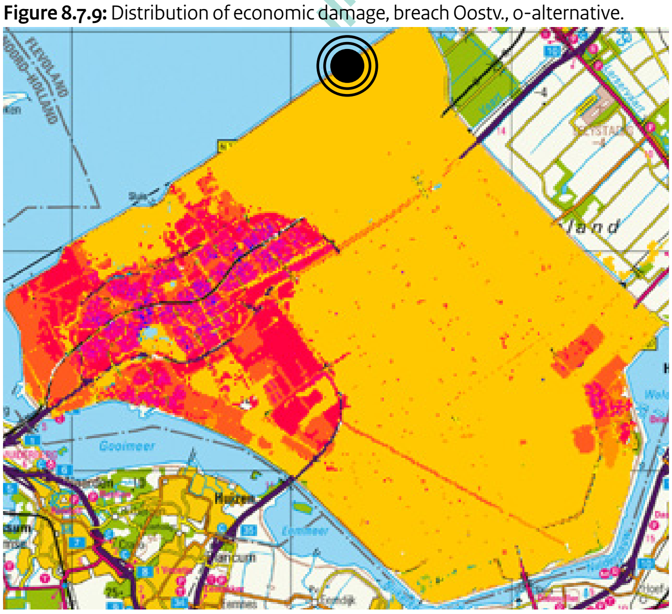


Figure 8.7.10: Max. water depth after breach near Zeewolde, o-alternative

Figure 8.7.11: Time of getting wet, breach Zeewolde, o-alternative.

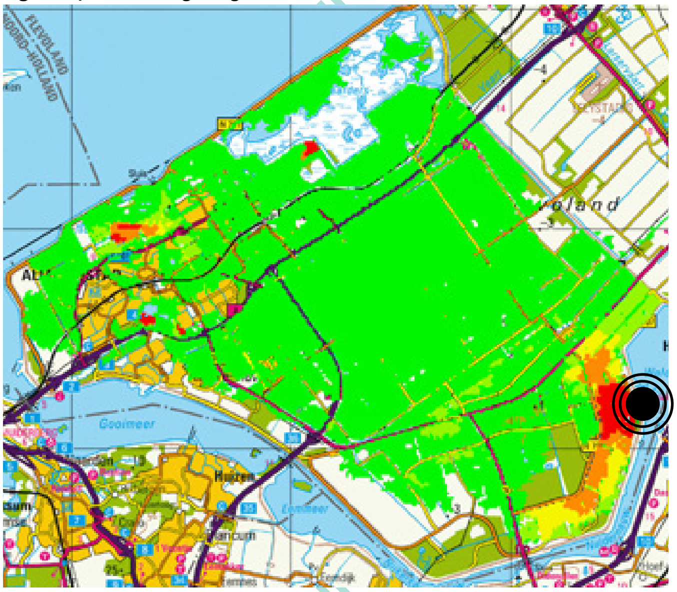


Figure 8.7.12: Distribution of economic damage, breach Zeewolde, o-alternative.

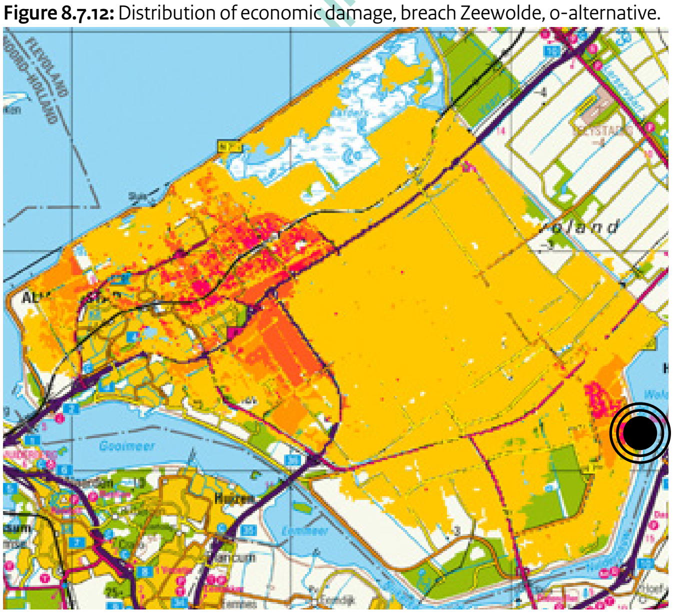
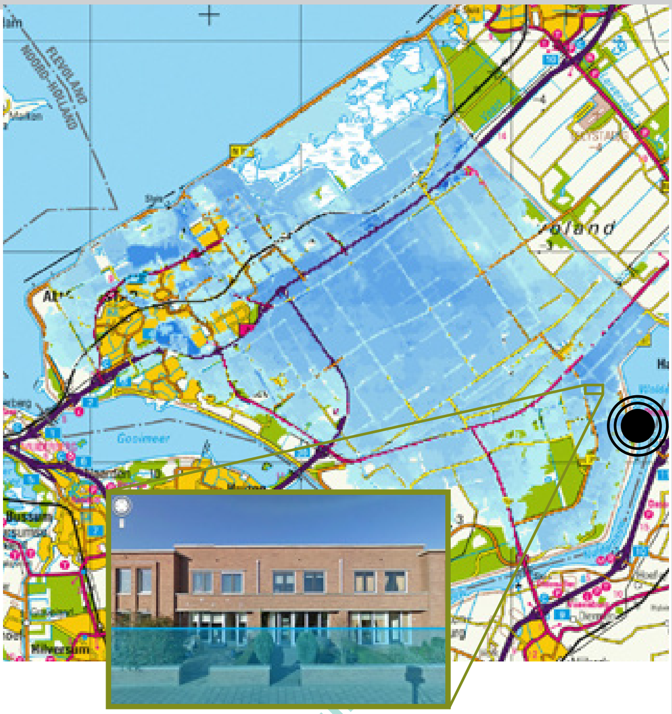


Figure 8.7.13: Max. water depth after a breach near Oostvaardersplassen, alternative 1a.

Figure 8.7.16: Max. water depth after breach near Zeewolde, alternative 1a.



ca. 1.5 m

Figure 8.7.14: Time of getting wet, breach Oostvaardersplassen, alternative 1a.

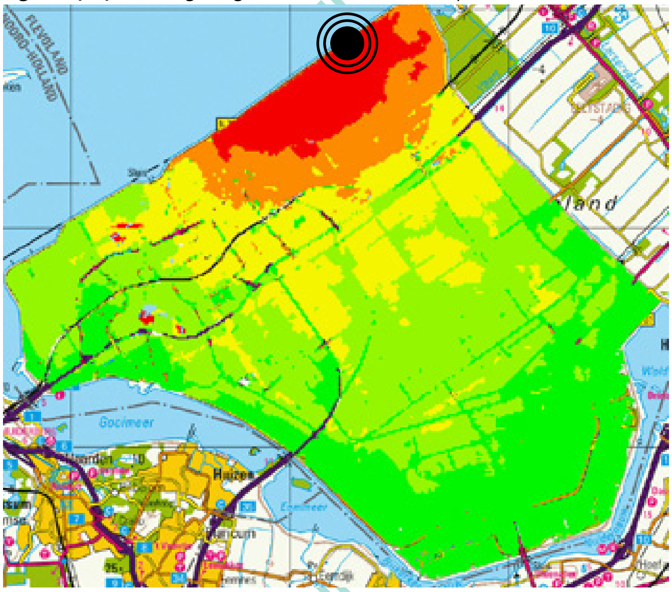


Figure 8.7.17: Time of getting wet, breach Zeewolde, alternative 1a.

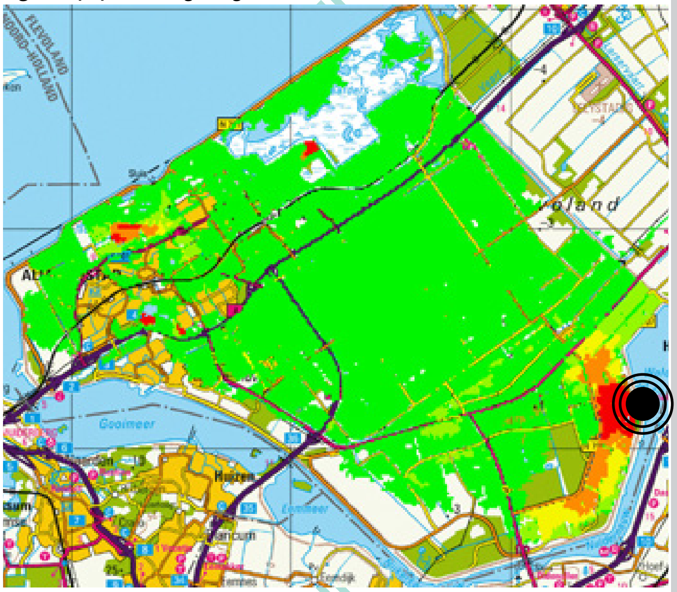


Figure 8.7.15: Distribution of economic damage, breach Oostv., alternative 1a.

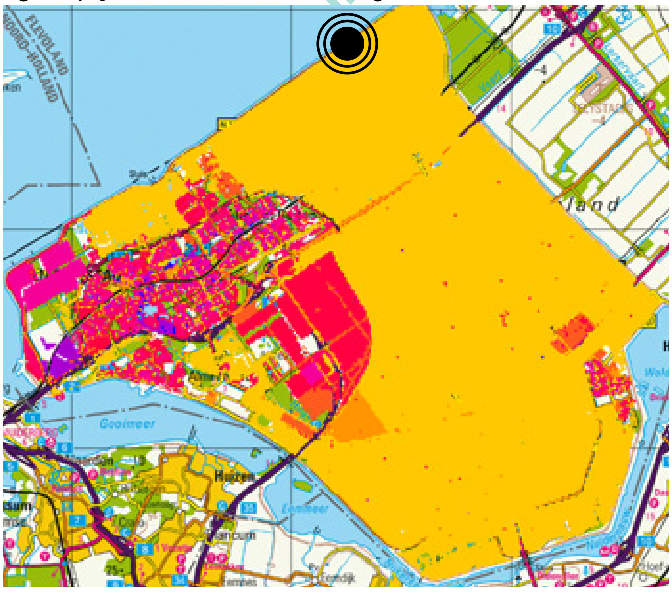


Figure 8.7.18: Distribution of economic damage, breach Zeewolde, alternative 1a.

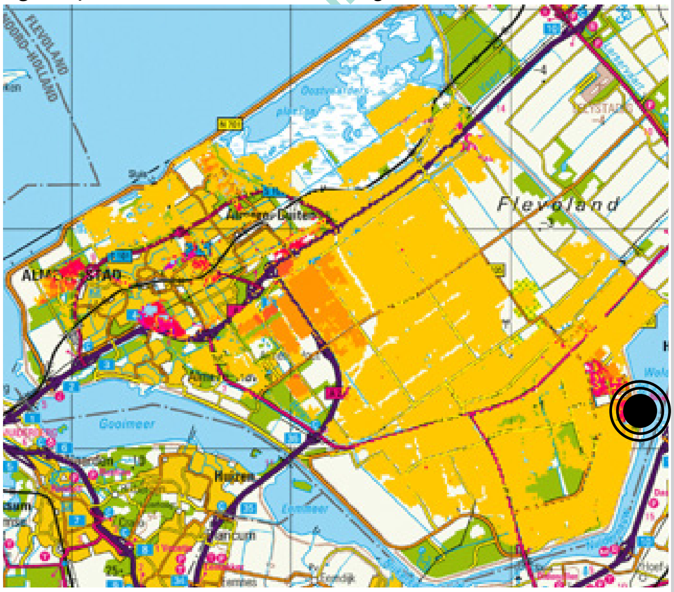


Figure 8.7.19: Max. water depth after a breach near Oostvaardersplassen, alternative 1b.

Figure 8.7.20: Time of getting wet, breach Oostvaardersplassen, alternative 1b.

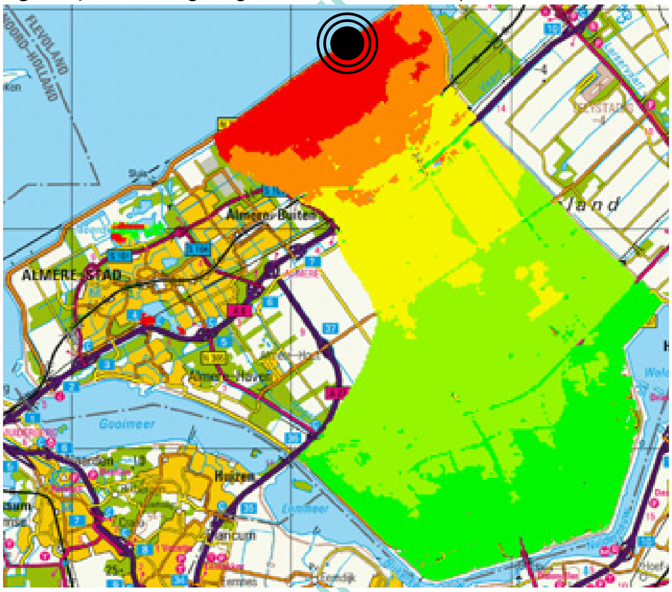


Figure 8.7.21: Distribution of economic damage, breach Oostv., alternative 1b.

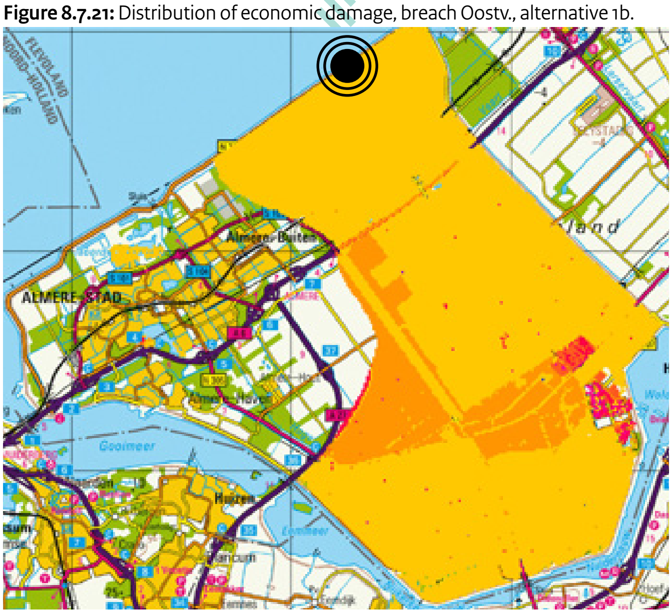


Figure 8.7.22: Max. water depth after breach near Zeewolde, alternative 1b.

Figure 8.7.23: Time of getting wet, breach Zeewolde, alternative 1b.

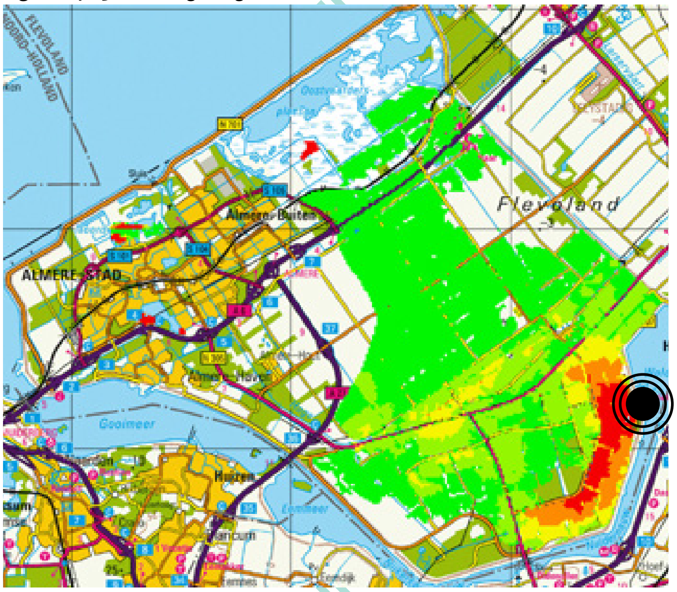


Figure 8.7.24: Distribution of economic damage, breach Zeewolde, alternative 1b.

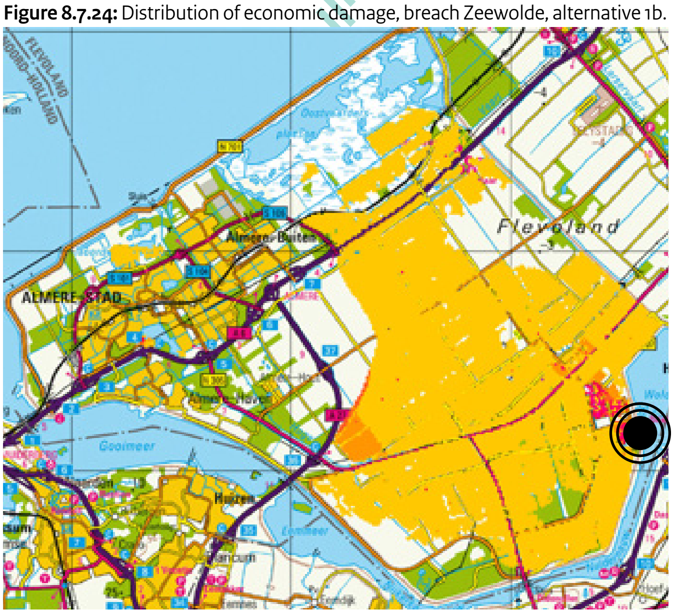


Figure 8.7.25: Max. water depth after a breach near Almere, alternative 2b.

Figure 8.7.28: Legend for maximum water depth (in meters).

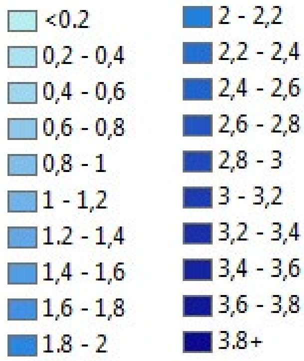


Figure 8.7.26: Time of getting wet, breach Almere, alternative 2b.

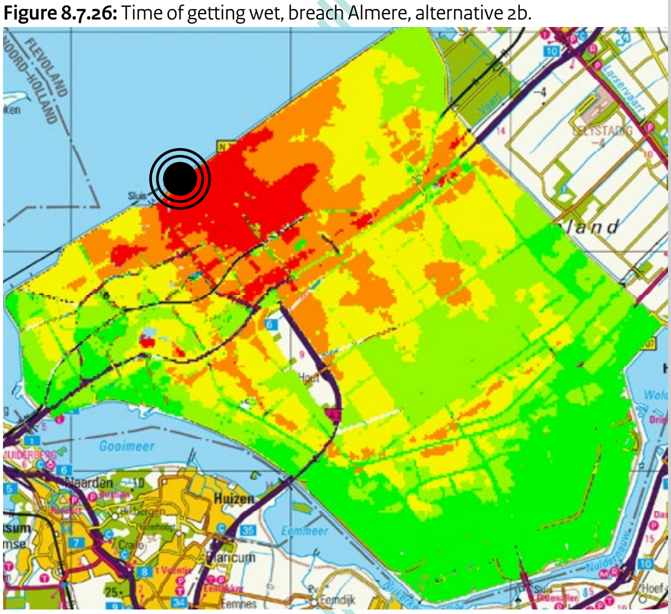


Figure 8.7.29: Legend for time of getting wet (in hours).

Figure 8.7.27: Distribution of economic damage, breach Almere, alternative 2b.

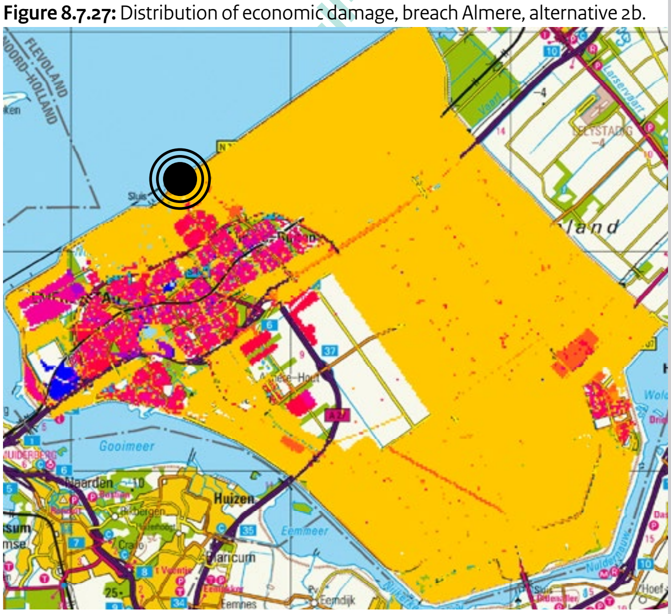


Figure 8.7.30: Legend for economic damage (in billion euros).

Figure 8.7.31: Max. water depth after a breach near Oostvaardersplassen, alternative 2b.

Figure 8.7.34: Max. water depth after breach near Zeewolde, alternative 2b.

Figure 8.7.32: Time of getting wet, breach Oostvaardersplassen, alternative 2b.

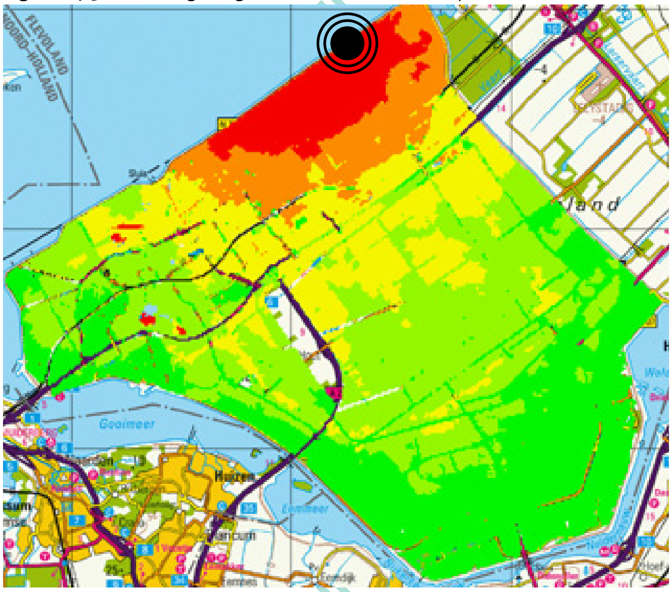


Figure 8.7.35: Time of getting wet, breach Zeewolde, alternative 2b.

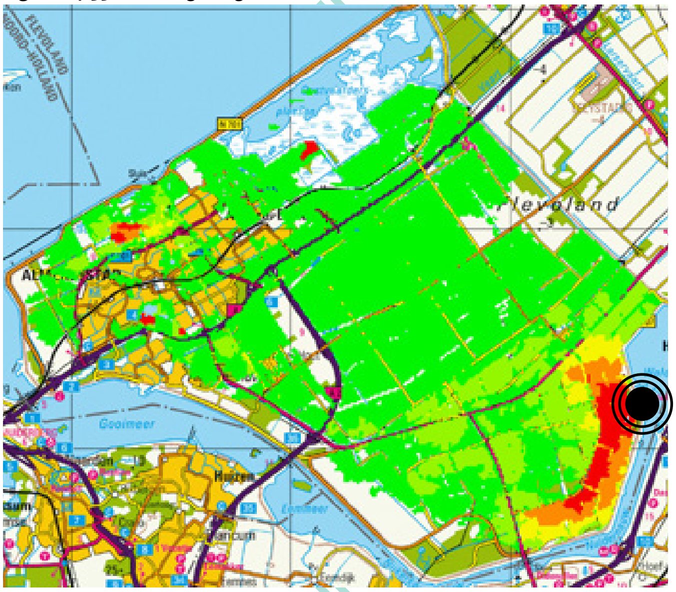


Figure 8.7.33: Distribution of economic damage, breach Oostv., alternative 2b.

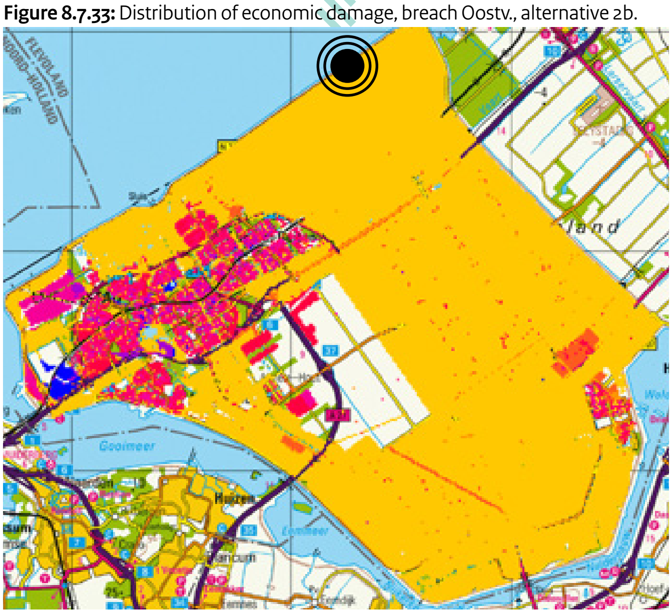
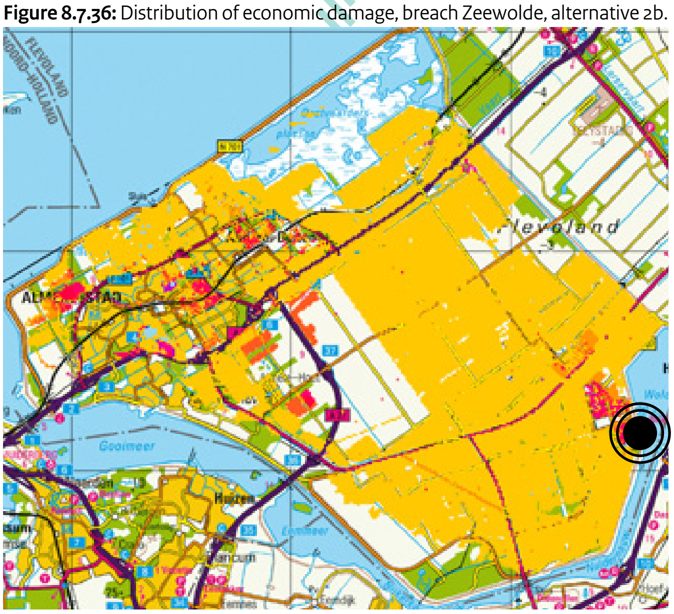


Figure 8.7.36: Distribution of economic damage, breach Zeewolde, alternative 2b.



8.7.2 Damage Scanner and Land-Use Planner PBL

In order to determine the cost-effectiveness of the alternatives, the expected reduction of damage has to be established. For this, the three alternatives have been run through the Land-Use Planner of the PBL (Dutch: Ruimtescanner). The Land-Use Planner is an instrument which makes the simulation of future land-use possible. It is an integrated spatial information system of geographical databases and algorithms, which translates land-use claims to possible changes in land-use (Schotten et al., 1997: 7). In the 0-alternative, the land-use map for the scenario 'DRUK' ('busy') have been used. For alternative 1 and 2, preconditions have been given to certain areas in the Southern Flevopolder, for instance where housing is not allowed, or where a certain amount of program in a certain density has to be realized. The outcome of these simulations in the Land-Use Planner are shown in figures 8.7.37 to 8.7.40.

These land-use maps, together with the maps of maximum water depth, flow velocity and ascent rate in the flooding scenarios, have been used as input for the GIS-application the Damage Scanner. Based on this, the Damage Scanner makes calculations of the expected amount of damage in each flooding scenario. The maximum damage value is based on rebuilding values (buildings), replacement values (contents) and market values (agriculture) (Jongman et al., 2012: 3740). Figure 8.7.43 shows the maximum damage per housing type (Kok et al., 2005: 24-25), and the division of housing types per living environment type used for the expansion areas in the different alternatives is shown in fig. 8.7.44. This output is made possible by Bas van Bemmel, Arno Bouwman and Bart Rijken (PBL), and is shown in the previous maps, and in the table in figure 8.7.41.

Figure 8.7.37: Land-use map for the 0-alternative according to 'DRUK' scenario Land-Use Planner.

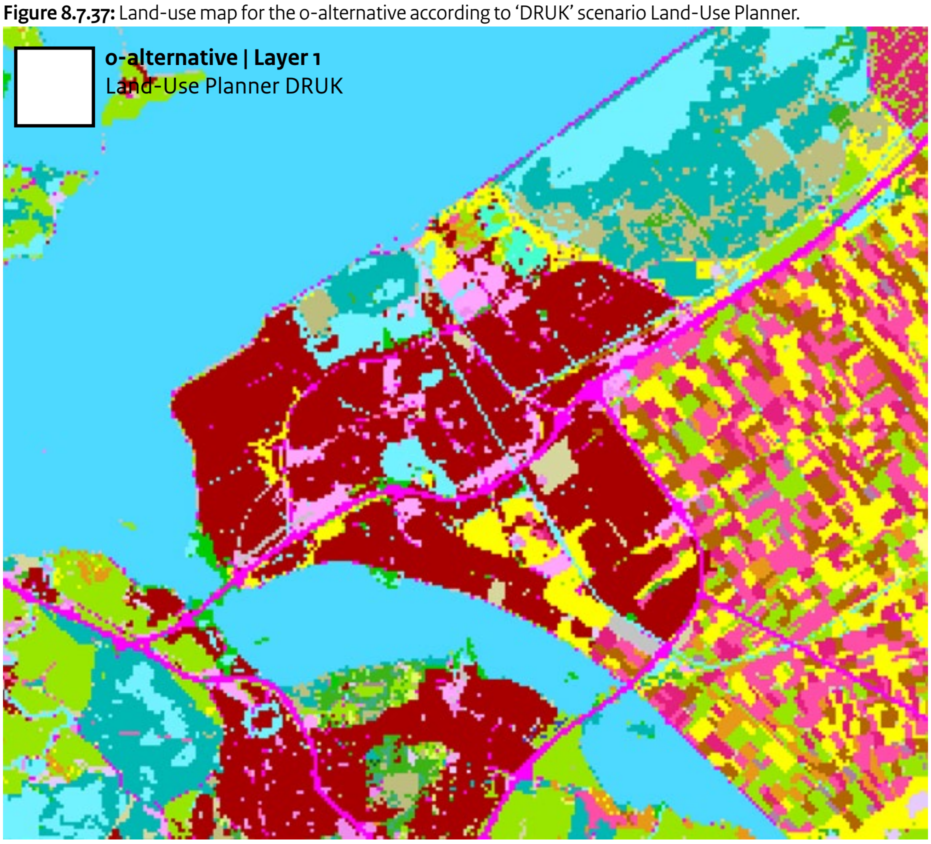


Figure 8.7.38: Legend Land-Use Planner.

Figure 8.7.39: Preconditions and input for the Land-Use Planner in alternative 1.

Alternative 1 | Layer 1 & 2
Kaart voor RuimteScanner
Dichtheden

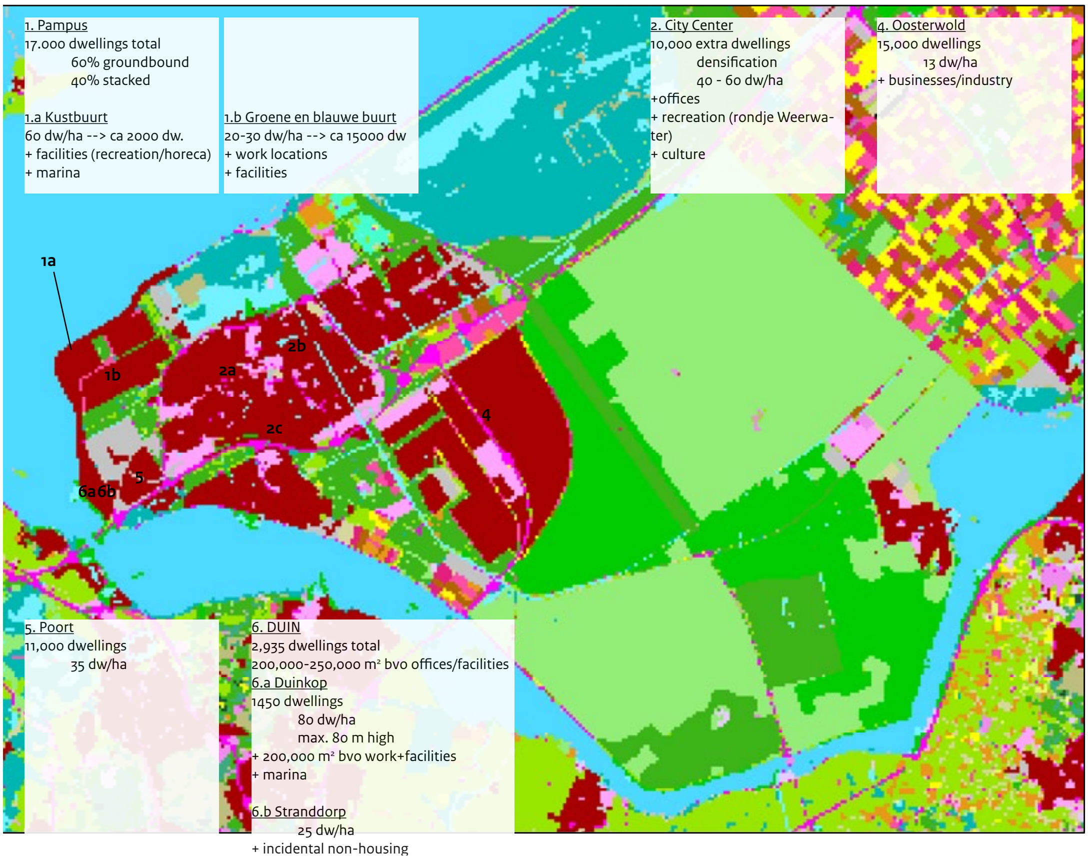


Figure 8.7.40: Preconditions as input for the Land-Use Planner in alternative 2.

Alternative 2 | Layer 2 & 3
Kaart voor RuimteScanner
Dichtheden

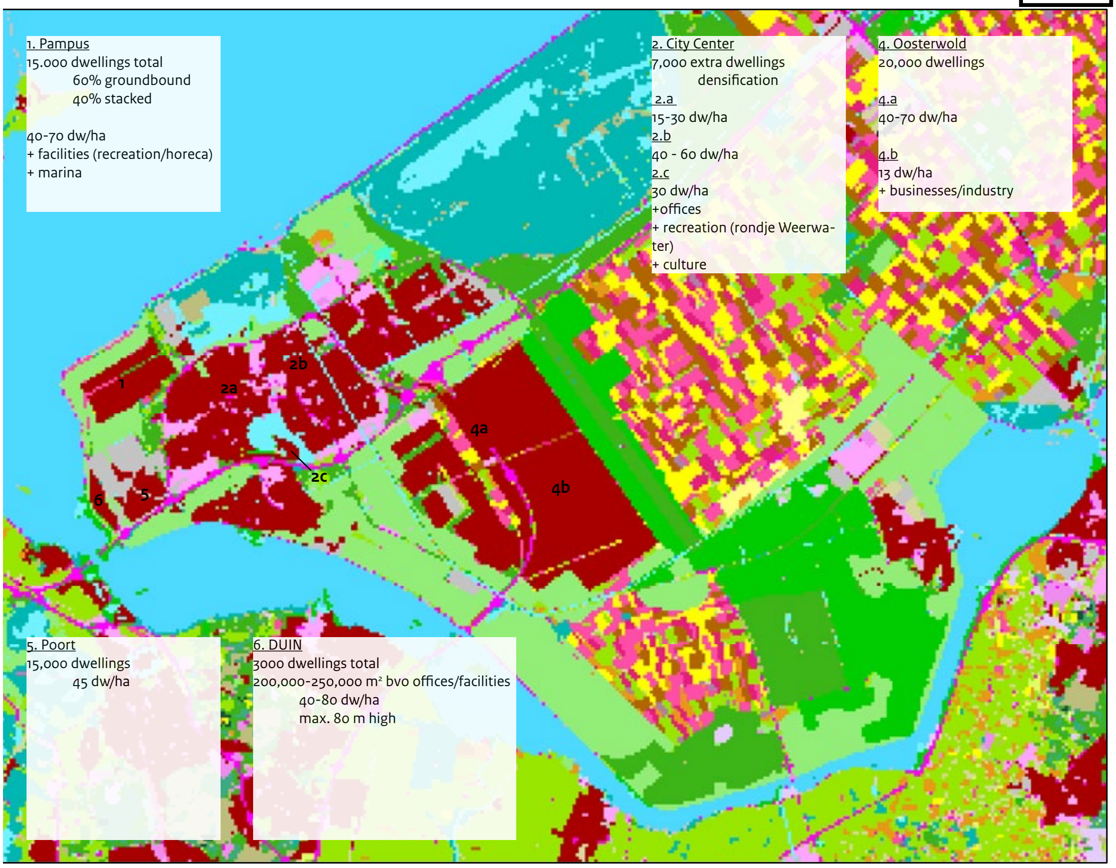


Figure 8.7.42: Demarcation of area1 (red) and area 2 (green).

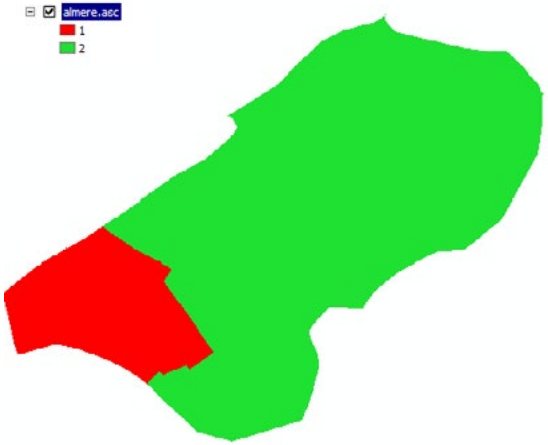


Figure 8.7.43: Maximum damage per housing type, M € per piece.

Farm	0.402
Family house	0.241
Low-rise house	0.172
Middle-rise house	0.172
High-rise house	0.172

Figure 8.7.44: The division of housing types per living environment type used for the expansion areas in the different alternatives.

Living environment \Housing type	*Farm*	*Family house*	*Low-rise*	*Middle-rise*	*High-rise*
Central urban (*Centrum stedelijk*)	0	0	0	0.5	0.5
Green urban (*Groen stedelijk*)	0	0	0.5	0.5	0
Rural (*Landelijk wonen*)	0	1	0	0	0

Figure 8.7.41: Estimated costs by Damage Scanner in M euros, per alternative and dike breach location, divided into housing and non-housing, and Area 1 (urban area of Almere) and area 2 (rural area; see figure 8.7.42.).

		Breach location	**Almere**			**Oostvaardersplassen**			**Zeewolde**		
Alternative			*Area 1*	*Area 2*	*Total*	*Area 1*	*Area 2*	*Total*	*Area 1*	*Area 2*	*Total*
0-alternative		housing	4.515	251	4.766	4.514	251	4.765	586	175	761
		non-housing	4.404	1.213	5.617	4.403	1.213	5.617	1.056	433	1.489
		total	8.920	1.463	10.383	8.918	1.464	10.382	1.642	608	2.250
Alternative 1	**a**: 1m high bicycle dike	housing	-	-	-	9.273	251	9.524	681	197	877
		non-housing	-	-	-	1.505	2.059	3.564	163	484	647
		total	-	-	-	10.779	2.309	13.088	844	681	1.525
	b: full compartmentalization	housing	-	-	-	44	300	344	20	203	223
		non-housing	-	-	-	155	2.208	2.363	72	626	698
		total	-	-	-	199	2.508	2.707	92	829	921
Alternative 2	**a**: floodproof zone in new dev. area	housing	7.874	254	8.128	7.871	254	8.125	669	222	890
		non-housing	1.379	1.589	2.969	1.379	1.589	2.968	195	582	777
		total	9.253	1.843	11.096	9.251	1.843	11.093	863	804	1.667
	b: floodproof zone extended to existing city	housing	7.849	254	8.103	7.846	254	8.100	681	222	903
		non-housing	1.367	1.590	2.960	1.366	1.590	2.956	195	582	777
	Damage in M €	total	9.215	1.845	11.063	9.213	1.844	11.057	876	804	1.680

8.7.3 Cost estimation for realization different alternatives

The cost estimation for realization of the 0-alternative regarding urban development, nature development and accessibility has been established according to Ecorys (2012). For this cost estimation, the Hollandse Brug alternative has been chosen, because this alternative of the Schaalsprong most likely will be chosen, and therefore will be the current direction of policy. Regarding safety against flooding, it is assumed that current policy means a purely preventive strategy. There are three possibilities for strengthening the current primary dikes: strengthening the weak spots, raising the dikes to an economic optimal safety level which takes into account the situation in 2030, and reducing the probability of flooding with a factor 10 (Bossenbroek, 2012; De Grave & Baarse, 2011; Kind, 2011; Kind, 2013). The total cost estimation for realizing the 0-alternative shows a positive balance, so a benefit. The minimum benefit amounts to around 103 million euros, when the probability of flooding of dike ring part 8-2 is reduced by a factor of 10 and the high quality public transport line is realized in the form of a bus, and there will be no extra adjustments to the train network. When however only the necessary dike reinforcement of the weak spots is done, and an intercity stop in Almere Poort and high-speed trains to Almere Centrum are realized, the expected maximum benefit can amount to around 896 million euros (see figure 8.7.45).

In order to establish the cost-efficiency of alternative 1 and alternative 2, additional costs of both alternatives have to be determined, shown in figures 8.7.46 and 8.7.50. Costs for the compartmentalization dike and bicycle path have been derived from ProSes (2004: 34) and De Grave & Baarse (2011: 115). The costs for the unbreachable dike with urban or green functions have been derived from the feasibility study coastal zone Almere-Poort (Oranjewoud, 2006). This study concerns the construction of the 1.5 km long unbreachable urban dike for the plans of DUIN in front of Almere-Poort, so with the same profile as the planned unbreachable dike in alternative 1 (figures 8.7.47 to 8.7.49). For an urban dike, additional measures should be taken, such as drainage mats and (optionally) sheet piling at the site of buildings, which brings along extra costs per linear meter.

Kind (2013: D-4) shows an overview of costs of water robust building, in euros per dwelling. This overview has been used to determine the additional costs for alternative 2. To verify these estimations, an expert judgement session with Frans van de Ven (TU Delft) has been held.

Figure 8.7.45: Cost estimations for realization of the 0-alternative (regarding safety against flooding, urban development, nature development and accessibility).

Project		Costs unit	price/unit	source	total	Stakeholders/ to whom the effect occurs
I Safety against flooding		km	M €/km		M €	
• Regular dike reinforcement weak spots (piping, overtopping, etc.)	Piping	15	-0,3	Bossenbroek, 2012; Kind, 2013: C-5	-4	RWS, Water board Zuiderzeeland
or	Infra	54,54	-2,5		-138	
	total				-142	
• Regular dike reinforcement to economic optimal safety level dike ring section (*dijkringtraject*), +20-+40 cm	8-2-1	23,98	-3,8	De Grave & Baarse, 2011: G-1; Kind, 2011: 52, 85, 88	-91	RWS, Water board Zuiderzeeland
	8-2-2	5,62	-2,8		-16	
	8-2-3	25,54	-2,3		-60	
or	total				-167	
• Costs for reducing the probability of flooding by a factor of 10 for dike ring part (*dijkringdeel*) 8-2 Flevoland Zuidwest				De Grave & Baarse, 2011: 109	-200 -275	RWS, Water board Zuiderzeeland
• Give Knardijk C-status	Replace sluices			Exp. judgement Van de Ven	-80	RWS, Water board Zuiderzeeland
	total			*min.*	**-142**	
				max.	**-355**	

II Urban development		# dwellings	price/ #	source	M €	
• Costs land acquisition			€300000 /ha	Ecorys, 2012: 51	-405	Government
• Costs land preparation etc.					-1352	Government
• Other costs					-1008	Government
Of which costs Stedelijke Bereikbaarheid Almere				Ecorys, 2012: 14	-830	Government
• Land sales revenues				Ecorys, 2012: 51	1972	Government
Of which land revenues for dwellings	free sector	13.751	44.724	Ecorys, 2012: 49	615	
	social housing	5.892	18.500		109	
	total	19.643	36.858		724	
Financial balance ground exploitation					-793	Government
Social benefits urbanization					1244-1614	
• Actual price rise dwellings				Ecorys, 2012: 51	275	Government
• Economic value ground					573	Land owner
• Adjustment for taxes					-132	Government
• Accessibility correction in house prices				Ecorys, 2012: 14	0	Inhabitants
• Consumer surplus social housing	social housing	17.259		Ecorys, 2012: 52	438	Inhabitants
• Radiation effects: greater living comfort				Ecorys, 2012: 54	90-460	Inhabitants
	total			Ecorys, 2012: 57 *min.*	**451**	
				max.	**821**	

III Nature development				source	M €	
• 1st phase TBES (financially covered measures)	Pilot primal swamp (NMIJ)			Ecorys, 2012: 88	-6	Government
	improvement fish migration				-1,2	Government
	Shelter Measures Hoornse Hop				-9	Government
	Mitigating measures TBES				p.m. (-)	Government
• Recreation, tourism					p.m. (+)	Inhabitants, companies
	total				**-16,2**	

IV Accessibility			M €	source	M € relative to baseline	
• Investment costs (excluding the costs of mitigating measures)	Absolute		-232	Ecorys, 2012: 61	-100	Government
Pakket Stedelijke Bereikbaarheid Almere			-35,7	Ecorys, 2012: 61	0	Government
• Cost management and maintenance				Ecorys, 2012: 14	-30	Government
• Costs of mitigating measures				Ecorys, 2012: 62	-7	Government
• Public transport exploitation	BTM (bus, tram, metro)				25	PT operators/ Government
	Train				70	
	total				95	
• Travellers' benefits public transport					110	
	Time savings			Ecorys, 2012: 14	110	Travellers
	Ride costs				0	Travellers
	Comfort				0	Travellers
	Reliability				0	Travellers
• Indirect effects (agglomeration, job market)					30	Employees, companies
• Noise hindrances	# people	11169		Ecorys, 2012: 78	p.m.	Society
• Noise loaded surface Eemmeer & Gooimeer	ha	389			p.m.	Society
• Air quality (highest concentration)	NOx	22,8			p.m.	Society
	PM10	23,7			p.m.	
• Physical integration (qualitative)				Ecorys, 2012: 14	-	Society
• Climate					0	Society
• Ground					0	Society
• Water					0	Society
	total				**98**	

Alternative/ extra measures:		M € relative to HB	source	M € relative to baseline
IC stop in Almere Poort	extra costs for realization, management and maintenance)	0	Ecorys, 2012: 82	
	extra benefits travellers and public transport operators	135		
	total balance	135		**233**
High-speed trains to Almere Centrum	extra costs for realization	0		
	extra benefits travellers and public transport operators	103		
	total balance	103		**201**
Tram instead of HPT+ bus	extra costs for realization, management and maintenance)	-102		
	extra benefits travellers and public transport operators	-53		
	total balance	-155		**-57**

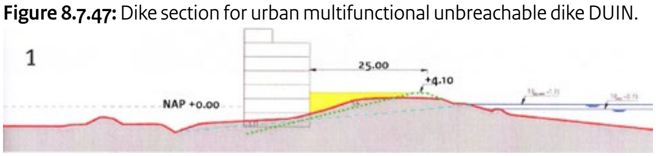
V Total costs for realization	M €
min.	**22,8**
max.	**895,8**

Figure 8.7.46: Cost estimations for realization of alternative 1: alternate and/or additional costs occur regarding safety against flooding and urban development.

Project		Costs: unit	price/unit	source	total	Stakeholders/ to whom the effect occurs
I Safety against flooding		km	M €/km		M €	
• Regular dike reinforcement to economic optimal safety level dike ring section (dijkringtraject), +20-+40 cm	8-2-1	14,5	-3,795	De Grave & Baarse, 2011: G-1; Kind, 2011: 52, 85, 88	-55,0	RWS, Water board Zuiderzeeland
	8-2-3	25,54	-2,3		-60	
	total				-115,0	
• Give Knardijk C-status	Replace sluices	19	p.m.	Exp. judgement Van de Ven	-80	RWS, Water board Zuiderzeeland
		m	€/m			
• Multifunctional unbreachable dike	urban	8300	-737,5	Oranjewoud, 2006:15-16	-6,12	Municipality of Almere, Water board Zuiderzeeland
	urban with sheet piling	8300	-2124		-17,6	
	green	6200	-472		-2,93	
• Compartmentalization dike 1 m height	bicycle path	16700	-80	ProSes, 2004: 34	-1,34	Municipality of Almere, Water board Zuiderzeeland
		M€/km				
	green dike	16,7	-2,25	De Grave & Baarse, 2011: 115	-37,6	
• Compartmentalization dike 3.5 m height		16,7	-7,875		-131,5	Municipality of Almere, Water board Zuiderzeeland
	total			*min*	**-163**	
				max	**-347,1**	

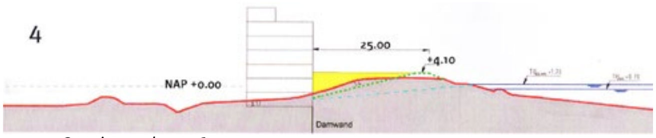
II Urban development		# dwellings	€/dwelling	source	M €	
• Floodproof housing Oosterwold		8000	-10000	Kind, 2013: D-4	-80	Government/ real estate developer
• Actual price rise dwellings on multifunctional unbreachable dike					p.m. (+)	Government/ owner
• Radiation effects: greater living comfort					p.m. (+)	Inhabitants
	total				p.m. (+?)	

Figure 8.7.47: Dike section for urban multifunctional unbreachable dike DUIN.



source: Oranjewoud, 2006: 26

Figure 8.7.48: Section for urban multifunctional unbreachable dike DUIN, including sheet piling.



source: Oranjewoud, 2006: 27

Figure 8.7.49: Indicative cost estimation for multifunctional unbreachable dike coastal zone Almere-Poort (DUIN).

	unit	€/unit	amount/ linear m	amount total water defence	costs €	€/ linear m
Heightening boulevard (+1 m + 20% settling); suction dredger	m^3	-8	30	45000	-360000	-240
drainage mats at the site of buildings*	m^2	-20	11	16875	-337500	-225
Elevating access roads; suction dredger	m^3	-8	20	30.000	-240000	-160
Sheet piling inner slope at the site of buildings, estimated length 10 m**	pcs	-1300	1	1.500	-1462500	-975
subtotal						-625
General costs, profit and risk 18%						-112,5
total						-737,5

* excluded from price for green unbreachable dike
** excluded from price for green unbreachable dike, optional for urban unbreachable dike

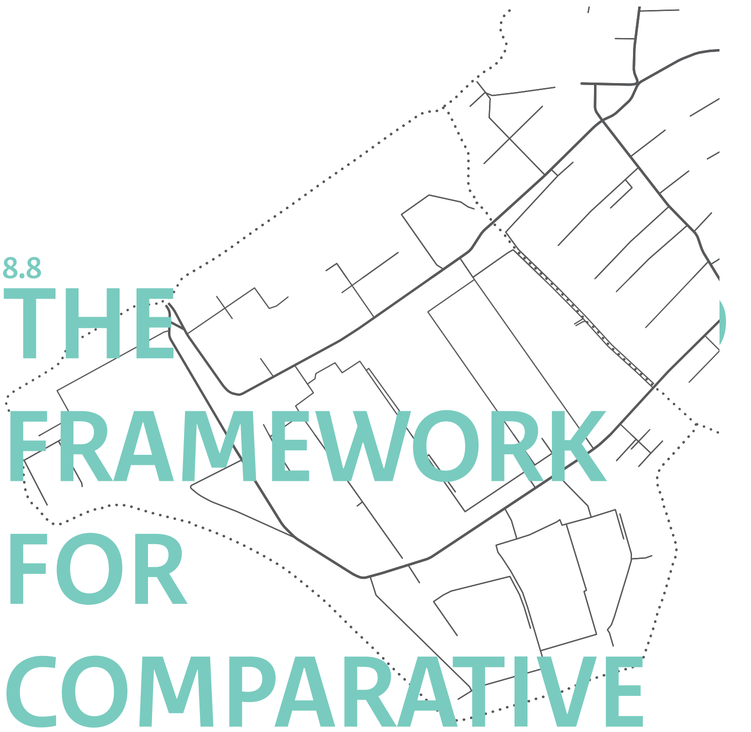
source: Oranjewoud, 2006: 15-18

Figure 8.7.50: Cost estimations for realization of alternative 2: alternate and/or additional costs occur regarding safety against flooding and urban development.

Project		Costs				Stakeholders/ to whom the effect occurs
		unit	price/unit	source	total	
I Safety against flooding		km	M €/km		M €	
• Regular dike reinforcement weak spots (piping, overtopping)	Piping	15	-0,3	Bossenbroek, 2012; Kind, 2013: C-5	-4	RWS, Water board Zuiderzeeland
	Infra	54,54	-2,5		-138	
	total	54,54	-2,6		-142	
• Give Knardijk C-status	Replace sluices	19	p.m.	Exp. judgement Van de Ven	-80	RWS, Water board Zuiderzeeland
	total				-222	

II Urban development	#dwellings	Min (€/dwelling)	Max (€/dwelling)	source	Min M €	Max M €	
• Living on the first floor (including utilities); development in risk zone fast & deep	15000	-18750	-30750	Kind, 2013: D-4	-281	-461	Government/ real estate developer
• Dwelling with elevated ground floor; parts of development in risk zone slow & deep	20000	-3000	-11000		-60	-220	Government/ real estate developer
• Measures to utilities; vulnerable and vital functions	1000	-7000	-9000		-7	-9	Companies
• Measures to roads; all new development	60000	-250	-2250		-15	-135	Government
total					**-363**	**-825**	


Hoge Knarsluis



8.8

THE FRAMEWORK FOR COMPARATIVE ASSESSMENT FILLED IN

Gooimeerdjik-Oost near Almere Haven, source: Van der Neut, 2011.

8.8 The framework for comparative assessment filled in

The framework for comparative assessment is generally filled in by means of literature review (Asselman & Alberts, 2008; Baan et al., 2008; Kolen et al., 2012b; Ruitenbeek, 2010). Expert judgement is used to verify the assessment for the effects on spatial quality, flexibility, governmental feasibility and possibility to link to other (climate) challenges.

The cost-effectiveness has been established with help from Nathalie Asselman (Deltares), Bas van Bemmel, Arno Bouwman and Bart Rijken (PBL). Verification of the estimated costs for realization has been done with help of Frans van de Ven (TU Delft).

A session for expert judgement with Leo Pols, Arjan Harbers and Kersten Nabielek of the PBL helped to assess the effects on spatial quality, flexibility and possibility to link to other (climate) challenges.

Regarding governmental feasibility, numerous people, including Joost Tennekes (PBL), Peter Otten (Municipality of Almere), Martin Nieuwjaar and Jeroen Doornekamp (Province of Flevoland), mr. Hupsel and mr. Walters (Security region Flevoland), Joan Meijerink (Water board Zuiderzeeland) have contributed to the assessment.

8.8.1 The 0-alternative – continuing current practice

The 0-alternative serves as a reference for the impact assessment and analysis of the two alternatives. In determining the impact of this strategy all criteria are therefore reviewed neutral ('0').

	Cost-effectiveness	Flexibility	Spatial quality	Governmental feasibility	Link to other challenges
0-Alternative	0	0	0	0	0

++ = high
+ = more than average
0 = average
- = less than average
-- = low

Cost-effectiveness criterion	Score	Explanatory notes
€ costs of realization	0	Estimated benefits vary between +23 M € and +896 M €, of which costs for preventive measures are minimum -142 M € and maximum -355 M €
# reduction of risk of victims	0	Estimated number of people affected in worst case scenario is 142.000. Estimated number of victims in worst case scenario is 1000 deaths (Asselman & Alberts, 2008: 39).
€ reduction of risk of damage	0	Economic damage according to Damage Scanner in scenario DRUK2030 of the Land Use Planner is 10 billion euros in case of a dike breach near Almere or Oostvaardersplassen, and 2 billion euros in case of a dike breach near Zeewolde
Sensitivity to different breach locations	0	More sensitive to a dike breach at the Markermeer (north-western side) than at the smaller lakes (Zeewolde), because in the first case the water depths are much larger.

Flexibility criterion	Score	Explanatory notes
Realization period	0	Rise with increasing safety standards through 6-year / 12-year testing. In the coming decades, a number of dike improvement projects should be started. Average duration of a dike reinforcement project is 5 to 10 years. Schaalsprong realized in 2030.
Sensitivity to uncertainties in assumptions or preconditions	0	The safety level meets the standardization of probability of exceedance in the entire dike enclosure (now and in the future). However, the probability of flooding is much greater. Thus, this does not mean that there is no chance of a disaster as a consequence of a dike breach. Other failure mechanisms (such as piping) create weaknesses in dike sections 5, 34 and 35.
Robustness	0	Dikes are designed for 50 years. Because of higher preconditions dikes are usually replaced earlier (after 25 years), renewed or upgraded.
Phaseability of execution	0	Dike reinforcements can be implemented in phases. The development principle of Oosterwold is organic building, which can be phased well. However, plans for Pampus and Weerwater depend on realization of HOV and lowering/covering A6.
Possibilities for anticipation on future developments	0	Future developments are not (also) driven by flood protection.

Spatial quality criterion	Score	Explanatory notes
Impact on cultural and landscape values	0	Raising dikes or dike reinforcement has an effect on the landscape (visible intervention); whether this is a problem or opportunity depends on the local situation and the design and integration of the intervention. The large scale organic development of rural areas can have negative consequences for the historical parcelling.
Impact on Natura2000 and EHS	0	Interventions in the Markermeer ask for ecological improvement and nature compensation (TBES project).
Added relation with water	0	Raising dikes deteriorates the contact with the water, increases the barrier effect.
Effect on usage, experiential and future value (score on Spatial Quality Matrix)	0	Lesser barrier effect between Stad and Haven by lowering A6, but entrance of the Weerwater as Koolhaas had once meant it will be lost. Creates a dual centre, not a connecting one.

Governmental feasibility criterion	Score	Explanatory notes
Water management policy	0	This strategy consists of the continuation of the current policy and therefore fits within the current water management policy. However, when no adjustments to current policy are made, climate change can cause problems in the future.
Spatial planning policy	0	This strategy consists of the continuation of the current policy and therefore fits within the current spatial planning policy. However, when no adjustments to current policy are made, climate change can cause problems in the future.
Realization period	0	Average dike reinforcement takes 5 to 10 years. Plans for Schaalsprong must be achieved in 20 years (2030). Within this time several election moments for water board and municipality take place.
Governmental support	0	Plans for the Schaalsprong are set in *Integraal Afsprakenkader* RRAAM (2010) between the national government, Province of Flevoland and Municipality of Almere.
Social support	0	Usefulness/necessity of raising dikes/dike reinforcement is acknowledged, but also always leads to resistance. Subsequently, social support depends on the way it is designed and integrated. In the case of Almere, no houses are built on the dike, so resistance to continuing check and reinforcement will not really be an issue.

Possibilities to link to other (climate) challenges criterion	Score	Explanatory notes
Opportunities for water storage for intense rainfall	0	Current policy is not doing much with this; largest expansions (Oosterwold) planned on lowest point of the polder, without additional measures.
Opportunities to reduce heat stress	0	Current policy is not doing much with this; Almere is not a compact city, and current policy focuses on maintaining / enhancing the polynuclear structure separated by green areas.
Economic and social consequences	0	Major economic growth, growth of population numbers. No connection to existing city, problems like crooked commuter balance will be further increased (there will be even more people going to Amsterdam). No differentiation of living environments compared to existing neighbourhoods.

8.8.2 Alternative 1 – compartmentalization, multifunctional unbreachable dike & water storage

Generally it can be concluded that alternative 1 scores negative on the governmental feasibility criterion. However, cost-effectiveness, possibilities for flexibility, effect on spatial quality and possibilities to link to other (climate) challenges are more than average.

	Cost-effectiveness	Flexibility	Spatial quality	Governmental feasibility	Link to other challenges
Alternative 1	+	+	+	-	+

++ = high
+ = more than average
0 = average
- = less than average
-- = low

Cost-effectiveness criterion	Score	Explanatory notes
€ costs of realization	+	Super dike construction is more expensive than regular dike reinforcement, but additional costs outweigh increase in value of real estate by radiation effects, and by the costs saved for continuous dike heightening (super dyke is being built on safety standard for 100 years in the future).
	0	Minimum costs are 136 M €. Maximum costs are 347 M €.
	-	Raising surface level + mounds relatively expensive, but if you place them in a smart way (allowing them to together form an unbreachable dike), the effectiveness of the measure increases.
# reduction of risk of victims	++	A compartmentalization dike means that a breakthrough in the rural area does not lead to flooding in the urban area. After norm differentiation using an unbreachable dike in the compartment with the largest population, the risk of casualties is almost 0 (a reduction of 91% compared to the 0-alternative, which means 12800 people affected, and 100 fatalities) (Asselman & Alberts, 2008: 39). In the rural area is however impoundment of water takes place, making evacuation more difficult and sheltering in that area is not possible.
€ reduction of risk of damage	++	After norm differentiation using an unbreachable dike in the compartment with the largest economic value, the risk of damage here is almost 0. This means a reduction from 10.4 billion euro to 2.7 billion euro in case of a dike breach near Oostvaardersplassen. In the Zeewolde scenario this means a reduction from 2.2 billion euro to 0.9 billion euro. NB: if only the bicycle path of 1 m high is realized, damage will be higher in the compartment with the most economic value in case of a dike breach near Oostvaardersplassen, because intensification takes place in this alternative 1 (Damage Scanner PBL runs May 2014).
	+	The amount of days needed to pump the compartment empty is reduced from 111 to 89 (Asselman & Alberts, 2008: 31), so recovery can start sooner also (and time means money).
Sensitivity to different breach locations	+	The safety level increases in urban areas, by the construction of guiding river, compartment and unbreachable dike. Water will only come in this area through the dike with a controllable inlet at Lepelaarsplassen.
	0	The safety level in rural areas decreases by compartmentalization (higher water levels and upward force). Because of the construction of the break free dike however, in the rural area the total length decreases of the dike where a possible breach occurs.

Flexibility criterion	Score	Explanatory notes
Realization period	+	Bicycle path on compartmentalization dike (1m) can be constructed quickly.
	-	Full compartmentalization by means of water retaining landscape takes a long time.
Sensitivity to uncertainties in assumptions or preconditions	+	Low sensitivity to uncertainties in preconditions, because the high level of protection is achieved by unbreachable dike.
	-	If later on another safety approach is chosen (full focus on prevention or water guiding through the area), the investments in the compartmentalization dike have been in vain.
	-	The effectiveness of a dike with controllable inlet and guiding river is not to prove exactly and therefore sensitive to assumptions and uncertainties.
Robustness	+	The compartmentalization dike (1m) is constructed at once (in 2020), with an expected lifespan of 100 years.
	+	A (multifunctional) unbreachable dike is constructed in phases, appropriate for the expected future situation, with an expected lifespan of 100 years.
	-	Adjustability unbreachable dike is low, in case it should be made higher (estimating height required in 100 years is imprecise, depends on many uncertainties).
	-	The additional structures in the area (guiding quay, compartmentalization dike) must also be maintained.
Phaseability of execution	+	The construction of compartmentalization dike (1 m) takes place at once, and then gradually the mound structure as compartmentalization is developed.
	+	Water safety meets the standard coming decade. Therefore, the construction of a (multifunctional) unbreachable dike can be implemented in phases (until 2050), linked to other spatial developments.
	+	The changes within the compartment and at the multifunctional unbreachable can be implemented linked to other projects.
Possibilities for anticipation on future developments	+	Through extra protection, development of urban areas may take place and be encouraged.
	0	When expanding urban areas and activities outside the compartment, damage and casualty risks also increase. In time, compartmentalization strategy can be a limitation for new urban developments. However, the planned area of compartment is now as big as Amsterdam inside the ring + Southeast (about 600,000 inhabitants), so unlikely.

Spatial quality criterion	Score	Explanatory notes
Impact on cultural and landscape values	+	Building on mounds is a nice illustration of historical heritage as we used to do.
	+	In the rural area its rural character is maintained and opportunities can be used for innovative land use and recreation from urban areas. This fits well with the population development which is expected to stagnate or shrink in the coming decades in rural areas, and to grow in the urban areas.
	+	Emphasis on development in the city, the living environment in the polder will be more attractive for wealthier people (low densities there very plausible).
	+	Make decisions on short term, then execution can take place in phases until 2100 (unbreachable dike has to be done before

		2050 and bicycle dike 1 m before 2020), linked to other spatial development. This provides opportunities for integration in the landscape, perception and awareness.
	+	Added value through bringing back the historical course of the river Eem.
	+	The key intervention in the polder sticks to the historical parcelling.
	-	From a cultural perspective, the polder is a typical example of land reclamation. Introducing so much water in the key intervention in the polder takes away this cultural value.
Impact on Natura2000 and EHS	+	No expansion in Markermeer/IJmeer, so no negative consequences for EHS and N2000-areas.
	+	Enough space to realize Oostvaarderswold (ecological connection between Oostvaardersplassen and Horsterwold) outside the compartment, also along guiding river.
	+	Realizing a gradient near the mounds, and creating a sandy, dry and warm spot can increase biodiversity. Goes well together with EHS.
	-	Dike reinforcement along Lepelaarplassen can have negative consequences for EHS and N2000-area.
	-	Realizing large bodies of water can hinder certain species of animals.
Added relation with water	++	Multifunctional unbreachable dike increases the contact of residents with the water.
	++	The wetland area, guiding river and bringing back the historical course of the Eem also increases the experience and contact with the water.
	+	High densities along the water (multifunctional unbreachable dike) are very plausible.
Effect on usage, experiential and future value	+	Opportunities for development spatial quality and the experiential value through proper integration of the guiding river and multifunctional design unbreachable dike.
	+	This strategy provides good opportunities for expanding regional water system and giving a more watery character to the dike ring area. This also contributes to greater awareness.
	+	The recreational usage value increases, because the introduction of new water bodies gives a boost to aquatics sector.
	+	The future value in terms of water safety and sustainability is positive, because the alternative adds robustness to the system.
	0/-	The future value in terms of spatial planning however is more fragile, because phasing might be more vulnerable.
	0/-	Compartmentalization dike may have a negative effect on the spatial quality of the landscape and the experience of it. This also applies to building on high locations. It all comes down to the local situation and the design and integration of the intervention.
	0/-	The living environment of the key intervention in the polder matches the environment of Noorderplassen already realized in Almere. Realizing the same kind of environment again in the polder means less housing differentiation overall.
	-	In the key intervention in the polder facilities will have little support base, and also the exploitation of the public transport line will be difficult.

Governmental feasibility criterion	Score	Explanatory notes
Water management policy	-	Adjustment of policy frameworks for water management is required because the protection against high tides is achieved partly through measures in layer 2. Differentiation of safety norms by higher protection standards urban areas, and no additional dike reinforcement after 2020 in the rural areas.
	-	Adjustment of policy frameworks for water management is required in relation to the addition of new regional barrier and dike boundaries.
	-	Financing of Rijkswaterstaat & water boards depends on various parties. Especially now it is difficult for property developers to sell. Rijkswaterstaat has to wait for this.
	-	The additional structures in the area (guiding quay, compartmentalization dike) must also be maintained. Question is whether water board or municipality is responsible for this.
Spatial planning policy	0	Lack of clarity about responsibilities for developing multifunctional unbreachable dike (dike built for 50/100 years, zoning plans change every 10 years → how is safety guaranteed dike after this? And does water board do that, or municipality?)
	-	Adjustment of policy frameworks for spatial planning is required in relation to the addition of new regional barrier and dike boundaries.
	- -	Adjustment of the spatial planning policy framework is necessary due to necessary spatial planning guidance and space reservations for multifunctional use unbreachable dike. Cooperation with water boards and other parties completely opposes the way it's always done.
Realization period	+	Realization bicycle path on compartmentalization dike can be quick (2020).
	+	Bicycle dike 1m in time can be expanded to mound dike as full compartmentalization.
	+	The adjustments by interventions in layer 2 within the compartment and at the multifunctional unbreachable dike can be developed linked to other projects, making them less drastic for daily practice in the area.
	-	Interventions in layer 2 call for more time regarding spatial planning procedures (2030). Unbreachable dike, when phased piece/mound by piece even longer (2050). After 2030 spatial planning guidance remains important in case of new developments.
	-	In the case of the multifunctional unbreachable dike Rijkswaterstaat cannot decide what to do every five years, because the dike body is integrated in the super levee itself.
Governmental support	+	Plans for a multifunctional and accidental unbreachable dike at DUIN have already been made and the construction has started; these plans were not made from a water safety perspective, but from experiential values, so from multiple perspectives a multifunctional unbreachable dike may expect support.
	+	Security region: because of the compartmentalization the area that is to be evacuated in case of a (impending) dike breach or flood is smaller. This allows all the attention and capacity to focus on the evacuation of the rural areas. NB: Apparent security: in alternative 2 people are better prepared, now totally unprepared in urban areas.

	+	Security region: shelter is possible in (part of) the dike enclosure, therefore fewer people need to be evacuated from the dike enclosure, roads become less congested, and there is less need for care outside the dike enclosure.
	0/-	When compartmentalization takes place only by 1 m high dike: water guidance through the area makes evacuation in an emergency situation more difficult. It places extra demands on the design of evacuation routes (altitude and bridges) from the part through which water is guided. In case of full compartmentalization by means of mound dike combined with the unbreachable dike, this no longer applies because theoretically a breach never takes place in this compartment. Therefore, the guiding river can better be realized only after full compartmentalization.
	-	The governmental support for this strategy is limited, because it is more expensive than other strategies, and has a huge impact on the area.
	-	Many parties are involved and have to cooperate, are not used to doing so.
	-	The moment things have to be done is not in the hands of executing parties.
	-	Oosterwold is meant to have a low density. This alternative however means intensification. 'Red' and 'green' contour policy just has been abandoned, so there will be little enthusiasm for this.
Social support	+	In urban areas, the safety level is increased, so here support can generally be expected.
	+	Make decisions on short term, then execution can take place in phases until 2100 (unbreachable dike has to be done before 2050 and bicycle dike 1 m before 2020), linked to other spatial development. This provides opportunities for integration in the landscape, perception and awareness and eventually will lead to greater social support.
	+	Evacuation of large groups of people from urban areas in this strategy is no longer necessary, because urban areas are optimally protected. This allows all the attention to be focused on capacity and the evacuation of the rural areas, where the inhabitants are better protected in this way.
	-	Higher line elements (compartmentalization dike) and risk of higher water levels In the rural areas can lead to social resistance (however, lowest number of inhabitants).

Possibilities to link to other (climate) challenges criterion	Score	Explanatory notes
Opportunities for water storage for intense rainfall	++	Guiding river and watery living environment Oosterwold provides opportunities for water storage.
Opportunities to reduce heat stress	+	Guiding river and watery living environment Oosterwold provides opportunities for water storage, and thus for cooling.
	-	Densification can, unless well designed, lead to more heat stress.
Economic and social consequences	++	Subarea with metropolitan area of Almere gets extra protection, so favourable conditions for economic development.
	+	For recreational sector, this strategy may be positive because the development offers good opportunities to improve the spatial quality (e.g. multifunctional dike along IJmeer / Markermeer).

	+	Several expansion areas have different characters (high / low density, high rise / low rise), which improves the differentiation of living environments.
	0	The economic impact on the area near Zeewolde is neutral. Under normal circumstances, there are no significant differences.
	-	The consequences in rural areas are greater at potential breakthrough, because of greater water depths. This is disadvantageous to the economic activity here (mainly agriculture).

8.8.3 Alternative 2 – Floodproofing vulnerable & vital objects, total evacuation of residents

Because the gains of this alternative are mainly extracted from the reduction of victims, which are not easily monetized, it is hard to establish the cost-effectiveness of this alternative. Probably, it will score more than average on this aspect.

Generally it can be concluded that alternative 2 also scores negative on the governmental feasibility criterion. However, possibilities for flexibility are more than average, because of the administrative nature of interventions in layer 3, and the flexible structure of the skew grid. The reliance on human action however gives this alternative an uncertainty, so this alternative is not without risks. Regarding spatial quality and possibilities to link to other (climate) challenges, there is not much difference compared to the 0-alternative.

	Cost-effectiveness	Flexibility	Spatial quality	Governmental feasibility	Link to other challenges
Alternative 2	0/+	0/+	+/-	-	0/+

++ = high
+ = more than average
0 = average
- = less than average
-- = low

Cost-effectiveness criterion	Score	Explanatory notes
€ costs of realization	-	Adjustments to buildings may cost between 363 and 852 M € more than the 0-alternative. These costs will however be greatly reduced when these measures are taken into account in new development from the beginning. Costs for water safety are less than the maximum costs in the 0-alternative (222 M € versus 355 M €). These extra costs however might weigh up to the positive balance of the total costs of the 0-alternative.
# reduction of risk of victims	++	This strategy focuses on complete evacuation of residents, if not horizontally out of the dike enclosure, then vertically in buildings/shelters.
€ reduction of risk of damage	0/+	Maximum damage occurs, same as 0-alternative. This means a maximum damage of 11.1 billion euro in the Almere and Oostvaardersplassen scenario, and 1.7 billion euro in case of a dike breach near Zeewolde. However, no damage will occur to vulnerable and vital functions, which will be protected.
Sensitivity to different breach locations	0/+	The zones where water will arrive immediately or quickly can cope better with the location of the dike breach due to the building rules for urban development. In zones where water arrives slowly and deep, there is no difference compared to the 0-alternative.

Flexibility criterion	Score	Explanatory notes
Realization period	+	Realization of interventions in layer 3 can be done soon (2020)
	+	Interventions in layer 2 and 3 can be executed in phases until 2100 and link to other spatial developments.
Sensitivity to uncertainties in assumptions or preconditions	0	The risk zoning could not be accurate, due to the selection of breach locations, but this is not likely.
	-	Depending on the self-reliance of citizens.
Robustness	+	A grid is easily adjustable, has a sustainable floor plan.
	-	The additional structures in the area (flood escape areas) must also be maintained.
Phaseability of execution	+	As long as the infrastructure is there, the skew grid can be filled in in phases.
	+	The floodproof zone for vulnerable and vital functions can be started in the new development areas, and until 2100 be expanded in the (green arms of) existing urban areas.
Possibilities for anticipation on future developments	0	Because of risk zoning, places where can be built change (no buildings in immediate & deep, which is a large part of Pampus). This however can be compensated at other places.

Spatial quality criterion	Score	Explanatory notes
Impact on cultural and landscape values	+	When designed well, the height differences can be experienced, for instance when you see that the higher sand bodies have different vegetation (for example like Schokland, or how the Dutch sand ridges used to be).
	0/-	From a cultural perspective, the polder is a typical example of land reclamation. Introducing so much sand and high grounds in the key intervention in the polder takes away this cultural value. On the other hand, living on mounds is typical Dutch historical practice.
	-	The skew grid at Oosterwold ignores the historical parcelling.
Impact on Natura2000 and EHS	+	In zones where water arrives immediately and deep (risk zoning) nature is developed.
Added relation with water	0	No changes compared to the 0-alternative: still building behind the dike.
	-	Compared to 0-alternative more difficult in polder key intervention to realize a water parcel.
Effect on usage, experiential and future value (score on Spatial Quality Matrix)	+	Possibilities for enhancing spatial quality and experiential value by a proper integration of flood escape areas.
	+	The key intervention in the polder will have a larger support base for facilities and the public transport line, because of higher densities (urban usage value).
	+	Depending on the elaboration of the concept into a design, this alternative provides many starting points for a high experiential value (height of the floodproof zone; would be more attractive if elongated and thinner, after the example of the dike between Cabo de Palos and San Pedro del Pinatar in Spain).
	+	Compact new development gives the chance to add something new to the city of Almere.
	+/-	Higher densities in the polder lead to more employees here. This relates to the other centres of the city, takes something away there. This however strengthens the concept of multinuclearity.
	-	Future value: risk whether it works out economically, less flexible in this sense than 0-alternative.

Governmental feasibility criterion	Score	Explanatory notes
Water management policy	-	Adjustment of policy frameworks for water management is required because the protection against high tides is achieved partly through measures in layer 2 and layer 3, and no additional dike reinforcement after 2020.
Spatial planning policy	0	The rules for building can be acknowledged in zoning plan or building permit; possibilities are there.
	-	Adjustment of the spatial planning policy framework is necessary due to necessary spatial planning guidance, adjusting capacity evacuation routes and space reservations for floodproof zone.
	-	Zoning has to be established in structural vision (Province?). If in conflict with plans from municipality, could get complex.
	-	Security regions have to be more involved in spatial planning policy. Now their advice in the plan making process is asked for in a very late stage.
Realization period	+	Realization (administrative) interventions in layer 3 can be soon (2020); creating/improving evacuation plans regarding flood scenarios is a no-regret measure.
	+	Interventions in layer 2 and 3 can be implemented in phases until 2100 and link to other spatial developments.
	-	As quickly as the city transforms, you can increase safety. Rijkswaterstaat cannot, for example, guarantee the safety in 2020 → too long-term for safety people (not for spatial planning)
Governmental support	++	Security region: shorter evacuation routes because of flood escape zones in the area. There must be paid sufficient attention to the capacity of evacuation routes, the organization of shelter locations and the risk communication beforehand on the shelter locations and routes leading there. If the situation takes a long time it may be necessary for the liveability to do proceed to evacuation, but then there is more time to prepare the sheltering outside the dike enclosure and the evacuation itself. Parties are very well prepared, high awareness.
	+	High rise in the quickly & deep risk zone will contribute to urban character (depending on the design), which will make the city more attractive to investors/future inhabitants, which is what the government wants.
	0	The governmental support in terms of realization cost is the same as the 0-alternative, because in the new areas only infrastructure is adjusted. Making vulnerable and vital infrastructure and functions floodproof is done in consultation with these companies by themselves.
	-	Almere is always the city with the suburban living environments; building too much high rise may mean that you are building something for which there is no demand.
	- -	Politics: a sign is given of 'not safe' in existing neighbourhoods, which may lead to investors and companies withdrawing from the polder. This is not a sigh that the government would like to give.
Social support	+	Shorter evacuation routes because of flood escape zones in the area.
	+	The visual effect may appeal to society: the idea that a lot is being developed in their city.

	0	Placing utilities in buildings on first level is not noticeable in housing prices.
	0/-	In alternative 2 no regular dike reinforcements are included, with the idea that the level of safety is achieved with measures of safety layer 2 and 3. This approach is currently not supported. When additional dike reinforcement is applied, the measures of safety layers 2 and 3 are interpreted as the realization of additional protection of certain areas and to reduce the residual risk. The support for this begins to grow.
	0/-	The reason for not sleeping on the ground floor in quick & deep risk zones is hard to see in everyday life (in contrast to for instance Hamburg, Germany). It might be frustrating for people to think you cán sleep there, but “you are not allowed”. Is solvable by placing for instance parking space for bicycles and cars, or facilities on ground level.
	-	There is a demand for suburban living environments; high rise in quick and deep risk zones may lead to a surplus of apartments.

Possibilities to link to other (climate) challenges criterion	Score	Explanatory notes
Opportunities for water storage for intense rainfall	0	No difference compared to 0-alternative.
Opportunities to reduce heat stress	0	No difference compared to 0-alternative.
Economic and social consequences	+	Risk zoning leads to spatial differentiation of living environments (high / low density, high rise / low rise).

8.9 Reflection P5

1. Project description

And the relationship with the theme of the studio

In the Randstad and the major cities in the Netherlands still remains a task of densification, mostly in areas with a high flood risk (PBL, 2011: 16; Van Drimmelen & Oosterberg, 2005). Typical example of this are the plans for Almere 2.0: 60,000 new dwellings for a growth from 190,000 to 350,000 residents and business areas for 100,000 new employees planned for 2030 in a deep polder. This means more dwellings on the same surface, more construction in the subsoil and increased use of the outdoor space. Question is how planners and urban designers can spatially anticipate on flood risk in new developments and re-development areas. Nowadays, it is either fighting against water, or working with it. The traditional Dutch flood management still focuses on prevention. Over the years, a feeling of insecurity led to heightening dikes, which led to a greater sense of safety. Because of this, the land will be more intensively used, which will again lead to more flood risk, and so back to heightening dikes, and so on. Professionals often refer to this as the "control paradox" (Wiering & Immink, 2006).

This illustrates the dominant approach towards water management, a technical one aimed at ensuring safety and protecting land by blocking out water (Voogd & Woltjer, 2009: 189). It also illustrates the lack of integration between water management and spatial planning: water boards construct and maintain dikes, and behind the dikes planners and urban designers develop land use plans, without worrying about flood risk. Raising dikes however not always contributes to spatial quality of an area. Furthermore, implementation of climate proofing measures in urban development today may considerably reduce costs for tomorrow (PBL, 2011: 44). Spatial measures can be taken not only to prevent floods, but also to lower the impact. This approach, the so-called multi-layer safety approach (MLS), has been introduced in the National Water Plan (NWP) (VenW et al., 2009). Somehow a balance must be found between measures on these different layers.

Besides these safety assignments, there are a lot of spatial planning assignments which are typical for every urban area in the Netherlands, e.g. realising desired program, spatial quality, water nuisance, drought and water shortages, as well as heat stress in extremely hot summers. Furthermore, the current economic climate calls for a new, more flexible spatial planning form and a different role of the urban planner in area development in the Netherlands. How to deal with this in a smart way, integrating water safety and other assignments of spatial planning? And how do we balance the measures on different layers of MLS, while adding to spatial quality and all these other assignments?

Goal of this graduation project is to apply multi-layer safety, with the focus on spatial interventions, in areas with a major development task, such as Almere 2.0.

The aim of the research and design project will be developing a framework for balancing different types of measures, based on their cost-effectiveness, impact on spatial quality, flexibility, governmental complexity and possibilities to link to other climate challenges. This framework will help to decide under which conditions and where certain measures to reduce flood risk are sensible physical interventions to control the probability or impact of floods and to reduce the damage and number of victims. The study is aimed at collecting the required knowledge, which helps managers, politicians and policy makers to make an integral comparative assessment. This framework will be applied on different alternative designs made for the municipality of Almere and the Southern Flevopolder, to help decide how to facilitate the Schaalsprong Almere 2.0 in a flood proof manner.

"Due to a changing climate and changing insights concerning sustainable relations between cities and water-landscapes, new interventions will be needed to create a new urban delta-landscape. […] Delta Interventions […] is an inter-disciplinary studio which, on a wide variety of scales, deals with the necessary transformation of the delta " (Nillesen, 2012: 3). The subject chosen for the graduation project and design is therefore well related to the theme of the studio Delta Interventions.

2. Relevance

Scientific relevance

Flood risk and the roles of spatial planning and water management are subjects that to a large extend have been mentioned in scientific and professional literature.

Over the past few years there has been a call for alternative flood control policies, with more integration of water safety and spatial planning, e.g. Brouwer and Van EK (2004), Tromp and Van de Ven (2011), Reinhard and Folmer (2009) and Wiering and Immink (2006). With the National Water Plan becoming active, and the introduction of the latest Dutch Delta Programme (DP2013), there has been given response to this. However, amongst professionals there is still a discussion about the real need for multi-layer safety (see quotes from WaterForum on the right) .

The tendency of this discussion amongst professionals points out the need for an applied method or tool for an integral approach, exactly the added value of this project. This project tries to provide handles for integral assessment in different domains and policy levels.

This framework for comparative assessment will not only be applicable for the context of Almere and the Southern Flevopolder, but it will be transferrable to other locations of new development or redevelopment in deep polders with a high flood risk.

Societal relevance: the relationship between the project and the wider social context

The fact that also in society there is a need for other measures than purely prevention, also because of the visual pollution and the possibly negative effect on the spatial quality that dike reinforcements and raised dikes entail, is illustrated by Markus (2012), on the right . In this case, inhabitants of Uitdam fear for a loss of the unique town character, and a loss of visual relation with the water, due to planned dike reinforcements, which can have a negative effect on the market value of their houses. This is one of the reasons why in this graduation project the contribution to spatial quality is one of the criteria used in the framework for comparative assessment of the alternatives.

In a broad sense, the societal relevance of this study lies in the fact that in the Netherlands there are many social activities and planned development that take place in areas with a high flood risk. This study provides tools to deal with this and still expand and redevelop in these areas, and thus will have a wide support base.

In a narrow sense, this study is relevant for the new residents, businesses, employees and visitors of Almere that will be attracted to the city through the Schaalsprong 2030.

"Political choice for multi-layer safety bizarre"

Source: Vrijling, *Professor in Probalistic Design and Hydraulic Structures TU Delft,* in: Lammers (2012) on *WaterForum,* 27 April 2012.

"Constructing dikes only is not sufficient"

Source: Jonkhoff, *economist TNO,* and Van Ginneken, *Project manager at Royal HaskoningDHV* (2012) on *WaterForum,* 4 July 2012.

Inhabitants of Uitdam are not afraid of the water

Residents of village in Noord-Holland take action against horizon polluting dike reinforcement

Source: Markus (2012) in *Trouw,* 18 October 2012.

"It has also allowed me to gain a deep insight into issues, such as responsible water management, which are fundamental to our country"

Source: His Majesty King Willem-Alexander on the occasion of his investiture (RVD, 2013).

3. Reflection on methods

Research

Methods for data collection that have been used consist firstly of **literature review**. Secondly, **case studies** have been done to get more insight on different measures that are suitable for different contexts.

Thirdly, to get a grip on cost-effectiveness, spatial quality, flexibility and governmental complexity, many **professionals** have been **interviewed**, such as planners and designers.

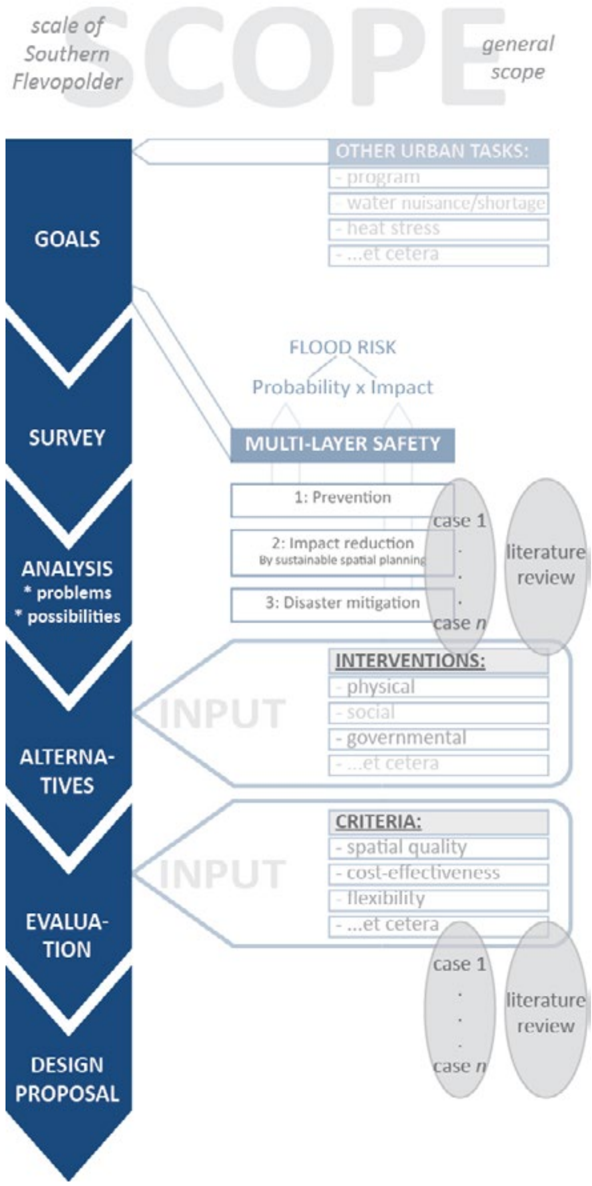
To identify spatial factors that will not come up through literature study, other **digital sources** have been consulted: Google Maps, Google Earth, and Bing Maps, et cetera. For the specific context of the southern Flevopolder, **field work** through **site visits** has been done.

Design

The research has led at a general scope to a theoretical framework on what kind of interventions to enhance water safety are imaginable. Also, a theoretical framework on the framework for comparative assessment has been made.

At the scope of the Southern Flevopolder, analysis has led to identification of problems and possibilities, which together with the input of the overview of interventions has led to three alternative structural visions for the Southern Flevopolder. **Research by design** was essential to generate these alternatives, and to come to a final selection – "*vallen en opstaan*".

To evaluate these alternatives, a design for key interventions has been made. The framework for comparative assessment coming from the research has been applied, and also a **panel of experts** has been consulted. This method turned out to be very usefull: it gave me many new insights, experiences in the actual practice, and on top of that a free job interview. It however comes with a downside, because you are really dependent on others for gathering information. Especially around April and May, with a lot of holidays, many (*vooral ambtenaren*) professionals were unreachable (some even for over a month).



The initial intended process is shown here on the right. In this scheme, an important arrow is missing, namely from the design proposal back to the alternatives. This is because making a design for the key interventions has led to alterations in the alternatives. It sometimes turned out that what seemed like a good idea on a large scale, did not provide the city or identity that you want on a small scale, and sometimes local conditions are just not suitable for certain interventions or design solutions.

The relationship between the methodical line of approach of the studio and the method chosen

"Delta Interventions is a design studio with a strong emphasis on the translation of research output into design concepts" (Nillesen, 2012: 3). This is exactly what was done when translating the overview of interventions into alternatives fit for the Southern Flevopolder and into the key interventions.